DEVELOPING ICT-ENABLED SERVICES IN TRANSITION COUNTRIES

a studio-based approach for logistics brokering

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a studio-based approach for logistics brokering

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To my dad, Mwenya Tulula, to my mum, Anna-Mary Mugimba†

Colophon

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PREFACE AND ACKNOWLEDGEMENTS

Over the recent years the focus of ICT has shifted from national interests to worldwide developments, with most enterprises increasingly applying ICT on virtually all their business activities. Globalisation and ICT are reinforcing the linkages between the developed, transition, and developing world. The trend has generally been towards the deployment of services using the Internet, given the complexity and volatility of today's business demands that have rendered inadequate the reliance on "traditional" service delivery methods. Although many developing and transition countries have reported major infrastructure difficulties such as low level of telecommunication services, this should not be taken as an excuse for slow action. Becoming a link in the global ICT chain opens economic, social and cultural opportunities, and also presents new and unique challenges. In the research presented in this thesis, we examined issues in developing ICT-enabled services in transition countries with the aim of developing tools to facilitate and improve the development of services. We used the domain of rural logistics to develop a suite that consists of software services and guidelines to assist organizations to develop efficient logistics brokering services.

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1. ICT-enabled services in Transition Countries

1.1 Introduction

As we make progress in the third millennium, we are experiencing an important change in our daily lives, the move to an Internet-based society (Turban et. al., 2005). The growth of Internet infrastructures and the World Wide Web has created new opportunities, such as sourcing strategies that enable access to skills and expertise, and the provision of critical services (Qureshi, 2003). The United Nations Conference on Trade and Development (UNCTAD) annual report for 2004 pointed out that enterprises and society at large widely accept that information and communication technology (ICT) is at the centre of an economic and social transformation that is affecting all countries. While ICT improves productivity in existing activities, it also makes possible the emergence of new activities such as online service delivery and the production of different types of ICT services. These ICT-mediated activities enable the delivery of high-value-added services that can boost local economies. There is a valid case for presenting this argument for rural areas whose context is characterised by poor road networks and numerous small, spatially isolated actors for whom service delivery results in high transaction costs occasioned by the long distances to service delivery points. There is need to invest in ICT-enabled service delivery and support systems that will improve the general accessibility to services by rural households and enterprises. Delivery of services using ICT is expected to accelerate development in such areas, following on the work of Cunden & van Heck (2004) which states that ICT and especially the Internet significantly reduces the cost of doing business and establishes complex relationships between organizations and their stakeholders.

The use of ICT in service delivery makes it possible to extend services to areas that where no service previously existed, or where service delivery was haphazard. In the quest to reduce the digital gap between rural areas in developing and transition countries and their urban areas, and that between developing and transition countries and developed countries, the crucial role of ICT and its potential for speeding-up the pace of development and solving the problem of exclusion from main stream services in rural areas is paramount. Recognition of the vital need to deliver ICT-based services in rural areas is inevitable, especially as a means for leapfrogging and bridging the gaps in mainstream service delivery. The specific use of ICT to accelerate development and promote economic growth in a region is often referred to as *technology leapfrogging*: the implementation of a new and up-to-date technology in an application area in which at least the previous version of that technology was not deployed (Davison et. al., 2000). One area in which ICT can be used to leapfrog and improve service delivery is in the domain of logistics. Logistics is defined by the Council of Logistics Management as the process of planning, implementing, and controlling the efficient and effective flow and storage of goods, services and related information from point of origin to point of consumption for the purpose of conforming to customer requirements (CSCM, 2005). Torres & Miller (1998) observe that when value is added to a transaction during the process, the transaction may be referred to as a logistics service since the customers receive more than the product. The customers receive a bundle of products provided by the supplier, such as payment terms, merchandising support, and the delivery of goods.

Logistics services are defined by Bhatnagar & Viswanathan (2000) as solutions that encompass transportation, warehousing, inventory recording, packaging, and handling of customer returns, among others. Logistics services are essential components of economic development in all countries, but particularly so in those still in the process of development (Jacobs & Greaves, 2003). To overcome the challenges of service delivery occasioned by the lack of accessible transport services, it is important to apply joint approaches to service development that enable stakeholders to

come up with services that link national and local levels. The logistics problems in rural areas of developing and transition countries stem from several causes, the most obvious simply being that the countries are developing. According to Jacobs & Greaves (2003), during the development process, the demand for logistics services increases and rural communities experience many problems that have ready-made solutions developed in the Western world or for urban areas, but that need considerable adaptation to tailor them to the particular needs and conditions of each rural context.

The challenges facing developing countries in their attempts to leapfrog technologically also vary greatly by geography, culture and level of economic attainment (World Bank, 2003). In order to offer higher value end-to-end services, it is desirable to provide a means for composing, customising, and deploying ICT-enabled services in a very flexible and efficient way, based on the specific context of the area in which the services are delivered. The most commonly used means for flexible ICT-enabled service delivery is via web services technology, which allows enterprises to outsource parts of their business processes, and also provides the opportunity to offer new value-added services via the Internet through composition from pre-existing web services, possibly offered by different companies. These ICT-enabled services can be pre-assembled or created on the fly, and can be dynamically adapted to changes in the business environment (Casati et. al., 2000).

In developing and transition countries, it is difficult to rely on the Internet for service delivery since it is not ubiquitous, it is expensive, and where available the users are faced with bandwidth related problems. There is also the ever-present problem of intermittent power supply. This means that even though the technology of web services can be used as a vehicle for developing services, the services would have to be usable via technology devices widely available in rural areas e.g. mobile phones, thereby eliminating bandwidth-heavy technologies. This calls for the need to provide core services in reusable software components that can be combined and deployed easily and flexibly, and at the same time taking advantage of already existing services and technology devices in rural areas. To mitigate the intermittent power problems, there is also a need to provide middleware services that ensure that even in cases of power loss during a service delivery, it is possible to resume transactions from where they left off.

Based on the preceding discussions, the stand taken in this work is that effective ICT-enabled service systems development approaches need to be promoted, and where possible, replicated and scaled accordingly to promote the wider impacts of ICT in transition countries. Effectiveness of the service development process, expressed as a combination of usefulness, usability, and usage by Keen & Sol (2007), can be achieved through an environment that involves rural stakeholders with the aim of meeting the highly specific rural users' expectations and service needs. The environment in which tools to support the development of services are deployed should enable stakeholders to focus on the relevant service design issues and treat context specific issues from various view points. To facilitate effective development of ICT-enabled services, the environment and support tools should be used to identify, develop, prototype, and test new services jointly with the stakeholders.

There is need to support the development of services using approaches that help to illustrate, simplify and manage ICT-enabled service delivery operations in rural areas. One of the basic means employed to enable and improve ICT service delivery is through the use of portal technology (Boyson, et al., 2004), which makes services accessible and easy to use from remote areas. This technology can be adapted and used to deliver services to people in dispersed locations such as the rural areas, as long as the stakeholders have means to access the services. The challenge now becomes to support the human realities of the service stakeholders, who perform actual design and development of ICT-enabled services, with the means for identifying, developing, prototyping, and

testing new services. Through this work, we would like to facilitate and improve the development of ICT-enabled logistics brokering services in rural areas. We would like to ensure that the services are user-centric, bearing in mind that rural users of the services are expected to work and live with the services in their daily life settings yet unlike their urban counterparts, they are not forced to be in contact with technology on a daily basis. The basic aim is to provide facilitation and support for service development through an environment in which we deploy software tools, and methods, which can be used to develop logistics brokering services that fit into the daily life settings of the rural stakeholders.

In this research, we studied the challenges faced in developing ICT-enabled logistics brokering services in rural areas, based on the premise that logistics brokering can address rural access and mobility issues and enhance the ability to deliver services in a more efficient way. We adapted definitions of information systems development taken from the work of Sol (1982) and Wijers (1991) to define service development as a stepwise problem solving approach for the transformation of user requirements into performance criteria and operational structures. We used the work of Gronroos (2001) and Kasper et al. (1999) to define services as activities or series of activities of intangible nature that take place in interaction between customers and systems of the service provider, which are provided as solutions to customer problems and add value to customers. Transition countries are defined as a separate group of countries that are more advanced in their own right, and lie between the developed and developing world in economic terms (UNDP, 1999). The term is applied by the United Nations to refer to countries at different stages of 'transition' from a centrally planned economic system to a social order based on a market economy, referring mostly to countries of the former Soviet Union. Though these countries are far from being a homogenous lot, there are some denominators that are common to them. One of these is the penetration of the Internet, which varies from country to country but is still very low by the standards of countries in Western Europe and North America.

For this research, we expanded the definition of transition countries to include countries that are more advanced in the developing country spectrum, and especially those whose economy is in transition from that which was exclusive for a group or region, to a more inclusive economy e.g. where a certain section of the population was previously 'locked out' of economic development activities. This is because we believe that there are many changes experienced in such countries during the transition period that make the countries different from the typical developing country. These countries can be noted for their preliminary activities to launch ICT-enabled services. In the context of this research, ICT-enabled services are defined as services whose delivery is based on the use of technology to facilitate the communication and processing of information by electronic means, and may incorporate current technology standards such as those implemented in web services.

We define logistics as that part of the supply chain process that plans, implements, and controls the efficient flow and storage of goods, services, and related information from the point of origin to the point of consumption, conforming to customer requirements (Lummus, et al., 2001; Mentzer, et al., 2001; CLM, 1998). Further, we use the definition of rural logistics services taken from Site & Salucci (2006), which states that these are services that are concerned with passenger and freight movement by motorised and non-motorised means of transport in low population density areas. Logistics brokering is defined as the provision of logistics services through a central agency, which may also be an individual. The main focus of this research is on improving the development of ICT-enabled logistics brokering services in rural areas of transition countries.

The aim is to develop an approach that can be used to facilitate the development of logistics brokering services that are tailored to the context of a rural environment. Given the virtual

explosion in mobile device ownership, mobile service coverage, and usage in many rural areas, as well as the steadily increasing range of Internet connectivity, computing knowledge, and other ICT-enabled functionalities, there is a great potential to harness some of the web-based capabilities for service delivery in these areas. With specific reference to rural areas, we state that the use of ICT-enabled logistics brokering services in rural areas is expected to reduce the economic and service access barriers associated with small enterprise sizes, long distances from amenities, and low-volume supply chains. Further, we state that ICT-enabled logistics brokering services are also expected to help to realize the underutilized potential for service delivery in rural areas.

The basic challenge to the development of logistics brokering services in transition countries remains the provision of an environment through which rural stakeholders can jointly define their service needs, and to develop and use context-based software tools in a user-centric manner. To overcome this challenge, we need to come up with means to facilitate user-centric service specification, development, and testing of services that can be used to enhance significantly the capabilities of rural inhabitants and lead to better services. The environment should enable stakeholders to leverage the technological response to barriers preventing rural service delivery and underpin the involvement of rural communities in service development.

1.2 ICT-enabled Services and Transition Countries

The trend of ICT-enabled service delivery worldwide has generally been towards the deployment of services via the web, given that the complexity and volatility of today's business demands have rendered "traditional" service delivery methods obsolete (Feiman & Knox, 2002). Services that are delivered via the web are basically services that request, and are given access to, resources via an HTTP request (McGraw, 2001). Whether the requested services and/or resources perform an operation or return data to the requesting client does not matter. The HTTP request does not have to be one made over the Internet and can be done on a private network. The technology is used essentially as a tool or enabler to provide services, in which most of the functions tend to be human-intensive.

The services can be internal to the organisation i.e. meant to increase the operational efficiency through work force residing within the organisation, or they can be outsourced (McGraw, 2001). Web-enabled services expose, or consume, functions or content programmatically via the Internet and can be viewed as building blocks for distributed systems. They are made up of a general-purpose architecture that enables distributed applications to be assembled and developed from a web of software services (Turban et al., 2004; McGraw, 2001). According to Glass (2000), a service can aggregate other services to provide a higher-level set of features. The web-enabled technologies and architectures can be adapted and used to deliver ICT-enabled services in transition countries, especially since services can be remotely produced and delivered, particularly when they do not require manipulation of physical objects or close interaction with the customer (Davis et al., 2002). The rapid growth of trade in services is a significant feature of contemporary economic development driven by advancements in ICT. Services were traditionally regarded as non-transferable and non-storable, requiring joint production between producer and consumer making them essentially non-tradable (Davis et. al., 2002). In particular, ICT has become an important tool for improving productive capacity and increasing international competitiveness by reducing the transaction costs involved in the production and exchange of goods and services. This has in turn increased the efficiency and effectiveness of management functions, thereby enabling firms to exchange and access more information (UNCTAD, 2003).

The diffusion of inter-networked multimedia technologies within the business sector is lowering the cost of transacting and communicating among firms, making it possible to disaggregate or unbundle

the production and consumption of information intensive service activities, thereby inducing the emergence of markets for services. Unbundling or disaggregation of information-intensive services can be used to separate production from consumption and to permit previously non-tradable services to be actively traded regionally and internationally, and this is advantageous for transition countries (Davis et. al., 2002; Vaknin, 2000; Singh, 2001).

Despite the wide range of benefits that can be brought about by ICT, the development and adoption of ICT to enable service delivery in transition countries have so far been limited. Reasons for this include among others: intermittent power supply, lack of awareness of what ICT could offer; insufficient telecommunications infrastructure and Internet connectivity; expensive Internet access; attempts to transfer service delivery systems from developed countries; shortage of requisite human capacity; failure to develop services that meet local needs; and the lack of transparency (UNCTAD, 2003). Evidence from the literature suggests that ICT is capable of providing solutions to some of the service delivery problems being faced in transition countries.

The benefits of the information revolution should be exploited by businesses in developing countries to make contacts, check prices, display goods and enter into contracts (Moyi, 2003). Evidence from Ghana, indicates that workers in enterprises without telecommunications waste up to half of their time travelling from place to place (UNDP, 1999). The implication of this is that supportive mechanisms that are ICT-based are likely to have a higher payoff, and make the workers more effective in their service delivery. However, there is also increasing evidence that ICT-based services that ignore the ‘organic information systems’ and ‘indigenous knowledge’ prevalent in the way of working of the communities in rural areas of transition countries fail to meet their objectives. Since communication is essentially a social process, the essence of communication and development should not be to change people but to give people access to useful information and to create new opportunities so that people can change themselves (Moyi, 2003).

Globalisation and new services enabled by ICT are reinforcing the linkages between the developed, developing, and transition world. There has been extensive growth in the usage of ICT in the delivery of services in transition countries and among others, drivers for this phenomenon have included: the rapid pace of technological advancements in communication and information services that have opened up new communication possibilities; the steady pace of decline in communication infrastructure costs; the pace of decline in unit cost of computing power; an increasing tendency to reduce overheads by outsourcing of non-core activities; and growth in Internet usage.

In general, the effective development of ICT-enabled services in transition countries still faces the challenges associated with overcoming the problem of lack of usable approaches and supportive technology tools for developing and deploying services over distance. There is a need to develop approaches and tools that facilitate service development in areas where people and activities are widely distributed over distance, and where there is weak or non-existent service coverage. By providing support for the development of services using ICT, several other problems in rural areas related to isolation from services will be solved.

1.3 Challenges of developing ICT-enabled services in rural areas

The main challenge is to provide an environment for the development of services that enables us to overcome the problem of lack of services occasioned by a sparse population and limited access to services in rural areas. Considering that intermittent power supply or total lack of it may still be a problem in rural areas for a long time to come, there is also a need to develop services that can be consumed from a distance, hosted in places where there is a more stable power supply. We need to facilitate the development of high-quality and user-centric ICT-enabled services that can be flexibly

composed, customised and deployed to meet local needs, and accessed using the technology available to most rural stakeholders. This means that we need to come up with means that enable stakeholders to define concise service requirements which will in turn be used to develop services that meet local needs. To do this, there is need to improve the effectiveness of support offered for service development in rural areas.

One of the general challenges of ICT-enabled service delivery in the rural areas is the fact that the Internet is not ubiquitous, and where available, it is characterised by dismally low penetration rates, low numbers of phone lines per household and low reliability of the telecommunications infrastructure. This is in addition to the fact that the cost of accessing the Internet is still prohibitively high in most developing and transition countries (Vaknin, 2001). These reasons make it increasingly difficult to deliver ICT-enabled services over the Internet, although the situation is slowly changing due to the increasing availability of mobile devices and service delivery options in most rural areas. The service delivery options and technology devices enable the development of services that leapfrog generations of technology in rural areas. Some other challenges include the following.

- The majority of the organizations found in rural areas tend to be small and medium enterprises (hereafter referred to in this thesis as SMEs), and they operate in business environments characterized by fragmented and incomplete information. They are characterized by limited awareness of markets, technology, policy, regulations and finance. Wherever service delivery systems exist, they are usually haphazard, unsustainable, driven by the needs of the source rather than the needs of the recipient, and are inaccessible to poorer entrepreneurs. This makes it difficult to conceptualize and develop services that suit the rural environment and support rural business processes from the service end user perspective.

- Given the small nature of the local enterprises in rural areas, commercial consideration and immediate return on investments are the main driving factors of their businesses. This means that they may have an ever changing base of customers and needs, depending on which is most profitable at the time. It is not uncommon to find actors playing more than one role in a business transaction. To work with the different customers, the SMEs have to be dynamic during their interactions, and this means that the services developed for them need to be flexible and reusable to suit many of their activities and roles. The situation is further complicated by the fact that some of the business relationships are loose and informal. It is difficult to scope the exact service functionality that is essentially self-sufficient to be included in a given business process. It is also quite challenging to develop services in such a way that reflects the multiple individual needs of work and everyday life in rural area contexts.

- Rural environments tend to pose very specific requirements for service development, which make it insufficient to transfer existing urban standard technological and application solutions. Understanding the potential of using ICT-enabled services requires an understanding of user requirements in the context of the already functioning service delivery system, to complement existing local institutions and social networks in rural areas. The challenge occasioned by this is that many rural SMEs are unwilling to volunteer business information since they regard it either as a threat to their competitiveness or an invasion of their privacy. This leads to a situation in which it is quite difficult to know who does what, how, when, where, and for whom. Creating a catalogue of currently delivered services is not a simple task. This is complemented by the general culture of mistrust among potential

service providers and customers in the rural areas. It is difficult to establish new ways of working that can co-exist with existing ones.

- Inaccessibility or poor accessibility to infrastructure is a key impediment to service delivery in rural contexts. Based on the poor terrain and dispersion of populations in rural areas, there is a lower possibility to exploit fast connections for information transfer if they require wiring, something that is not economically advantageous in areas characterised by low density, and economically poor, populations. It is difficult to develop high-level services that can be consumed from a distance and in a distributed manner, especially using web services technology if the area is faced with intermittent power conditions. The challenge lies in developing services that enable business processes to be carried out in a way that makes good use of the available technical resources and devices.

- A survey carried out and presented by Moyi (2003) revealed that poor access to crucial infrastructure such as power and telecommunications in developing countries implies that enterprises have to spend much time, effort, and resources in receiving and relaying information to customers, suppliers and business colleagues. In rural areas there is the added difficulty of providing consistent levels of ICT-enabled services given the intermittent conditions that the service delivery infrastructure is vulnerable to e.g. power blackouts and loss of telecommunication signals. The challenge is to develop services that are robust enough to withstand the unreliability of the infrastructure. The challenge lies in developing ICT-enabled services that can be assembled at run time, and only when needed, given such infrastructure conditions.

- New technologies are not yet perceived by some of the rural SMEs as essential to obtaining better results and to easing and speeding up work. Potential end-users of services have very little insight into the available or potential benefits of using ICT-enabled services. In some cases the end-users are constrained by their environments, while in other cases they are constrained by poverty and low business volumes. It is difficult to develop user-centric portfolios of services that facilitate business processes of SMEs operating in rural environments. In general, it is difficult to approach service development in rural areas from the urban service delivery perspective.

Due to the low demand for services in rural areas, service providers are faced with the challenge of offering innovative services without having to change the focus of their core business processes, and where possible, the Internet can be used as a medium for access to pools of services. The improved service delivery offered via the Internet can be done through the use of a brokering service. Providing services through the Internet via a brokering service is probably a cheaper alternative to options such as providing resident ICT support personnel within small organizations, whose core business is not ICT-related. Components of a service can be hosted outside the enterprise in partner and/or customer environments thereby making the service system architecture a set of interfaces and service level agreements. However, this is one of the things that make development of services in rural areas challenging since the business environment is dominated by businesses that largely work on informal contracts.

The development of ICT-enabled services for use in rural areas presents various aspects and problems that need to be solved, some of which have been presented as challenges. The problem solving view on information systems development presented by Sol (1982) suggests that we do not apply methods and tools as a goal in itself, but to support the problem solving process by defining ways of using information technology effectively in organizations. Methods provide structure by helping us to identify useful strategies and techniques for specific problem classes. Systems

development is a problem solving process which is too complex to be conducted without plans and structure (Sol, 1982), and the specific aspects of a system and parts of a system must be considered individually. We follow this with an observation from the work of Wijers (1991), who states that structuring systems development really means structuring the types of problems to be solved.

Based on the challenges presented in this section, we state that the development of ICT-enabled services in rural areas is not sufficiently facilitated. There is need to facilitate the development of services by applying ICT to business processes that effectively exploit and manipulate available information. The development of ICT-enabled services needs to be enhanced substantially, and this can be done best through the use of an environment with support tools that allow for complex services to be defined and developed simply. The services should be easy to develop and change, to accommodate unanticipated user applications. Providing effective support should make it simple to develop services that use the available technology in rural areas to incorporate multi-party services into a business process in a flexible, ad hoc and agile manner.

1.4 Enabling the development of ICT-enabled services

According to Peltz (2003) the IT industry has used a number of terms to describe how service components can be connected together to build complex ICT-enabled business services. Workflow and document management systems exist as a means to handle routing of work between various resources in an organization. Business process management systems (BPMS) have been widely used to enable businesses to build top-down process design models consisting of various business integration activities (Peltz, 2003). Web services are considered to be a contemporary paradigm for the development of distributed, Internet-based and platform agnostic business applications (van den Heuvel & Maamar, 2003).

According to Sadiq & Racca (2004) most service development platforms have historically focused on making things work very well together inside the network environment of the enterprise. However, to embrace the truly global nature of today's business environment, technologies have to allow applications that enable the extended enterprise, which also encompasses its business partners. Web service technologies outshine everything else in this area (Sadiq & Racca, 2004). The main appeal of web services to the business community is that they can facilitate interaction between complex heterogeneous and highly distributed enterprise information systems using virtually all interoperation aspects (van den Heuvel & Maamar, 2003). With the introduction of web services, concepts such as 'web services composition' and 'web services flow' have been used to describe the composition of web services in a process flow.

The technological situation in most rural areas requires the development of services that run over a long duration given the bandwidth limitations experienced, which also limits the kinds of technology that may be used. According to Peltz (2003), a number of important technical requirements must be addressed when designing business processes involving multiple services running over a long duration. Knowledge of these requirements helps us to position the various standards and technologies that have been introduced for invoking services in an asynchronous manner to achieve reliability, scalability and adaptability; and the dynamic and flexible orchestration that is adaptable to meet the changing needs of a business. To enable the development of ICT-enabled services in rural areas, there is need to involve stakeholders at various levels to provide insight into important issues that may affect the implementation of services. This also allows the stakeholders to share expertise, and provides a solid enabling environment for the development of services. The local stakeholders provide knowledge that may be lacking at the strategic level, and involving them in the development of services makes it easier for the service initiatives to find market.

The focus of this dissertation is on an approach that facilitates different actors to interact and to develop ICT-enabled logistics brokering services that effectively address local user needs. The approach provides an environment in which appropriate software tools are deployed to support service development in such a way that it allows rural stakeholders to contribute to the development of services that can be used irrespective of the remoteness of the service providers. The approach is aimed at overcoming the barriers preventing the development of ICT-enabled services in rural areas of transition countries, by involving relevant rural stakeholders in the decision-making process during the development of services.

1.5 Studio-based development of services

According to Papazoglou & van den Heuvel (2006), the development of services is about identifying the right services, organizing them in a manageable hierarchy of composite services, and choreographing them to support a business process. The development of services requires the handling of many complex decisions that involve judgement, where information is not sufficient to point to the single best choice, and where many parties' interests and values must be addressed. This makes it necessary to provide an environment in which integrated sets of technical and management tools can be used to develop services. These tools should offer the stakeholders the ability to focus on relevant service design issues and enable the development of services that exploit the resources available. The tools should also aid the decision making process in the development of services.

The technical tools should be designed in such a way that they offer methodologies for the development of ICT-enabled services that meet the highly specific rural users' expectations. These tools should be deployed in an environment that provides support for gathering user requirements and the development of services for use in these rural environments. According to Keen & Sol (2007) there is a need to help technology professionals and specialists leverage their contribution through the provision of effective support for the decision process, as well as in the design and deployment of appropriate information technology capabilities. Such help should be effective in supporting the service development decision-making process.

Keen & Sol (2007) state that effective support for service development is expressed using a combination of three U's: *usefulness* of the tools and methods i.e. the value they add to the decision processes; *usability* of the tools i.e. the mesh between people, process and technology; and *usage* i.e. their flexibility, adaptability, and suitability to the organizational, social, and political context. The development of services requires an environment that places equal emphasis on all three U's. Stressing the three U's equally results in a concept referred to by Keen & Sol (2007) as a studio, in which suites are deployed using experiential methods known as recipes.

The concept of studios has emerged as the guiding framework for applying principles for handling the process side of systems in terms of their reality in organizational life. A suite is a well-chosen set of services to support a decision making process, and is basically a combination of information technology tools and the development methods used to apply them (Keen & Sol, 2007). The suites are embedded in the studio, which in turn provides experiential process methods and recipes for leveraging the suites. A studio is the environment in which suites are deployed, giving an interactive environment with a clear purpose: to generate the best production of services within the constraints of cost, time, program and topic. Studio-based support for the development of services is identified by the following elements:

- target: the target domain should be in the arena of ill-structured, multi-disciplinary, and multi-actor problems

- process: decision support should be embedded in a studio-based process
- technology: decision support should include suites to support studios. Suites are integrated IT development tools, systems and analytical methods that are explicitly aimed at enhancing the studio decision process.

The introduction of a studio in the development of services places the emphasis on leveraging the agility and effectiveness of decision support systems to a level that has already been achieved in more operational management based decision making (Jacobs, 2005). For the development of ICT-enabled logistics brokering services in rural areas of transition countries, the need to provide effective support is paramount, since we need to handle multiple perspectives of service development problems to enable integrative thinking about the solutions. The focus of this dissertation is on developing a studio containing an appropriate suite to support the development of ICT-enabled logistics brokering services in rural areas.

To provide effective support for service development, we need a studio containing a suitable suite that provides the necessary support for developing, composing and invoking ICT-enabled logistics brokering services. The main challenge is to ensure that the suite provides adequate support for the development of services that can be flexibly composed, customised and deployed in a distributed manner, based on concise service requirements that meet the logistics services needs of the rural stakeholders. One way of ensuring that the user requirements are met is to involve the service end-users and other stakeholders early, often, and actively, in the identification, development, and testing of services within the studio. The basic tenets of rural life are characterised by widely-distributed activities that need to be successfully integrated, and the studio and its suite should be able to capture the current ways of life and provide support for the creation of ICT-enabled services that complement these ways of life. Effective support for service development is highly desirable as it facilitates the easy creation of services and business processes. The suite is aimed at facilitating the development and testing of the logistics brokering services.

The studio-based approach to the development of services supports the use of experimentation and rapid prototyping, which are very valuable for meeting the challenges to logistics brokering service development presented in section 1.3. In order to meet those challenges, the studio and its suite should provide the stakeholders with support in developing flexible and reusable services that are driven by user needs; developing services that can seamlessly connect to other services given the complexity of the rural business environment; and developing services that fit in with the local social systems. To meet these requirements, the studio should incorporate a suite that corresponds to the services that drive collaboration in rural environments with service end-users in the foreground. The focus of this research is on a studio that facilitates the development of logistics brokering services in rural areas.

1.5.1 Logistics brokering services

According to Site & Salucci (2006), logistics services in rural areas are concerned with passenger and freight transport in low density population areas, and include issues related to access to primary long distance transport networks and other amenities such as warehouses. Rural areas are far from homogeneous. In their work, Site & Salucci (2006) identify three main types of rural areas as follows:

- *mixed rural*: these are rural areas on the edge of a major urban town. Although rural in look and nature, many residents commute to the nearby town or city and the economy is governed more by the neighbouring urban area than by ‘traditional’ rural activities such as agriculture.

- *country towns*: these are small urban areas which often serve a large hinterland. Although these may be large villages or small towns, from a transport perspective they are rural rather than urban as they generally do not have their own urban public transport network and it is normally feasible to walk for any trip within the town.

- *deep rural*: these are rural areas with a sparse population and which are remote from any urban centre. Sometimes they suffer from depopulation due to young and working age people moving out, causing a periodic demand for logistics services. Some deep rural areas may be in mountainous regions, causing further isolation.

The focus of this research is on the development of logistics brokering services for the third category, the deep rural areas. The rural dweller living in such areas has a different set of priorities and needs than their urban counterpart, or the rural dwellers in the other two types of rural area. The poor state of roads, especially in times of heavy rain, and the dispersed nature of the population in such rural areas make it difficult and expensive to serve their environment with public transport. The rural residents in such areas tend to have a low level of income and have little or no choice about their mode of transport, and thus cannot travel as they might reasonably want to. In general, the difference between having access to logistics services and not having access to these services makes a far greater difference to rural mobility, opportunities, and participation in society and quality of life for the rural dweller than it does for an urban dweller (Site & Salucci, 2006). For example, the need for emergency and health services, the need for access to education and child care, or the need for agricultural products to reach their markets from the dispersed regions, offers the opportunity to deliver logistics services more efficiently through a brokering service.

Rural areas have a unique set of characteristics associated with the operation and maintenance of logistics services, which make brokering a viable option as compared to situations where there is a regular demand and supply of logistics services. There is a generally low level of provision of infrastructure and service accessibility is low, and because transport services in rural areas are infrequent, characteristics such as good and reliable connections for delivery of integrated information services are important. In some rural areas, public transport is almost non-existent, and where it exists, information regarding the services is difficult to find. There is an increasing trend towards transport service provision in rural areas using demand-responsive services such as shared taxis, subsidised buses, etc. Logistics brokering services have a major role to play in service delivery in rural areas, and the delivery of the services can be greatly improved using ICT.

The significance of ICT-enabled logistics brokering services in rural areas is clearly seen when one considers that it is mostly the low density population of rural areas and the lack of access to transport service information that keeps many of the rural communities isolated. This in turn has had an impact on the transport disadvantaged and the economic vitality of the communities, and makes the reduction of isolation very important. It is in this sphere that ICT-enabled logistics brokering services can play a definite role despite the fact that there are several challenges to be overcome.

1.6 Research Objective

In the earlier sections of this chapter, we presented the challenges faced in developing ICT-enabled services in rural areas of transition countries. In section 1.3, we noted the main challenges of overcoming the problem of lack of services occasioned by the sparse population and limited access to services. We need to provide support that facilitates the effective development of services that can be flexibly composed, customised, deployed, and used in the rural areas. We also mentioned the

fact that the development of services in rural areas requires making several complex decisions regarding service design, and presented some arguments in section 1.5 on how a studio-based approach can be used effectively to bring together multi-stakeholder points of view and enhance the quality of services. We also presented the fact in section 1.3 that understanding user requirements in the context of already functioning service delivery systems is highly important when attempting to come up with portfolios of software tools that can be used to support the decision-making process in service development.

The concept of a studio as introduced in section 1.5 provides us with the background to develop the suite and recipes for development of ICT-enabled logistics brokering services. We also expressed the opinion that currently sufficient support is not provided for the development of services in rural areas to enable the exploitation and manipulation of available information to make proper and informed decisions on logistics service delivery in rural areas. We state, as expressed in section 1.5, that the use of a studio and a suite will provide the required support for development of ICT-enabled logistics brokering services in rural areas. As presented in sub-section 1.5.1, the domain of study for this research is logistics brokering services in rural areas.

The focus of this work is on how we can facilitate and improve the development of logistics brokering services that can be delivered using some of the ICT-enabled technology that is available in rural areas. Specifically, we deal with the problems faced and pertinent logistics brokering service delivery challenges faced by stakeholders in rural environments when translating (new) business strategies using the necessary ICT-enabled interventions. The research challenge lies in facilitating and improving the development of logistics brokering services in rural areas using ICT. The main objective of this research is:

> *To develop a studio to provide effective support for the development of ICT-enabled logistics brokering services in rural areas of transition countries*

Effective support as presented in the research objective means that in the service development process we should place equal emphasis on the usefulness, usability and usage of the ICT-enabled services in meeting the end-user needs. The output of this research is a studio-based approach and a suite for use to facilitate the development of ICT-enabled logistics brokering services in rural areas effectively. The studio is aimed at providing effective support for the development of logistics brokering services. The tangible features are a suite that supports flexible development of logistics brokering services, and a set of guidelines for using the suite in service development. A prototype of the suite was developed and used to test whether it facilitates and improves the effectiveness of support provided for the development of ICT-enabled logistics brokering services in rural areas. The *scope* of the research was limited to improving support and facilitating the development of logistics brokering services from the user requirements specification stage to the actual development of the ICT-enabled services i.e. from problem conception to the improvement in design, up to the development of options that provide a solution to the problems faced by the end-users in rural areas.

The *societal* relevance of the research lies in its contribution to user-centric collaborative tools and approaches for improving the development of ICT-enabled services in rural areas of transition countries. In section 1.2 we stated that web-enabled technologies and architectures can be adapted and used to deliver ICT-enabled services in transition countries, especially since services can be remotely produced and delivered, particularly when they do not require manipulation of physical objects or close interaction with the customer (Davis et al., 2002). We also stated that the effective development of ICT-enabled services in transition countries still faces the challenges associated with overcoming the problem of lack of usable approaches and supportive technology tools for

developing and deploying services that can be used over distance. Towards this end, the studio-based approach provides an all-inclusive environment that facilitates service development, while the suite provides the technological tools required to develop logistics brokering services in rural areas of transition countries.

The *scientific* contribution of this research lies in the result, which is a studio-based approach to the development of logistics brokering services, and its application in improving the effectiveness of support and facilitating the development of services in rural areas. The research contributes to literature on the creation of tools and methods to solve real problems in the development of services, and the usefulness of such tools in the actual development of services. In developing the studio the following current situations were taken into account: logistics services in rural areas are characterised by service delivery systems that are haphazard and driven by the needs of the source rather than the recipient; the organizations operating in rural areas tend to be small and driven by commercial considerations and immediate returns on their investments; the rural communities operate in a dynamic environment that needs services that can be adapted to ever-changing user roles; many of the small organizations operating in rural areas regard sharing of information as a threat to their competitiveness; and the rural environment is characterised by unreliable access to infrastructure, meaning that it is difficult to provide consistent levels of service using ICT.

1.7 Research Question

The research was aimed at improving the development of ICT-enabled logistics brokering services in rural areas of transition countries by providing facilitation support. In order to provide such support, we came up with a research question that enabled us to study the main issues and challenges to be considered in general when developing services for use in rural areas. This included looking at the current issues in developing ICT-enabled logistics brokering services, and how we could facilitate and improve the development of the services.

The main question for this research is:

> *How can we provide effective support for the development of ICT-enabled logistics brokering services in rural areas of transition countries?*

Effective support for the development of ICT-enabled services means that we should place equal emphasis on the usefulness, usability and usage of the services. To enable us to answer this question, we carried out an exploratory case study to learn more about the rural areas and to determine the challenges faced in developing logistics brokering services in these areas. The details of the case study are presented in chapter 2. We developed a prototype of the suite that can be used to improve and facilitate the development of robust ICT-enabled logistics brokering services in rural areas of transition countries. The suite, and guidelines for using it, facilitates local service brokers in developing logistics business processes through its practical and extensible services. The suite can be adapted and reused to develop logistics brokering services that meet the needs of the rural communities.

Several questions were also developed to guide the research. The next question was aimed at providing a general insight into the problem domain of the development of ICT-enabled services, thereby allowing us to learn about the pertinent issues and how they are tackled by other researchers. These issues are presented in chapter 3, which also covers aspects related to methodologies and frameworks that can be used to develop ICT-enabled logistics brokering services. To assist in analysing the main issues, we came up with the following question:

How can the current issues in the development of ICT-enabled services be contextualised to improve and facilitate ICT-enabled logistics brokering services in rural areas of transition countries?

This question was derived from a review of the challenges to the development of ICT-enabled services presented in section 1.3. Finding answers to this question helped us to identify and place into context the key issues to be considered in the development of ICT-enabled logistics brokering services in rural areas of transition countries. The aim was to improve service development by providing effective support for the local service brokers. The answers to this question led us to design and develop a suite for deployment within the studio to facilitate the development of ICT-enabled logistics brokering services, and to ask the following question:

What services should a suite for facilitating ICT-enabled logistics brokering services in rural areas of transition countries contain?

Providing answers to this question enabled us to specify requirements for the suite to facilitate the development of ICT-enabled logistics brokering services in rural areas of transition countries. We present the design and functions of the suite in detail in chapter 4, where we also present guidelines for deploying the suite within the studio. The answers to this research question provided input for the last research question.

Through this research, we developed a prototype of the suite, which needed to be tested within the context of rural areas to determine whether it provided adequate support and facilitated ICT-enabled logistics brokering services that meet local user needs. This led us to ask the following research question:

How can we use the suite to provide support for ICT-enabled logistics brokering services in rural areas of transition countries given their characteristics?

This research question is answered in chapter 6, in which a description is given of the tests carried out on the prototype of the suite in an empirical case study. Answering the four research questions led to the development of the studio and suite to facilitate the development of ICT-enabled logistics brokering services. The combined answers to these questions contributed to achieving the research objective.

1.8 Research approach

According to Galliers (1992), a research approach is defined as a way of going about one's research, which may embody a particular style, and may employ different methods or techniques. Galliers (1992) further states that by considering the object of the research, it is possible to use it to identify those approaches most likely to be appropriate for one's study. In studying information systems research approaches, Orlikowski & Baroudi (1991) found that the approaches used are not rooted in a single overarching theoretical perspective, but exhibit a set of philosophical assumptions regarding the underlying nature of the phenomenon being investigated, the appropriate research methods to be used, and the nature of valid evidence. We present the philosophy used to answer the research questions in three different dimensions: research philosophy, research strategy, and research instruments.

1.8.1 Research Philosophy

All research is based on some underlying assumptions about what constitutes valid research and which research methods are appropriate. The most pertinent philosophical assumptions are those

that relate to the underlying epistemology, assumptions about knowledge and how it can be gained, which guides the research. The research philosophy underlines the way in which data on the phenomenon studied is collected and analysed. In discussing philosophical assumptions Guba & Lincoln (1994) suggest four underlying "paradigms" for qualitative research: positivism, post-positivism, constructivism, or critical theory, depending upon the underlying philosophical assumptions of the researcher. On their part, Orlikowski & Baroudi (1991) following Chua (1986), suggest three categories based on the underlying research epistemology: positivist, interpretive, and critical. Yin (1994) and Benbasat (1987) are advocates of positivist case study research, whereas Walsham (1993) is an advocate of interpretive in depth case study research.

Positivists generally assume that reality is objectively given and can be described by measurable properties that are independent of the observer or researcher and his or her instruments. Positivist studies generally attempt to test a theory, in an attempt to increase the predictive understanding of phenomena. In line with this, Orlikowski & Baroudi (1991) classify information systems research as positivist if there is evidence of formal propositions, quantifiable measures of variables, hypothesis testing, and drawing of inferences about a phenomenon from the sample to a stated population. Interpretive researchers start with the assumption that access to reality is only achieved through social constructions such as language, consciousness, and shared meanings. Interpretive studies generally attempt to understand phenomena through the meanings that people assign to them and interpretive methods of research in information systems are "aimed at producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context" (Walsham, 1993). Interpretive research does not predefine dependent and independent variables, but focuses on the full complexity of human sense making as the situation emerges (Kaplan & Maxwell, 1994).

Critical researchers assume that social reality is historically constituted and that it is produced and reproduced by people. Although people can consciously act to change their social and economic circumstances, critical researchers recognize that their ability to do so is constrained by various forms of social, cultural, and political domination. The main task of critical research is seen as being one of social critique, whereby the restrictive and alienating conditions of the status quo are brought to light. Critical research focuses on the oppositions, conflicts and contradictions in contemporary society, and seeks to be emancipatory.

Design science is yet another "lens" or perspective that can be used to perform research into information systems and organizational phenomena (see Glass, 1999; March & Smith, 1995; Winograd, 1996): it compliments the positivist and interpretive perspective. Vaishnavi & Kuechler (2006) define design science as a research perspective that involves the analysis of the use and performance of designed artefacts to understand, explain and, very frequently, to improve the behaviour of aspects of information systems. Similar to the positivist and interpretivist research perspectives, the design science research perspective has been shown to produce scientific knowledge (March & Smith, 1995; Simon, 1996; Vaishnavi & Kuechler, 2006). Simon (1996) calls design science a science of the artificial, i.e. a body of knowledge about artificial (man-made) objects and phenomena designed to meet certain desired goals.

According to Vaishnavi & Kuechler (2006), design science by definition changes the state-of-the-world through the introduction of novel artefacts. In contrast to positivism, even the problem statement is subject to revision as a design science research effort proceeds (March & Smith, 1995). Epistemologically, design science strives to create innovative and valuable artefacts. Whereas positivists try to understand reality, a researcher using design science attempts to create things that serve human purpose (March & Smith, 1995). Axiologically, design science is value-oriented. Design researchers believe that the proverbial 'truth' is not 'out there': instead they facilitate its

enactment by creating artefacts (Orlikowski & Iacono, 2000; Purao, 2002). Its outputs are assessed against criteria of value or utility (March & Smith, 1995).

The choice of a research perspective should be based on the research objective rather than the research topic (March & Smith, 1995). From a synthesis of the discussion on philosophical perspectives by Myers (1997), we deduced that the ability to influence the effectiveness of support provided in the development of ICT-enabled services in rural areas of transition countries depends on our understanding of the technology and its social implications. The goal of this research was to improve the support provided for development of services. We therefore followed the design science philosophy based on the discussion by Hevner et al. (2004), which states that the design science research paradigm is used in information systems to address what are considered to be ill-structured problems. Hevner (2007) states that the design science artefact must be useful to information systems practitioners, emphasising its utility, and that exercising the artefact in the problem domain should add value to the information systems practise.

1.8.2 Research Strategy

According to Denzin & Lincoln (1994) a research strategy implements and anchors a paradigm in specific empirical sites, or in specific methodological practices, and outlines the sequence of data acquisition and analysis. The choice of a research strategy or inquiry system is based on the nature of the research problem, and on the status of theory development in the research field. The research problem was considered to represent an ill-structured problem. According to Sol (1982), ill-structured problems are vague and *do not* fulfil the following requirements:

- the set of alternative courses of action or solutions is finite and limited
- the solutions are consistently derived from a model of the problem situation that shows a good correspondence with reality
- the effectiveness or the efficiency of the courses of action can be numerically evaluated

The problem we studied in this research exhibited characteristics of an ill-structured problem because the alternative courses of action for providing solutions are unlimited. A great number of alternative solutions could be thought of to provide support for the development of ICT-enabled logistics brokering services in rural areas of transition countries. In addition, considering the complexity and dynamics of service delivery in rural areas of transition countries, there is probably no model available with sufficient correspondence from which solutions can be derived in an exact way.

We applied the design science paradigm discussed by Hevner, et al. (2004) to carry out the research. The first stage of the research was considered to be exploratory in nature, as we aimed to understand the domain of interest in more detail. The aim of carrying out exploratory research is primarily to formulate or elaborate a theory rather than to test the theory. A legitimate indication for exploratory research is that the research covers a relatively large area over which little useful theory is available, with many variables of unclear relative significance. Exploratory research was considered to be justified for this research because the field of logistics services is broad yet the theory regarding tools and methods for development of ICT-enabled logistics brokering services in rural areas of transition countries is not as broad. In order to carry out this research effectively, we developed the following checklist:

- proof of concept: the solution to the defined problem situation is clarified in context
- applicability of the solution: deals with the applicability of the solution to the studied problem

- application: the solution as applied in reality, to confirm its workability
- impact: of the solution in its real life application
- value: the value added to work practises by using the solution offered

From the checklist, we achieved the first, second, and fifth items through the exploratory case study. This means that we were able to study and provide information on proof of concept, and then applied the solution in the case study environment, and finally studied that value added by the solution to the process of ICT-enabled logistics brokering services in rural areas. The third and fourth items formed part of the testing cases that were carried out on usefulness of the studio-based approach, and enabled us to make conclusions related to the utility of the solution in the domain of ICT-enabled services in rural areas of transition countries.

1.8.3 Research Instruments

Research instruments are used to describe the way in which the data is collected and analyzed. A number of research instruments are used in the field of information systems ranging from case study, field experiment, laboratory experiment, survey, simulation, and action research (Galliers, 1992). The selection of a research instrument depends on the amount of existing theory available, on the nature of the research, and on the type of research question (March & Smith, 1995). Different research instruments were used to carry out this work.

Exploratory research was used for the inductive case studies with the aim of gaining a better understanding of the rural logistics services domain, and also to identify the requirements for designing the suite. This was combined with action research, which according to Rapoport (1970), aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework. Action research was used for inductive purposes to find out and observe what was happening in the research area and domain, and repetitively during the duration of the study. This is in line with the discussion by Baskerville (1999), which states that in essence action research is a two stage process: the *diagnostic* stage in which theories are formulated concerning the nature of the research domain, and a second *therapeutic* stage in which changes are introduced and the effects studied.

We then combined this with case study research to gain a deeper understanding of the problem at hand after the initial exploratory work. Case study research is the most common qualitative method used to study information systems (Orlikowski & Baroudi, 1991; Alavi & Carlson, 1992). Although there are numerous definitions for case study research, Myers (1997) uses the definition from Yin (1994) which states that a case study is an empirical inquiry in which a contemporary phenomenon is investigated within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.

According to Yin (1989), a case study is often based on opportunism, rather than rational grounds. However, it should be a conscious and formalized step of the research. Clearly, the case study research method is particularly well suited to information systems research, since the object of the discipline is the study of information systems in organizations, and "interest has shifted to organizational rather than technical issues" (Benbasat et al., 1987). In choosing the case study methodology for this research, we set out a number of requirements that enabled us to understand the current environment thoroughly with regard to the development of ICT-enabled logistics brokering services in rural areas of transition countries. The criteria used to select the case study were:

- an industry, domain, or business sector with inherently dynamic business processes. This led us to selecting the rural logistics domain, since there are very many business process involved in delivering logistics services in rural areas.
- a country with organizations that are actively involved in the process of developing, or intending to develop, ICT-enabled services for rural areas. This led us to select South Africa, since this is a country that is heavily involved in developing services for the previously under-serviced communities mostly found in rural areas.
- organizations within that country whose core business is not ICT, but in which the use of ICT-enabled solutions can greatly improve their business processes. The candidate organizations for the study were small businesses (SMEs) in rural areas particularly those involved in delivering logistics services e.g. transport firms.
- organizations whose business processes involve multiple stakeholders, each having differing or multiple interests in service delivery but lack the capacity to afford systems that enable them to seamlessly integrate with larger business partners. This motivated the choice of the small businesses, most of which are cash-constrained and lack the resources to enable them to link to the main industry supply chains.
- organizations with a variety of dynamic business activities but very few formal contracts between the service provider and customer. The rural enterprises fulfilled this requirement given that many of their business networks are informal.

The exploratory case study was intended to enable us to get a better understanding of the logistics service issues in rural areas, which would then allow us to create a pedestal from which to develop detailed requirements for the ICT-enabled logistics brokering services solution. Based on these requirements, we then designed the suite. The final step was to evaluate the effectiveness of the studio-based approach in facilitating the development of logistics brokering services that handle the issues identified in the case study. In line with the design science research perspective, the utility, quality, and efficacy of the constructed suite need to be evaluated using well-executed evaluation methods (Hevner, et al., 2004). The evaluation research instruments that can be used while following design science research are presented in table 1.1.

1. Observational	*Case study*: study the artefact in depth in business environment *Field study*: monitor use of artefact in multiple projects
2. Analytical	*Static analysis*: examine structure of artefact for static qualities (e.g. complexity) *Architecture analysis*: study fit of artefact into technical IS architecture *Optimization*: demonstrate inherent optimal properties of artefact or provide optimality bounds on artefact behaviour *Dynamic analysis*: study artefact in use for dynamic qualities (e.g. performance)
3. Experimental	*Controlled experiment*: study artefact in controlled environment for qualities (e.g. usability) *Simulation*: execute artefact with artificial data
4. Testing	*Functional (black box) testing*: execute artefact interfaces to discover failures and identify defects *Structural (white box) testing*: perform coverage testing of some metric (e.g. execution paths) in the artefact implementation
5. Descriptive	*Informed argument*: use information from the knowledge base (e.g. relevant research) to build a convincing argument for the artefact's utility *Scenarios*: construct detailed scenarios around the artefact to demonstrate its utility

Table 1.1: Design science research evaluation methods (Hevner et al., 2004)

In this research, we chose to use groups to test a prototype of the suite in a case study setting, and based the evaluation on a controlled experiment which was used to study the usefulness and usability of the suite in a rural environment. The testing of the suite was carried out using both

functional (black box) and structural (white box) tests during the implementation phase to identify defects and to check the execution paths, as recommended in the design evaluation methods by Hevner et al. (2004) presented in table 1.1.We also monitored the use of the suite in a field study among the end-users to study its usability in a real life setting. Evaluation of the value of the suite in the development of logistics brokering services was done by eliciting feedback from the case study subject using questionnaires and debriefing sessions at the end of the testing exercise. The debriefing sessions enabled us to get deeper insight into the reactions of the end-users of the suite in an independent manner. The findings of the empirical tests are presented in chapter 6.

1.9 Structure of the dissertation

The structure of this dissertation is shown in figure 1.1. We define the problem and present a description of the research methodology used to address the different issues in chapter one, including the research problem and questions addressed in this research. We present an exploratory case study that provides focus on the main issues to be considered in developing ICT-enabled logistics brokering services and further explains the research problem in detail in chapter two. We discuss the current practise and theories in the development of ICT-enabled services in general, and logistics brokering services in particular, drawn from the literature, in chapter three. We present the user requirements elicitation and design requirements for the suite in chapter four. In chapter five we discuss how a prototype of the suite was implemented. We conceptualize the test case for application of the suite, and carry out a case study in which we test the prototype and present the findings in chapter six. We make an evaluation of the research in chapter seven, in which we also present our findings, conclusions and proposed recommendations for further research.

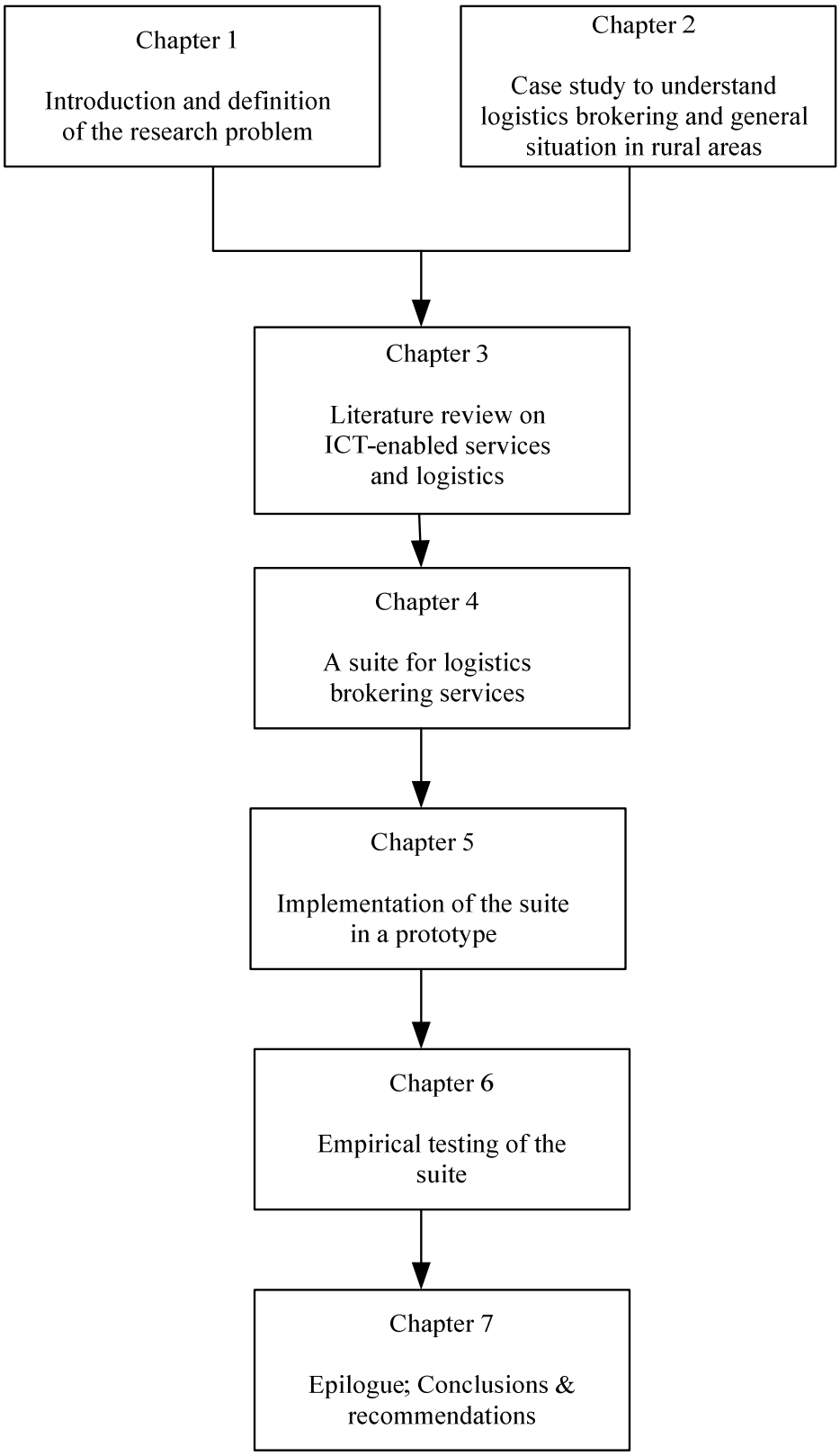


Figure 1.1: Structure of the dissertation

2. Situational analysis of rural logistics services

2.1 Introduction

In this chapter, we discuss the exploratory case study that was used to research and determine the main issues to consider when developing services in rural areas of transition countries. The case study was used to investigate how we could set up logistics brokering services to handle some of the logistics problems faced in rural areas. The reasons for carrying out this exploratory case study were threefold: to study the characteristics of the rural environment with the aim of understanding the area on which we would base the development of the logistics brokering services; to determine the current practices of delivering services within the rural areas with the aim of understanding the problems faced in developing services; and to derive a starting point for developing a solution to the logistics problems based on the characteristics of the environment and in relation to the drive for logistics brokering services. Through the exploratory case study, we were able to get a grip on the challenges and actual requirements of logistics brokering service development in rural areas, and to appreciate the need for providing effective support to improve the development of logistics brokering services through the use of ICT.

2.1.1. Why the case study

The logistics brokering services domain was chosen to enrich our understanding of service development and to provide a preliminary evaluation of what can be done to improve the delivery of logistics services in rural areas using ICT. Based on the case study criteria presented in section 1.8.3, South Africa was considered to be a suitable candidate for the study since this is a country that is striving to deliver ICT-enabled services to benefit previously under-privileged communities and rural areas. The introduction of logistics brokering services was one of the department of transport of the South Africa government's key areas of focus at the time of the case study. These two issues fulfilled our first and second criteria for the case study presented in section 1.8.3, with regards to a country and a sector. The case study enabled us to get a deeper insight into the challenges and the issues that have to be addressed when developing logistics brokering services in rural areas. It provided us with initial ideas on how we can provide effective support to facilitate and improve the development of ICT-enabled logistics brokering services, and enabled us to obtain a basis from which to develop the suite for deployment within the studio.

To accomplish the objective of this research, we chose to study the development of ICT-enabled services for, and by, the SME sector in South Africa, which provides more than 55% of total jobs and accounts for 22% of the gross domestic product (Ittmann, 2005). The selection of the sector was based on the fact that logistics brokering needs of the SMEs were expected to exhibit characteristics that can be found throughout the transition country spectrum. This also fulfilled our third, fourth, and fifth criteria for the case study presented in section 1.8.3. The choice of studying development of ICT-enabled logistics brokering services for, and by, rural-based SMEs was deliberate. This was due to the fact that the characteristics of the SMEs operating in urban areas of transition countries do not differ much from those of the developed world, and therefore not much would be learnt from studying them. We studied the current practise of ICT-enabled service delivery through which we learnt that service delivery in some areas of rural South Africa is currently supported by a software toolbox known as inTouch Africa®. We also paid visits to rural areas and carried out in-depth studies with the aim of understanding the environment in which the services are delivered and used.

The case study was done in conjunction with the Council for Scientific and Industrial Research (CSIR) of South Africa. The CSIR is heavily involved in research related to supply chain challenges

faced by SMEs, and has carried out studies which indicated that there is a need to expand small business initiatives to improve the performance of the national logistics system (Ittmann, 2005). We *participated* in a project aimed at *designing and developing* ICT-enabled logistics brokering services for rural areas, to be delivered through existing technological developments such as the widely available mobile phone network. Our role in this project was *to research, design and develop an approach to improve and facilitate the development of logistics brokering services based on the characteristics of the rural areas.* We supplemented the case study work with information obtained from internal reports and documents used and developed by the logistics service practitioners at the CSIR.

2.2 Background to the case study

In South Africa, there is an especially wide diversity of rural areas, characterised by widely varying climates, rainfall levels, population densities, levels of infrastructure development, and types of land tenure. Many of these differences can be ascribed to the legacies of apartheid, which are reflected by a combination of structural differences between the former white 'platteland' areas and the former black homelands. A related issue is that municipalities and provinces of varying sizes geographically can have varying service delivery and fiscal capacities. This has greatly affected the rollout of basic services in deep rural areas. Given the isolation of deep rural areas, the comparative scale disadvantages vis-à-vis commercial farming areas and enterprises, the historical backlogs, and the relatively low population densities and high poverty levels, Naudè & Brits (2003) identifies three problems that stand out:

- inaccessibility of services and markets
- fragmentation of land holdings and economic enterprises
- the dilemma of redressing historical the backlogs in infrastructure provision without reinforcing unsustainable settlement patterns

These problems in addition to other constraints faced by SMEs operating in these resource-poor rural environments of South Africa have had severe and extensive economic and social implications that affect the rest of the country (Ittmann, 2004). As a result of these problems, most logistical, marketing and related services are unreliable, ineffective and/or very expensive, thereby marginalizing and excluding most SMEs from 'mainstream' supply chains. There is need for the rural entrepreneurial support programs to develop community-based service models that can be used to address the key limiting factors associated with these deep rural locations.

Besides the infrastructure and other services which have been promoted, most rural areas have since 1994, benefited from a major government drive to extend access to basic services in previously disadvantaged communities and areas (Naudè & Brits, 2003). Although the speed and level of service provision are still significantly behind that of urban areas, impressive gains have been made in the overall provision of housing and housing-related infrastructure and the extension of access to water, electricity and telecommunications in rural areas. Moreover, whilst much of this was initially driven by national and provincial sector departments, local government has been playing an increasingly important role recently (Naudè & Brits, 2003).

Bearing this brief background in mind, we carried out the case study in deep rural areas, focusing on the logistics services problems faced in these areas. We carried out interviews with the logistics service practitioners, logistics service providers, and the rural stakeholders, consisting of small business owners and farmers. These groups of subjects for the case study were identified as the most important stakeholders in the logistics service delivery environment in rural South Africa. The participants were identified through stakeholder analysis, which is defined by Grimble & Chan

(1995) as an approach for understanding a system by identifying the key actors in the system and assessing their respective interests in that system. We first describe the area in which we carried out the case study before discussing the data collection procedure and findings.

The case study was carried out in the Eastern Cape province of South Africa, which was formed in 1994 out of the 'independent' homelands of Transkei and Ciskei, and the eastern portion of the Cape Province. The landscape of the area is extremely diverse: ranging from the largely arid and desolate Karoo in the western interior to the lush green Tsitsikamma temperate forest in the east, the fertile Lankloof and Sundays River valleys, and the rugged coast with interspersed beaches. The landscape in most parts of the province ranges from hilly to very mountainous, thereby making transportation quite difficult as it is not easy to cut roads through the mountainous environment.

The Eastern Cape Province is an agricultural region producing mainly grains and fruits, although there are some cattle and sheep ranches. It covers an area of 170,000 km^2, has a population of about 6.7 million, and is the poorest province in South Africa in terms of average monthly expenditure. This is largely due to the extreme poverty found in the former homelands where subsistence agriculture predominates, and the province's plentiful human and natural resources are employed below their productive potential, mainly due to an insufficient accumulation of physical and human capital. The province is divided into 46 municipalities, and the exploratory case study was mainly carried out in one of the more remote parts known as the O.R. Tambo District Municipality, which is situated along the eastern side of the province. We also carried out a study of the logistics services situation in the Central Karoo District Municipality.

Just as in other parts of the Eastern Cape Province, the two district municipalities of O.R. Tambo and the Central Karoo are afflicted by the economic ills of poverty that affect rural areas, key features of which are:

- relatively high rural population
- relatively high proportion of young people
- relatively low proportion of employed people
- relatively high proportion of poorly paid employees
- relatively dispersed population
- relatively low levels of service delivery

While majority of homesteads in the O.R. Tambo district municipality are characterised by locational inaccessibility, the main roads passing through the district and connecting it to other parts of the country are well maintained. In most cases the distance between homesteads and the road is largely covered by walking. We present a general description of the logistics situation in the O.R Tambo district municipality as observed through the case study and supplemented with information obtained from the work of Mashiri et al. (2005) as follows:

Description of the logistics situation in the O.R. Tambo District Municipality

The initial study was carried out in the Mthatha-Port St. John's-Lusikisiki corridor, an area whose main needs for logistics services were identified as being for the purposes of small freight transportation, and patient transport. The construction sector also indicated a need for coordinated transport.

In relation to small freight transportation in this area, there is an inherent and periodic need for transportation of high volumes of low value agricultural produce (e.g. maize), and low volumes of high value produce (e.g. grapes and honey), which leads to uneconomic utilization of the available logistics services. The roads are impassable in many parts of the area during the heavy rains. The

activity in which most of the rural communities are involved is agriculture, with a small proportion centred on SME activities. There is a generally lacking sense of competition among the producers of services and goods, leading to very little innovation and development among them. It is difficult to create efficient supply chains for example, because some of the local farmers and other small businesses, e.g. vegetable vendors, do not like the idea of mixing their usually small freights with others in the same transportation mode. The rural communities living in this area have to travel long distances and over generally rough terrain to get to the markets to sell their goods, which means that they carry less and therefore make less money due to low volumes and high costs of shipment. Most of the agricultural produce needs to be transported to the fruit market in Mthatha, although some of it is sold by the wayside near major roads.

The O.R. Tambo district has a very good climate for agricultural purposes. In many cases, the rains come at specific times of the year, which directly translates into planting times for the farmers, who in turn tend to grow the same kind of crops determined by the area in which their farms are located. Given that the weather patterns generally remain the same for a given area, it means that everything that goes into production of the farm produce is done at the same time by all the farmers in an area e.g. planting, spraying, weeding, harvesting, etc. As a result, all of them harvest their produce at the same time, and because transportation and storage facilities are not well developed, most have to sell their farm produce immediately after harvest. This means that they cannot bargain for better prices, and that they cannot defer their selling to wait for when the market is at its best. It is desirable to have logistics services organized around these peak activities to facilitate the marketing of produce from this area.

Within the district municipality there is a model of periodic markets, which are held at focal points, mostly close to major road networks and trade centres that act as feeders for the urban areas. Given that a lot of agricultural produce comes from far-flung rural areas, it is desirable to coordinate the service provision and schedules for the periodic transportation of the goods and the farmers to and from the markets. There is also a need to facilitate freight collection and distribution services in support of coordinated transport schedules, centres, and services. Coordination of local transport to coincide with local periodic markets, mobile clinics, school transport, etc. is desired. In some cases, there are brokers and middlemen who supposedly take the burden of going to the far-flung periodic markets from the farmers. They provide transport services as well as collection points at which they buy the produce, but these multi-tiered middlemen make the supply chain too long and therefore unproductive.

Another sector facing transportation problems is within the health system. With regards to the patient transport situation in this area, most visits to health facilities are for treatment, fetching medicines and visiting patients. Given the fact that most homesteads are inaccessible using motorized transport, the distance between the homestead and the road is largely covered by walking, and for the seriously ill a wheelbarrow is used to transport the patient to the main road. Where a wheelbarrow is unavailable, neighbours are hired to cart the ill to the main road e.g. in AIDS ridden households. Waiting for a passing light delivery vehicle (LDV) or taxi can be interminable as there is no regular service. In emergencies and when available, an ambulance, LDV, or taxi is used to ferry the sick to and from a hospital. In non-emergencies, non-motorised transport modes such as walking and wheelbarrows are used. Walking is the dominant mode of travel to clinics although taxis and LDVs (bakkies) are also used to transport patients to hospitals largely because of the distances involved. The health system has a shortage of emergency vehicles, and communication with ambulance staff is also difficult because of lack of infrastructure. Inadequate staff at facilities reduces service levels.

The road infrastructure to villages and particularly to homesteads is either non-existent or in a bad state of repair and so, not many taxis use them except for LDVs with high clearance. The lack of proper logistics services in this area has continued to mean that poverty levels remain relatively high and people do not have access to basic information services that can improve the quality of their lives. There is a potential to provide efficient and more coordinated transport services through a brokering service.

To corroborate some of the issues observed in this case study area and with the aim of developing a solution that can be generalized to the logistics problems of rural areas in South Africa, we carried out interviews with rural logistics practitioners and performed a literature survey on the logistics services situation in another rural district known as the Central Karoo.

Description of the logistics situation in the Central Karoo District Municipality
The hot and dry Karoo, found in the western interior of the Eastern Cape Province, is characterised by a sparse barren landscape where the main economic activity is buying and selling wool and meat from the hardy Karoo sheep. Transport services in the Central Karoo, with the exception of the national rail and bus services, are not well coordinated and public transport is in the main unscheduled. There is currently an over supply of transport operators, especially illegal operators. The over supply is more due to the general inability of rural folk to pay for services than not wanting to travel. The Central Karoo District municipality area is a vast, sparsely populated area. The low productivity of the land means that farms tend to be large. Consequently, the population outside the few main settlements is very remote from main services and difficult to serve by any means except private road transport. The long distances between towns make the use of motorised transport essential to achieve mobility.

Four national bus operators and the mainline rail service provide scheduled long-distance transport services to the area. The majority of passengers using these services travel between the main metropolitan centres outside the borders of the district. There remains a limited amount of trip making by rail between local towns, especially for Laingsburg residents. Other scheduled services are limited to scholar and employee bus contracts as well as a single regular unsubsidised commercial service within the town of Beaufort West. For the rest, public transport is unscheduled. Mini-bus taxis provide unscheduled but regular long distance services to Cape Town, Oudtshoorn, George, and Worcester, with limited intra-district travel. Special-hire trips are available to most places in South Africa.

Other long distance transport services are provided by the health department and vehicles belonging to sports clubs and other non-profit organisations. Most short distance transport occurs only within Beaufort West. A needs analysis of current users shows there is a large difference between monthly peaks and regular daily demand. Monthly peaks occur around ‘All Pay’ days in Beaufort West. Competition from informal sedans operating as public transport vehicles without permits, impacts on the demand for minibus taxi services. The situation is unsustainable for the number of vehicles competing for passengers. There is little other licensed transport in the District (Green et al., 2004).

2.3 The case study and findings

To carry out the case study, we identified the main stakeholders involved in the development and use of logistics brokering services in rural areas using stakeholder analysis as stated in the previous section, and presented them with the initial design of the logistics brokering system. To gather feedback on the initial design and to get more information from these stakeholders we used interviews, questionnaires and observations in the rural environment. The case study was carried

out in Tombo and in the King Williams Town area, and the data was collected using focus groups, divided among the following lines of stakeholders:

- *Logistics service practitioners*: these are the people involved in defining and developing logistics services for use in the rural areas. They have been providing solutions to the existing problems over a long period of time, and have experience of working in the rural areas. Their interest is to ensure that logistics services are utilised more efficiently than is currently the case.

- *Logistics service providers*: these include the rural trucking companies, railways, courier services, taxis, pick-up owners, etc., whose main work is to transport products or passengers from one point to another. They are revenue focused, and generate their income from the services they provide. This group also includes the alternative transport service providers, individuals who use their private cars to assist in transporting people and goods to-from the markets. They are not necessarily revenue focused, but offer the service either when requested or when they are travelling to or from the markets. They also include other government vehicles that provide some form of assistance e.g. on market days, and the storage facility owners who provide collection centres for people to store their products before being sent to the market e.g. when the goods can fill a truck load.

- *Customers*: these are the people who request and use the logistics services. They include the farmers, who mostly suffer from poor information on and access to major markets and travel long distances to get access to services. They generally have small farm sizes, low production densities, and uncoordinated supply chain volumes. They need the logistics services due to the limited bulk purchasing possibilities and discounts, inefficiently small vehicle or shipment sizes, which lead to high transportation costs.

- *Service delivery agents*: these are the stakeholders who are expected to coordinate the delivery of logistics services in the rural areas. They include service brokers, government and development agencies, and private entrepreneurs who aim to contribute to enhancing the sustainability of services while at the same time creating business for themselves. Ideally, a proportion of this group of people would be the managers of the logistics brokering service system when operational.

During the case study, the subjects were introduced to the concept of an ICT-enabled logistics brokering system using storylines and scenarios. They were expected to identify some of the functionality that would be desired in such a logistics service system, and to help to clarify the problems that may be faced in developing the service system. We carried out interviews with the logistics service practitioners before going into the rural areas to collect more data from the service delivery agents, customers, and the logistics service providers, using questionnaires, interviews and observations. The aim of the case study was to gather information in an exploratory manner to enable us to get a deeper understanding of how to solve the logistics problems in rural areas.

Through the interviews with the logistics service practitioners, we found that the main challenge they faced in developing logistics services was how to improve the coordination of logistics service processes in the rural areas. They identified the main problems as being the lack of consolidation and synchronisation of small freight volumes, passenger transport, and the presence of complex many-to-many movements. The main causes for these problems are the restrictions imposed by the general rural environment. The interviews also revealed that the rural communities had very little insight into the available or potential benefits of using consolidated logistics services due to the ever-present problem of lack of information.

Through the interview sessions with the farmers and observations made in the rural area, we found that in some situations the rural dwellers were generally constrained by their environments, which also dictate the kind of services that can be delivered to them. This sentiment was also raised by the logistics service providers, who said that they are restricted in the kind of areas they can deliver services to since their vehicles are not able to travel through some of the rough terrain. The population dispersion makes delivery of such transport services very uneconomical. The interviews with transport service providers revealed that the poor road conditions make it difficult to deliver services effectively since their vehicles break down often yet even when operational they are never filled to capacity, and therefore they are unable to make good business returns. Considering that the road networks play a major role in service delivery in general, this finding has a great impact on the development of logistics services in rural areas.

We observed that the rural areas are heavily underdeveloped and most of the rural dwellers live physically remote from the basic service delivery amenities. The areas have poor infrastructure, which results in fragmented distribution and service systems, low supply chain volumes, and long distances to markets. There are several cases of multi-tiered middlemen, who introduce inefficiency in service delivery. These characteristics also mean that there are currently very few efficient supply chains in the rural areas, and that although improvements in the current system may take time, there is still hope that things can be done better. More details on these findings can be found in (Muniafu, et al., 2005; Muniafu & Verbraeck, 2005).

The data collected from the service delivery agents and the customers revealed that many of the SMEs are characterised by low-scale and low-volume business activities. The interviews with this group of stakeholders plus the interviews with the logistics service providers revealed that they do not trust or share information on service delivery with each other. We also learnt that there is a lot of dynamic activity with a high incidence of both informal and formal relationships between the logistics service providers and customers in the rural areas, which make it very challenging to develop services in these areas.

When asked about some of the challenges the logistics service practitioners faced in developing ICT-enabled logistics brokering services in rural areas, they cited the lack of adequate bandwidth for service delivery, complemented by the low levels of connectivity and computer literacy in these areas. To add further to the difficulties faced in providing services in these rural areas are the high proportion of failed or unsustainable projects which were initiated for developmental purposes, coupled with the high numbers of informal and unrecorded SMEs. The implication of this observation is that there is need to develop solutions that are user-centric and represent the needs of the rural communities, since this will encourage the shared use and management of resources, and contribute to sustainability of the logistics service initiatives.

The logistics service practitioners also revealed that the logistics sector in the rural areas is characterised by the lack of information on available logistics services; the lack of cooperation and communication between stakeholders in the logistics service network; low logistics service levels; high levels of unmet transport needs; uncoordinated supply chains; and the non-existence of opportunities for more efficient provision of services. The implication of these revelations is that solutions developed should provide some support to alleviate these problems. Through observations made in the rural area, we also learnt that the currently used logistics services consist of a mixture of the following characteristics:

- privately-owned and stand-alone transportation services that provide access to major service centres in a region, e.g. to Tombo, or to the Kei fresh produce market in Mthatha

- feeder transportation services that merge into existing passenger transport services to enable access to major service centres, e.g. Port St. Johns
- ad hoc transportation services e.g. for the elderly and youth specifically aimed at reducing social exclusion
- transportation services for specific organizations within the community, e.g. hospitals, schools
- special transportation services for those rural residents who are unable to travel on regular passenger services, e.g. those going for treatment, medical appointments, etc.

A general finding from the case study reveals that in a low-density, low-travel volume context such as that in which we carried out the case study, provision of a mobility brokering centre is desirable. This is viable if the centre performs a range of functions, and provides sufficient benefits to both transport service operators and users. The logistics service providers and the customers revealed that they would be willing to use the logistics brokering services especially if they could clearly see the added value of using them. Through the use of logistics brokering services, the rural dwellers will be able to get information regarding the available transport, thereby making transport services more predictable as observed and presented by Green et al. (2004). This would also imply the need for people with an ability to run and manage the brokering services centres.

2.4 Problem analysis of the logistics situation

The main characteristics and manifestations of the logistics services situation from the data gathered in the case study are presented in this section. The aim is to analyse the problems faced and get a grip on how the current logistics situation can be improved through the introduction of ICT-enabled logistics brokering services. The findings from the case study revealed that, in general a lot has been done regarding the deployment of logistics services in the rural areas. In this research, we state that logistics brokering services can alleviate some of the problems observed through the case study and provide solutions to the problems of exclusion that are experienced in these rural environments.

Although the findings from the case study were multi-faceted, we learnt that the main issues that need attention in solving the logistics services problems are closely related to the mode of operation and the rural environment in which the service providers and end-users live. The transportation services in rural areas are mainly centred on the need for people to transport themselves, and to transport agricultural produce to and from markets. Agriculture is the main source of livelihood in these areas, and the transportation issues observed were related to out-bound logistics. Analysing the findings presented in the previous section led us to conclude that the development of logistics brokering services in rural areas needs to take on a different angle from that used in urban areas. The important findings that have direct influence to this and arising from the logistics services situation from the case study include:

- seasonality of agricultural production, which leads to seasonality of logistics service demand and subsequent under-utilization of available infrastructure
- uncoordinated demand for transport capacity, which results in inefficiently small vehicle or shipment sizes, high transport costs, limited bulk purchasing possibilities and discounts
- the inherent need for transportation of high volumes of low value produce, e.g. maize, and low volumes of high value produce, e.g. grapes and honey, which leads to uneconomic transport utilisation
- poor information on, and access to, major markets and specialized services, which leads to lack of knowledge about who is doing what, how, where, and when, resulting in the need to travel long distances to markets and incurring high transportation costs

- a general lack of accessible or scale efficient support services and infrastructure, resulting in poor communication and high transaction costs, lack of accessible storage facilities, underdeveloped brokerage services, which all lead to high transportation costs

We found out that there is currently a high incidence of and virtual explosion in mobile phone ownership, coverage, and usage in the rural areas of South Africa, and we believe that it is possible to deliver logistics brokering services using this technology. The servers should be located in areas where there is stable power supply, while the users would use their mobile devices to consume the services from a distance and in a distributed manner. The potential for replacing and supplementing costly physical interactions as observed in rural areas, with relatively low cost electronic or digital interactions can improve general accessibility to logistics services. The use of logistics brokering services can reduce the economic access barriers associated with small enterprise sizes, long distances to services, and low-volume supply chains. This would enable realisation of the under-utilised potential for agricultural and other resource-based activities. An important finding from the case study is that when developing logistics brokering service solutions to the problems encountered in these areas, the solutions will still need to incorporate the 'human-in-the-loop' mode of service delivery. This is because the people interviewed in the rural communities expressed their tendency to prefer using services that are delivered by people they already have dealings with, and can therefore trust.

Given the characteristics and findings presented in the previous section, there is a case for developing logistics brokering services for the purpose of consolidating and synchronising the small freight volumes of both passengers and farm produce often involving many origins and destinations, and inter-modal transfers, for example from LDV to large trucks. Some consolidation and synchronization currently occurs through informal networking, but this typically involves only a few shippers, one transport mode, and usually only one destination, e.g. to a fresh produce market. In such cases the consolidation and synchronisation problem is fairly simple, and may not normally require the services of a logistics services broker or the use of ICT-enabled scheduling systems (Naudè, 2005).

The ICT-enabled logistics brokering services would be very useful when it is necessary to coordinate complex, many-to-many movements, i.e. involving many origins and destinations, and inter-modal transfers (Naudè, 2005). Against this background, the development of ICT-enabled logistics services would be better coordinated through the use of a logistics brokering service system that can among others, mediate the situation by ensuring that a vehicle that is used to transport students to school early in the morning, can be used to provide specific services for hospitals the rest of the morning, transport the elderly to and from a pension payout location in the afternoon, and transport students home in the evening after school.

This would make the delivery of logistics services using ICT an ideal solution. In such a case, the logistics brokering services would be provided from focal points at which people regularly converge, such as schools or town halls, and the services can also be accessed using mobile phone technology. We found out through the case study that the focal points generally have some existing form of communications infrastructure in place, for example power, computers, and Internet.

Based on the findings from the case study, logistics brokering services are considered to be critical for improving the situation related to small freight and passenger transport service needs in rural South Africa. The use of ICT to enabled logistics brokering services is expected to provide the much needed bridge for the gap between the problems and constraints that were observed through the case study. The resulting logistics brokering service system should provide value added services that solve the rural logistics problems within the framework of the constraints that were identified.

Ideally, the logistics brokering services should integrate the various service needs into packages of key logistics services. To do so, it should utilise data and information from already existing services provided by other service providers, e.g. the transporters, thereby adding value by allowing for efficient use of the available transportation modes.

2.4.1 Implications for developing logistics brokering services

One of the main objectives of conducting the exploratory case study was to explore issues in logistics services in rural areas, and to determine how logistics brokering services can be enabled using ICT. The case study served to enrich our understanding of the rural logistics services sector and the available technology in rural areas. In this sub-section, we describe in detail the implications of our findings from the case study on how logistics brokering can alleviate the problems. The implications are based on the main findings, and are presented as follows.

Local intelligence: there is need to provide local information on the location of customers, logistics service providers, small businesses, etc. if the logistics problems are to be addressed effectively in the rural area. The logistics brokering services need to be supported with ICT to facilitate in determining where there is demand for logistics services and the best schedules and routes through which to deliver the services. Based on the analysis carried out in the early parts of this section, one can clearly see the need to develop logistics brokering services that are accessible regardless of distance of the customer from the service provider. Such services should be available for access anytime and anyplace given that some of the enabling service delivery technology, e.g. mobile phone, is generally available in most parts of rural South Africa. The development of logistics brokering services that can be offered using ICT-enabled technologies such as mobile devices or other remote service delivery technologies, e.g. wireless, could bring great benefit especially where exploitation of the services does not require wiring.

Improve use of available transport: the delivery of goods, inbound and outbound, and the transportation of people is an expensive service that few members of the rural community can afford on their own. There is a need to promote the joint use of transportation services as this reduces costs while providing access to products and services. Overall, we learnt that information about transportation services that are either being used or those that are available was often lacking mostly because the stakeholders were unwilling to share it. In developing logistics brokering services, we have to make assumptions about the missing information and develop models that emulate the existing way of doing things. We also learnt that the logistics brokering services developed must create direct value to the rural users, considering that they are not ‘forced’ to be in regular contact with technology like their counterparts in urban areas. The services should capture information related to areas in which there is a demand for logistics services, and maintain information on the logistics service providers in the area who are able to deliver the services. The logistics brokering service system should support the provision of coordinated transport services and information to improve the use of available transport capacity.

Lack of trust among stakeholders: we learnt that logistics service stakeholders in the rural areas do not trust each other and believe that sharing information gives undue advantage to their competitors. This means that there is need to provide an environment to bring together all the relevant stakeholders to show them the value of developing services jointly, and incorporating ways and means of fitting local user requirements and business processes. The implication is that using a studio-based approach to support service development may be very useful and usable in the development of logistics brokering services. This was considered to be especially so since, through the studio, we can bring together as many of the stakeholders as required, allowing them to interact freely to solve problems that are of relevance to their specific area.

Limited insight into transportation services: many rural dwellers have very little, fragmented information and limited insight into the transport services that they can use. The logistics brokering services developed should be compatible with the needs of the local situation, based on models that support service delivery within the context of the major characteristics of service users. The logistics brokering services should be fairly simple, easy to use, and solve real problems, e.g. link a farmer to suppliers, if they are to be of any use to the rural communities. Route plans need to be created with the aim of working out the best route to provide collection points for people and goods. Information on when a service is likely to be delivered should also be established and provided to the rural dwellers. To be of use the logistics brokering services should record details of the locations of clients demanding services in the region and the suppliers delivering logistics services in that region, to determine the best routes and appropriate logistics service providers to meet the demand.

Trust-related issues: the development of logistics brokering services for use by rural SMEs and other rural stakeholders requires the handling of many complex decisions involving judgement, and addressing the values of many different parties. Potential end-users of logistics brokering services in rural areas operate in a complex and dynamic environment that is not supportive of long-term business relationships, mainly due to economic issues, seasonality of service demand, and trust-related issues identified by Naudè (2005) as:

- concerns about the mixing of different loads such as bags of vegetables sent by two or more different shippers
- security-related uncertainties such as potential theft of goods and other losses
- delivery-related uncertainties such as whether and when the shipment is delivered, and in what condition

These issues have to be considered if the logistics brokering services are to be acceptable to all concerned parties. We also learnt that there is an inherent lack of trust among the logistics service providers, leading to a lack of transparency between operating partners. This implies that logistics brokering service interventions aimed at handling this problem should allow for development and use of services that do not give away unnecessary details of the logistics service provider. The logistics brokering service system should be based on tools that are developed in a less formal service oriented approach that enables loose coupling of services whilst allowing for greater flexibility in the technology of implementation. The service oriented approach should enable service delivery through a manual interaction process. This is based on the case study finding that the rural dwellers prefer to use services that provide some form of human interaction, with humans they can trust. The services should be developed in a way that incorporates an interface to enable the manual assembly of services based on specific user needs.

Ever-changing service provider roles: many of the logistics service providers in rural areas have ever-changing roles during service delivery e.g. some of them are categorised as SMEs providing transport with LDVs, for which the vehicle owners are the drivers. The logistics brokering service will have the main responsibility of establishing the need for logistics services in a given area. The broker needs to have the ability to procure logistics services from providers who are able to provide the services best. For example, in the case of health logistics, service should be procured from local transport operators with vehicles that can transport patients. The studio and its suite should support the service brokers in coming up with logistics brokering services that capture and implement the current way of working in rural areas. The logistics brokering service system should be built in such a way that the logistics service providers can be supported to serve many roles and enable the service brokers to take advantage of existing informal networks to create more business volumes for themselves. To achieve this, the brokering service should be provided with ICT tools that make it

possible to compose flexibly, customise, and deploy the logistics brokering services in the context described in section 2.2.

Services that add value: in the challenging environment in which rural SMEs operate such as the one described in the case study, the service broker has to devise ways of creating and maintaining value-added services. Adaptive technologies based on the knowledge of user behaviour and requirements, such as accessibility to the service, have to be considered in the design of services rather than basing the design of the brokering service on pre-configured preferences. This should be achieved through the provision of tools that support composition of logistics brokering services from a range of other services, built from a range of domain specific and common services or from services across domains. The logistics brokering services can then be accessed using mobile technology that widely exists in the rural areas of South Africa. When developing logistics brokering services, we need to consider that majority of the rural folk are cash constrained and would not be willing to pay for services that do not deliver demonstrable value to them. This means that we need to develop services that show direct value to the rural users.

Enable creation of service processes: there is a need for tools and models that allow logistics service providers, as well as the service broker, to create their own business processes to overcome the problems identified through the case study. The suite utilized by the service broker and service providers to support flexible assembly of services, should allow them to create their own processes and operations. Overall, the suite should support the development of logistics brokering services by the manual selection of basic services via an interface.

Seasonality of demand for services: we believe that it is very important to provide a logistics brokering service system with software tools that can be used to develop services in a one-off manner to meet the seasonality of demand for logistics services as observed through the case study. This implies the need for flexible and reusable service components that connect together easily and seamlessly when required for the delivery of logistics brokering services.

Technophobia and lack of computer literacy skills: this was addressed early and effectively in the rural areas surrounding Tombo, by setting up training services at the multi-purpose community centre (MPCC) in that region, although in some other regions this may be a major problem. The introduction of ICT-enabled logistics brokering services would be the next logical step in helping the rural communities to participate in the knowledge society. Several services targeted at rural communities are already being delivered using ICT, a good example of which is mobile banking services that enable the users to carry out financial transactions using their mobile phones. There is a need to build on the existing methods and ICT-enabled functionality of service delivery when developing the logistics brokering service system.

Mobile phone coverage: there is a virtual explosion in mobile phone ownership, coverage, and usage in large parts of the more densely settled parts of the rural areas in which we carried out the case study. We also observed that there is a steadily increasing range of Internet connectivity, computing services, data capturing services, and geo-referencing functionalities being added to and delivered over mobile communication devices. This means that there is potential to harness mobile technology for the provision of logistics brokering services using technologies such as location-based services, to collaborate and coordinate the logistics and procurement services. This is expected, in the long, run to reduce some of the problems and barriers to service provision associated with small enterprises and long-distance, low-volume supply chains. The high presence of mobile technologies in the rural areas, with most of the areas receiving sufficient coverage, means that a large section of the rural population would able to access logistics brokering services if they were delivered via mobile networks.

The use of a studio-based approach to support development of logistics brokering services is considered to be an ideal solution based on the issues observed in the case study and the implications they have on logistics in the rural environment. The stakeholder analysis that was carried out to identify the participants in the studio enabled us to focus the case study on identifying relevant problems faced by these stakeholders. The suite deployed within the studio should improve the service development effort through its software services and design guidelines that leverage the agility and effectiveness of the required support mechanism. It should facilitate logistics brokering services that meet the needs of people in rural locations.

2.5 Current practise of service delivery

Since 1994, the South African government has been keen to improve the delivery of development oriented services to previously under-serviced communities and to meet challenges such as those found in the rural areas (see section 2.2). The service recipients within these communities include ordinary citizens, community based organisations (CBOs) and SMEs. 'One-stop-service-shops' and multi-purpose community centres (MPCCs) have been considered as potential key service delivery centres for a wide range of services that communities can use for their own development. A wide range of service providers emerged through the initiatives of government at all levels, depicted in light green in figure 2.1. The community level service centres providing "walk-in support", and their target audiences are depicted in Figure 2.1, in which the SMMEs are taken to refer to SMEs in this research. An explanation of all the components of the diagram is given below the figure.

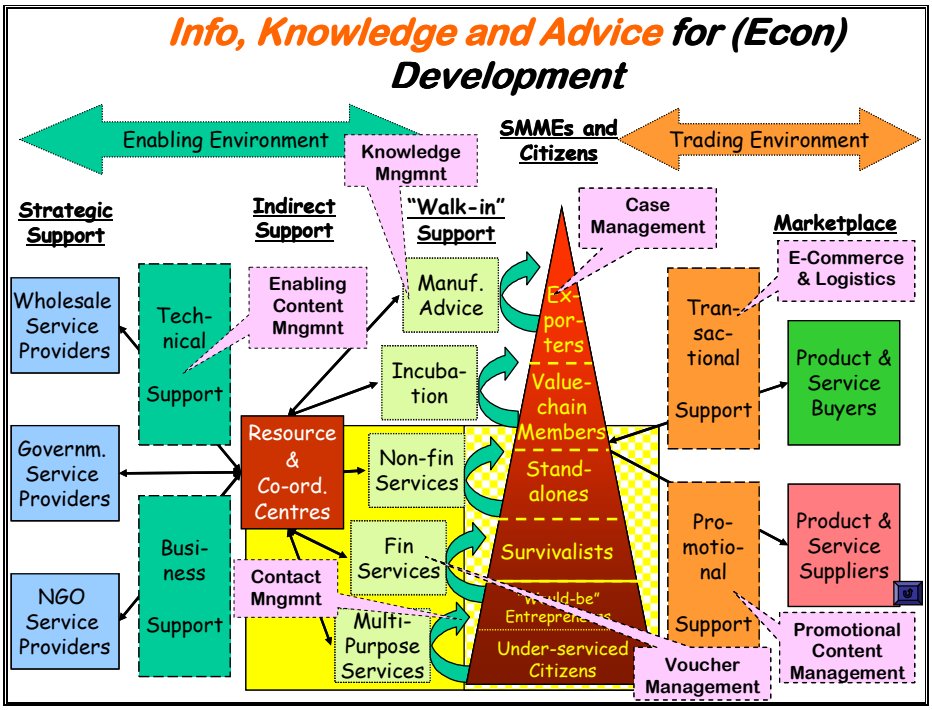


Figure 2.1: The Service Development Channel (Source: van Rensburg, 2004)

Two broad categories of services are delivered to the target audience indicated in figure 2.1. These are identified by van Rensburg (2004) as: (a) business support services and (b) technical support services, indicated in green dotted boxes. The delivery of these services, from a strategic level, is made more effective by the deployment of resource and coordination facilities, "Pump Station" Centres, which are deployed at provincial or district level, indicated in red. The effectiveness of the service delivery in this case is measured by the numbers of citizens served within the local area, who would otherwise have travelled long distances to receive the services. The "walk-in support"

centres also facilitate interaction between citizens, "prospective participants" in the economy, CBOs, SMEs and the marketplace through (a) promotional support services and (b) transactional, including logistical, support services, indicated in orange dotted boxes to the right.

Within the service "enabling environment" and commerce "trading environment" channel, a number of critical functions and processes have emerged that are very well supported by ICT. These functions are indicated in the pink 'call-out boxes' and are:

(a) *Case management*: extensive information is captured concerning individuals and institutions and businesses to provide a clear picture on the various roles of individuals within different institutions and to enable the compilation of SWOT analyses and business plans from the base data. All entities are also spatially referenced so that extensive GIS (geographical information systems) reporting can be done.

(b) *Contact management*: extensive reference information is captured for clients of the service providers. This includes interaction, contract and project detail per client and the outcome of such interaction. The level of detail for this data enables extensive monitoring and evaluation to be done by the service providers and all stakeholders for the needs and requirements of their target audience.

(c) *Content management*: promotional information of a client or company is captured and displayed on the local viewer and on the Internet.

(d) *Knowledge management*: the business "health check" and "business plan" are knowledge-based software, which assist councillors and entrepreneurs to do SWOT analyses and generate realistic business plans.

(e) *Voucher management*: developed to track the vouchers issued to young entrepreneurs and serviced by non-financial service providers.

(f) *E-commerce and logistics*.

In response to the various challenges encountered in the field of service delivery in rural areas, the CSIR developed a service deployment model that supports information, knowledge, and advice intensive SMEs known as Infopreneurs™ (van Rensburg, 2004). The Infopreneurs™ are self-employed social entrepreneurs utilising ICT to enhance the range of services they offer, and are the basic enablers and delivery channels for integrating 'service bundles' in under-serviced communities in a self-sustainable commercial manner. The Infopreneurs™ provide a front desk and outreach capacity at MPCCs. The objectives of the creation of the Infopreneurs™ model are:

- to assist in the establishment of a national trading and information support system for SMEs in South Africa. The information support system focuses on both the trading and the enabling environments and takes cognisance of and builds on, existing initiatives, and develops components collaboratively where required.
- to provide transaction and information bridges between the supply and demand parties in the trading environment, nationally and internationally
- to empower SMEs and the direct support structures through the accurate and timely provision of relevant reference information in the enabling environment
- to determine sustainability models for the provision of such services
- to increase the involvement of relevant stakeholders in the establishment of a national support system

The Infopreneurs™ currently provide the following main services:

- the creation and maintenance of a spatially-referenced district-wide enterprise database containing over and above the ordinary directory type information, information on the size, sector, legal entity, and staffing figures at ownership, management, and workforce level, of 1st and 2nd economy businesses. The database is used by the district and local municipalities for planning and supply chain activities.

- the provision of comprehensive promotional services for the local enterprises whose data is contained in the database.

- the provision of proactive linkage services with public and private sector buyers.

- the proactive supply of health check, SWOT analysis, and business planning services to the enterprises in the database, utilizing the knowledge-based modules developed for these explicit purposes.

A software "toolbox" known as inTouch Africa® is used to support the delivery of all these and other earlier-mentioned services and has been deployed in various types of the MPCCs, retail financial assistance institutions, and local level non-financial support institutions. The inTouch Africa® toolbox was developed by the CSIR to address bandwidth challenges in the rural African context, and it is currently used to support service delivery in rural areas. The toolbox enables decentralized creation, maintenance, distribution and presentation of information. It stores information at the point of use i.e. information is created and maintained as close as possible to the source, with the implied benefit being that the costs associated with retrieving information are dramatically reduced. In addition, the use of multimedia is no longer restricted by bandwidth limitations (van Rensburg, 2003).

The software suite is web-enabled and works by replicating information automatically, and updating information at the various access points. The ability of inTouch Africa® to update changes, instead of transferring bulky sets of complete data, further contributes to its cost-effectiveness in a low bandwidth service delivery environment. The design and architecture of inTouch Africa® that make it an ideal solution for ICT-enabled service delivery especially in rural areas is shown in figure 2.2 (van Rensburg, 2004; van Rensburg, 2003).

Considering that the technology for handling bandwidth related problems is already fully functional as exhibited by the ability of the inTouch Africa® software suite, we did not add any new technological solutions through this research but focused on providing support for the development of logistics brokering services that can be run on the existing technology. The basic idea is that the logistics brokering service system developed in this research would enhance and complement the services currently supported by the inTouch Africa® suite.

2.5.1 Description of the inTouch Africa® toolbox

We studied the technology that is currently used in the general delivery of ICT-enabled services in some rural areas of South Africa. We learnt that innovative technology solutions for handling bandwidth-related problems and for use in the delivery of services were present and we could focus our research on engineering solutions for developing logistics brokering services that could be delivered using the existing technology. First we provide a description of the currently used service delivery technology; we then discuss the challenges faced in the current service development. This

allows us to contextualise and set a basis for engineering solutions for ICT-enabled logistics brokering services.

Description of the technology

The design and architecture of the inTouch Africa® toolbox make it an ideal solution for delivery of services in rural areas, especially for the more remote areas of South Africa (van Rensburg, 2004). Figure 2.2 shows how the set of applications utilise a single database 'backend' maintained locally, e.g. at the MPCC.

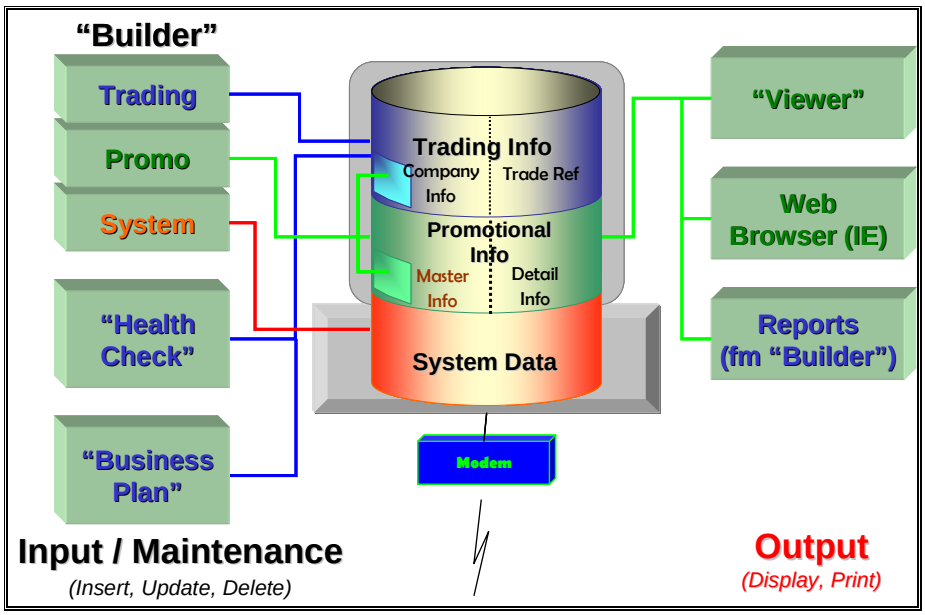


Figure 2.2: Application architecture (Source: inTouch Africa®, 2003).

The application architecture of inTouch Africa® as presented in figure 2.2 is divided into three parts, distinguished in the work of van Rensburg (2004) as follows.

- **Input and Maintenance**: the "Builder" mechanism allows controlled input and maintenance from the information or service provider side. The advantage of maintaining information at source empowers the owners to maintain their own information thereby reducing the risk of old outdated information significantly. The business "Health Check" and "Business Plan" are knowledge-based software tools which assist counsellors and entrepreneurs to do SWOT, strength, weaknesses, opportunities and threats, analyses and to determine action plans to address critical issues in the business and assist them in generating sound business plans.

- **Output and Presentation**: to display information, the presentation modules cater for browser-based and standalone display. The viewers have multilingual capabilities and utilize multimedia to ease and enhance interaction. Information can be found by using searches, or category selection. The contents of the database can also easily be printed in brochure format and distributed on CD-ROM. inTouch Africa® also provides extensive reports on various types of activities and interactions at the centre where these software tools are deployed and used.

- **Central Storage and Data Distribution**: the software utilizes and enhances the built-in replication function of the selected database. It can operate via dedicated Local Area Networks (LAN) or Wide Area Network (WAN), and via dial-up connections.

We present an example of wide area deployment of inTouch Africa® from the Northern Cape province of South Africa in figure 2.3, indicating how the database is synchronised with upstream or downstream databases according to the need of the local environment. This ensures cost effective use of expensive telephone connections and also leaves the responsibility and tools within the environment that has the closest contact and relationship with the local citizens and business community. The visibility of the information on the web ensures that local level entities, individuals, organisations and businesses, can be exposed to the desktops of those who prefer the comfort of home or the corporate office.

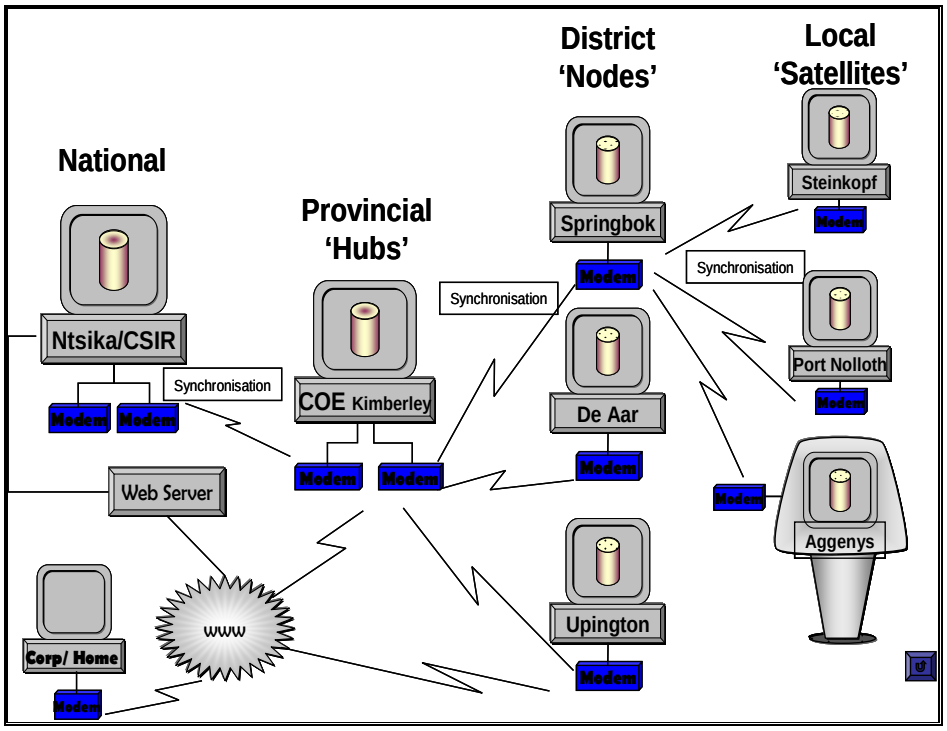


Figure 2.3: Wide Area Network Deployment (Source: inTouch Africa®, 2003).

The way of working implemented in the inTouch Africa® toolbox helps to overcome bandwidth problems in an appropriate manner. The system publishes the same information at a standalone point of use and on the web. The cost reduction stems from information having to be created only once for use on different media, including printed brochures and CD-ROM. This further compliments the standpoint of this research, that there is no need to introduce new technologies but rather work with existing ones to deliver the logistics brokering services.

2.5.2 Challenges currently faced in service development

Despite all the efforts that have been made at introducing ICT to enable service delivery in rural areas, one still encounters ineffectual and unsustainable application of ICT as an enabler of the broad-based service delivery channel (van Rensburg, 2004). At the moment, there is no formal support provided for the development of services in rural areas, and the development of the ICT-enabled services offered via the inTouch Africa® toolbox is done on ad hoc and reactive basis using rapid application development techniques. The software is developed using 'quick and dirty'

models of what is perceived to be the existing situation or a solution to a given need. These models are so-called because they do not accurately represent the exact existing situation, but can be used to demonstrate the functionality of the software tools. The software is then implemented and after deployment to the audience, an assessment is made of its usefulness in fulfilling the service needs for which it was designed.

The lack of precise empirical models of the prevailing situation means that it is difficult to determine how services can be designed, developed, and delivered to a target audience. The main influencing factors mostly arise from the information processes and characteristics of the rural environment. These factors are identified by van Rensburg (2004) and categorized as information creation and maintenance, information storage and distribution, information service brokerage, and information presentation. We present the implications to service development as follows for each of these categories.

- *information creation and maintenance*: there is a limited base for ICT skills and experience in the rural areas. This implies a need to develop services that are remotely hosted and that can re-use content, use single sources of information for multiple applications, and use universal formats that are preferably Internet supported.

- *information storage and distribution*: there is a lack of database administration (DBA) skills in the rural areas. The implication of this problem is that the information storage and maintenance should be remote and database based.

- *information service brokerage*: there is lack of clarity regarding service user needs, and an unreliable communication infrastructure. The implication of this is that the logistics brokering service system should provide a means to support the consolidation of service demands, and ensure that the rural communities can get a link to the rest of the economy.

- *information presentation*: it is preferable that the logistics brokering services are presented to the users using a familiar interface and feel that is not difficult to use, and that solves real service delivery problems.

The logistics situation in rural areas, as presented in sub-section 2.2, is multi-actor, with some of the service provider roles being played by more than one party at any given moment due to the nature of the business environment in rural areas. The ICT-enabled service deployment model currently used is ‘technology push’, and not ‘market pull’, with heavy reliance on the use of rapid application development models. The systems are developed and modified interactively and incrementally with the users since there are no empirical models with which to work. The result is the development of services that are either under-utilised or unused since in some cases the stakeholders feel that the services do not meet their needs. In some cases, the development of services is driven by demand, whereby the rural development practitioners interpret the need for a given service either from experience or interaction with end-user community, or generally just define services to meet development needs and goals set by the government. At other times, innovation also plays a key role, for example, the case in which the inTouch Africa® toolbox introduced a technology to ‘broadcast’ short messages of relevant information to groups of clients using short message service (sms) technology, after realising that most customers who use the services offered by the toolbox possess mobile phones.

The current practice of developing ICT-enabled services is based on continuously introducing modules into the inTouch Africa® toolbox to support service delivery, either based on the experience of the rural development practitioners or on perceived need for a given service. The

services are introduced to the rural communities, who are expected to give feedback about the services. In some cases this way of working has assisted the users in coming up with useful assessments of the percentage of their needs that the rapidly developed application meets. This feedback is then used as a starting point for the interactive development of ICT-enabled services. We learnt that end users of services in rural areas prefer to see 'working' models of the service before they clearly understand the added value to them. It is only after this that functionality can be added incrementally to the service the end users have seen. The biggest problem in the development of services in rural areas which was identified by the logistics service practitioners is that the developers mostly work with end users who are rarely able put service needs into proper words; hence the use of the quick and dirty application development methods to demonstrate functionality of software tools.

2.5.3 Lessons learnt from current practise of service delivery

Through studying the current service delivery practise, we gained insight into the usefulness and usability of existing technologies to address problems in rural areas. Given the analysis presented in the previous sub-section and the description of the current development and implementation of inTouch Africa®, we recognized the need to provide support for the development of logistics brokering services. We learnt that it is very difficult to develop services in rural areas since the environment is dynamic with very little transparency in the transaction environment. The entrepreneurs working in these areas look on information sharing as a threat to their business advantage. We present the lessons we learnt in this section as follows.

Emulate current way of working: the fact that those involved in development of services are at times required to change their software on the fly to deliver a given service implies that it is appropriate to provide them with support tools. These tools should be used to develop logistics brokering services that meet ever-changing customer and service provider needs in an easy and flexible manner. The main lesson learnt is that software tools developed to support service delivery should closely emulate the current way of working within the rural environment. The tools should support the service brokers by allowing them to develop and test the logistics brokering services. The tools should be accompanied by some guidelines on how to use them.

Support for development: many of the tools within the inTouch Africa® suite were developed in an ad hoc manner, and tend to be small-scale and mostly specialised fit-for-purpose applications. The lesson we learnt is that there is need to improve the support given to service brokers by defining reusable service components that can be configured to suit business processes rather than making specialised fit-for-purpose tools. We state that the adoption of service oriented architectures (SOA) will lower the entry barriers for integration and reuse of software services since SOA enables the development of reusable and standards-compliant applications.

Technological shortcomings: technology-wise, the ubiquitous infrastructure and service delivery shortcomings of rural environments in South Africa, e.g. limited bandwidth, have already been taken into consideration especially when developing the inTouch Africa® suite, and when setting up the Infopreneurs™ who utilise ICT to support clustering of enterprises and services that consolidate supply chains. Carrying on from the findings of the case study, the main challenge in providing logistics brokering services is to look for interventions that mitigate and improve the coordination of rural logistics service processes by consolidating small freight volumes and synchronising services, using the available technology. Such consolidation and synchronization of freight services can be used to handle the complex many-to-many movements and the inter-modal transfers required due to the end-user characteristics and their environment.

End-user environment: development of logistics brokering services in the rural environment must take into consideration issues that are part and parcel of the rural area such as the bandwidth limitations; intermittent power supply; end-user abilities and capabilities to access the services, e.g. via mobile devices; and poverty issues, which imply that the services developed need to be affordable and dependent on the local situation. There is need to develop cheap and simple to use services, and take into consideration a need for the development of logistics brokering services that can either be used on a self-service basis or with a human-in-the-loop.

In section 4.1, we explain how we engineered the logistics brokering service system, based on the findings from the case study and an analysis of the current service delivery practise.

2.6 Reflections

Based on the findings and the observations made through the exploratory case study and presented in this chapter, we learnt that it is very challenging to develop logistics brokering services in rural areas especially because of the environmental and technological constraints. The objective of this research was to use the studio-based approach to support and improve the development of ICT-enabled logistics brokering services. In line with the main objective and the fact that we studied services delivered to and by rural SMEs, we reflect on several issues that can be summarized as follows.

- information about logistics services in rural areas is almost non-existent. The SMEs operating in rural areas are mostly cash-constrained and operate in business environments characterized by fragmented and incomplete information regarding services. The SMEs are mostly unable to afford the information systems that can enable them to integrate seamlessly with larger business supply chains. This makes it important to develop logistics brokering services that do not place much burden on the SMEs, but are adaptable to allow the small businesses to connect seamlessly with their business partners and services. Developing services that do not allow for seamless integration of service providers may be of no use. This contributes to the relevance of the research objective and the need to provide support for the development of ICT-enabled logistics brokering services.

- the SMEs in the rural areas we studied have an ever changing base of customers and needs, and it is not uncommon to find actors playing more than one role in a business transaction. This makes developing logistics brokering services more challenging since the services need to be flexible and reusable to suit many of the activities and roles of the customers and SMEs. The situation gets especially complicated given that most of the business relationships are informal. There is a need to facilitate the development of services to support each role. Service orientation and service-oriented architectures provide useful solutions since they facilitate constant change in business processes, and can be used to develop applications to support particular roles in a service. Service orientation provides a clear separation between private/internal processes from public/external processes. We decided to use service orientation as a basis for developing the suite to facilitate and improve the development of logistics brokering services in rural areas. The principles of service orientation are discussed in chapter 3.

- in rural areas, the SMEs and partner organizations operating there are unwilling to volunteer or share information since this is regarded either as a threat to their competitiveness or an invasion of their privacy. This leads to a situation in which it is quite difficult to know who does what, how, when, where, and for whom. Creating a catalogue of currently delivered logistics services is not a simple task, which implies that it is quite challenging to come up

with services that require inputs from competitors. There is need to develop support tools that reinforce ways of working that co-exist with current ones. The development of logistics brokering services should define services for each individual partnership in a business process in the rural areas as observed through the case study. Using the support tools should facilitate the development of services and capture the details of clients and service providers within a given rural area. This supports the relevance of our research objective, which was to improve the development of ICT-enabled logistics brokering services in rural areas.

- we learnt that ICT-enabled service delivery is currently taking place in rural South Africa, and that in some cases it is quite successful. From an analysis of the logistics services situation in the rural areas, we observed the need for service brokers to be familiar in detail, with local situations in the areas that they serve. This would improve the identification of design requirements of logistics brokering services. To support the service brokers in attaining these goals, we need to come up with a ready-to-use set of tools that can support ICT-enabled logistics brokering services. The tools should capture and effectively represent the rural area situation. Tools that provide the service broker with adequate support will improve the development of ICT-enabled logistics brokering services and provide answers to our research questions.

- from the findings of the case study, we learnt that there is need to improve the level of communication, organization, cooperation and coordination of logistics activities in rural areas between the different stakeholders and users of services, and to provide them with support for decision making. This is based on that argument that the design of feasible and appropriate local models should support joint development of logistics brokering services for SMEs and other rural stakeholders. Such models will enhance the understanding of the challenges faced by rural SMEs in their attempt to link to the main supply chains. A studio-based approach to the development of services enables us to bring together as many stakeholders as are required to reach consensus, and we believe that it provides effective support for joint development of services. The suite is deployed within the studio to provide the required technology support. This is relevant for our research objective. The design and implementation of the suite are discussed further in chapters 4 and 5.

In general, we learnt that for ICT-enabled logistics brokering services in rural areas to be effective, they need to solve real problems and offer direct benefit to the rural community. When designing the suite for ICT-enabled logistics brokering services we need to consider the factors described in this section. The ICT-enabled logistics brokering service system should be simple to use, and also be cheap given the high poverty levels found in the rural areas. The studio-based approach used this research is aimed at improving and providing support for the development of ICT-enabled logistics brokering services in rural South Africa. The structure of the suite was based on the importance of designing a service system that responds to the needs of rural people rather than simply transposing successful urban service delivery models.

3. ICT-enabled logistics brokering in practise

In this chapter, we discuss the theoretical concepts derived from literature and from the case study in relation to the development of ICT-enabled logistics brokering services. In the first section, we provide a brief background to the current trend and underlying themes driving the development of ICT-enabled services. We then discuss the impact of ICT on logistics services with the aim of identifying the main themes to be considered when developing ICT-enabled logistics services, and what to consider in logistics brokering services. We follow this discussion with an introduction to the concept of service orientation and service oriented architecture as basis for the development of ICT-enabled logistics brokering services. The 'service' concept is defined at a high level to provide an overview of business services and service orientation. We then look at various service design methodologies and frameworks that can be adapted and used to engineer ICT-enabled logistics brokering services in rural areas. The aim of this is to understand and examine possible themes that can be applied in the development of logistics brokering services. We conclude the chapter with a presentation of reflections drawn from the literature and from the case study findings presented in chapter 2, to form a starting point for the design of a suite to facilitate ICT-enabled logistics brokering services.

3.1 Introduction

The two main underlying themes behind the major ICT service challenges of cutting costs and utilizing existing technology to the maximum are heterogeneity and change. Most enterprises contain a range of different systems, applications and architectures of different ages and technologies (Endrei, et al, 2004). Integrating products from multiple vendors and across different platforms has almost always been a nightmare. According to Chaffey (2005), globalization and E-business are accelerating the pace of change. Globalization leads to fierce competition, which leads to shortening product cycles, as companies look to gain an advantage over their competition. Customer needs and requirements are changing quickly, driven by competitive offerings and the wealth of product information available over the Internet (Chaffey, 2005). In response, the cycle of competitive improvements in products and services is further accelerated. Improvements in technology continue to accelerate, feeding the increased pace of changing customer requirements.

Businesses must rapidly adapt to survive, let alone to succeed in today's dynamic competitive environment, and the ICT infrastructure must enable businesses' ability to adapt. As a result, business organizations are evolving from vertical, isolated business divisions to form horizontal business-process-focused structures, moving towards the new ecosystem business paradigm. Business services now need to be componentized and distributed (Endrei, et al., 2004). According to Sadiq & Racca (2004), much has been accomplished by designing services as independent tiers that interoperate only with those that are directly adjacent. In this way logic is boxed into a logical hierarchy that makes solutions more scalable and easier to understand, maintain, and change. This thinking started with the client/server model (Sadiq & Racca, 2004). As more modern enterprises evolved, the need for separating both the presentation layer and the data layer from the business logic layer became self-evident, giving way to the three-tier client/server model. Initially, the layers were simply the data layer, the presentation layer, and the application layer in the middle. The application layer implemented generic reusable services.

As services started being abstracted from the application logic, the concept of application servers as business logic containers became more popular (Sadiq & Racca, 2004). The idea was that these containers would encapsulate and hide the implementation of low-level services such as database access, transaction management, connection management, high availability, clustering, application programmer interface (API) management, messaging, and presentation. In this way, the applications

built on these platforms could be totally independent of the different implementations of the services they used and the developers could concentrate on coding the business logic. Furthermore, business logic could be exposed as services to be used by other applications that could run within the application server or not (Sadiq & Racca, 2004). The application server providers, seeing the impressive adoption rate of web servers as the preferred way to create ubiquitous "thin clients" that implemented the presentation logic and some business logic, scrambled to add this functionality to the application servers to create a single platform for everything. A fuzzy boundary between the business logic in the application servers and the presentation logic in the web servers is presently the state of the art for constructing and/or front-ending enterprise applications (Sadiq & Racca, 2004).

Integration takes centre stage in support of the idea of front-ending enterprise applications. The objectives of enterprise application integration (EAI) are to facilitate automated interaction between disparate enterprise applications or inter-enterprise transactions (Gorton & Liu, 2004). EAI takes existing applications as the primary interfaces with existing users and tries to eliminate swivel-chair operations where some users spend time moving data from one application, internal or external, into another to maintain synchronicity and consistency of data (Lee, et al., 2003). EAI assumes that existing applications have all the necessary functionality to support complete automation of business processes (Sadiq & Racca, 2004). The objectives and implementation approaches of EAI methodologies limit them to being used exclusively as integration methodologies. As business performance improves and applications adapt, these integration brokers require business-level standards and an ability to translate from many to many, which poses major impediments (Sadiq & Racca, 2004). In addition, the handcrafted EAI adaptors or connectors to back end applications are not reusable in different environments because they are sensitive to different implementations of back-end systems.

Another popular trend is that of service or component brokering (SCB). All methodologies, in one way or another, that expose application services in the form of reusable functions or components fall in this category. This includes remote procedure calling (RPC), object request brokers, and application servers, where the objective is to provide a platform on which application services can run, invoke each other, and be invoked as components. The SCB methodology makes it easy to develop Greenfield applications, implementing solutions under a three-tier architecture where the business logic is separated from the presentation logic, and is reusable (Sadiq & Racca, 2004). As with any platform, to obtain the benefits of separating business logic from presentation logic, it is necessary to build new applications on the SCB platform of choice. According to Sadiq & Racca (2004) SCB platforms are not really good at interacting with other types of SCB platforms as they typically use messaging systems that they do not usually provide. SCB platforms respond to the three-tier client/server methodology, which is an approach for developing new applications.

3.2 Impact of ICT on logistics services

The impact of ICT on logistics services has had varied results. In addition to the special opportunities that ICT knowledge can offer for the logistics service providers, they all have to reach a certain standard to survive in the market. Their ICT systems must be able to support the goods and information flow and allow integration with their customer's systems. Computerized systems are basic pre-requisites for every logistics service provider, together with seamless systems integration across company boundaries. ICT makes it possible to process more information, more accurately, more frequently, from more sources. According to Boyson et al. (2003) a key to enhanced supply chain operations, of which logistics forms a great part, is not solely efficient information transfer, but timely information availability. The use of information systems to ensure visibility (transparency) of item demand, location, and status to all parts of the logistics network is an

important attribute. The availability of the Internet and the associated technologies provides an opportunity to make further significant improvements to break down functional barriers and enhance the flow of information.

According to Delfmann et al. (2002), many promising e-commerce companies have failed or are struggling for economical survival, something that can be attributed in part to neglect of logistics as a key factor of success. Logistics service providers need to confront the changes in their marketplace introduced by ICT. Logistics functions include the planning, implementation, and control of the flow of goods, services, and related information. A clustering of logistics service providers presented by Delfmann et al (2002) consists of three major groups. The first group consists of service providers offering only standardized and isolated logistics services or distribution functions e.g. transportation, warehousing, etc. The services they fulfil for their customers are standardized. These companies are highly specialized in their field and do not take over coordination or administrative activities for their customers. They mostly handle homogenous objects and optimise their whole logistics system with regard to these special logistics objects, and are referred to by Delfmann et al. (2002) as standardizing logistics service providers.

The second group consists of companies which combine selected standardized services into bundles of logistics services according to customer wishes, referred to by Delfmann, et al. (2002) as bundling logistics service providers. They provide operational coordination and arrangement of the services while the disposition lies in the responsibility of the buying company. Frequently, these bundles of services consist of core logistics activity such as transportation, which is combined with secondary activities such as assembly and quality control. The bundles are offered undifferentiated for all potential customers and can thus not be regarded as customized services.

The third group of logistics service providers is referred to by Delfmann et al. (2002) as customizing logistics service providers. These companies design logistics services and logistics systems according to the preferences of their customers. They use ICT to combine and modify components of logistics services especially for the needs of one specific customer, and usually take over coordination and administrative responsibility for their customer as well. They offer services which are not originally attributable to the logistics functions, and their core competencies can be seen on the conceptual and coordination side. The clustering of the logistics service providers is presented in table 3.1, from Delfmann, et al. (2002).

Standardizing	Bundling	Customizing
Standardized	Disposal by the customer	Individual, complete logistics solutions for specific customers
Disposal by customer	Combination of isolated services and coordination by the logistics service provider	Responsibility for important customer logistics functions
Optimization and offering of singular logistics services	Optimization of the bundle of logistics services	Administrative and disposal tasks

Table 3.1 Logistics service provider clusters (Source: Delfmann, et al., 2002)

With the application of ICT to support the delivery of services, logistics service providers are faced with changes in their respective market environments. The clusters presented in table 3.1 all affect the structure of the logistics industry as a whole, with the implication that appropriate software tools for controlling and managing the extended supply chain need to be developed. ICT has enabled logistics service providers to plan and use available capacity more effectively by combining service offers and requests from several Internet based service providers. A good example of this is when logistics service providers make better use of available warehouse and transportation capacities by

consolidating cargo, reducing empty miles and raising loading rates using ICT to plan and schedule the services. Despite the availability of the special opportunities that ICT offers to the logistics service industry, logistics service providers need to reach a certain IT standard to survive in the market (Delfmann, et al., 2002). The IT systems implemented must support the goods and information flow and allow for integration with their customers' systems.

According to Hull & Su (2004), an increasing amount of organizations implement their core business and outsource other application services over the Internet. Thus, the ability to select efficiently and effectively and integrate inter-organizational and heterogeneous services on the web is an important step. In particular, if no single web service can satisfy the functionality required by a user, there should be a possibility to combine existing services to fulfil a request (Hull & Su, 2004). The currently dominant theme is to use web service composition which lets developers create applications on top of the native service-oriented computing capabilities of description, discovery, and communication. Such applications are rapidly deployable and offer developers reuse possibilities and their users seamless access to a variety of complex services.

Web service technologies are becoming more widely used in enterprise application development and integration, with one of the critical issues being finding more efficient and effective ways of designing, developing and deploying web services based business systems; more importantly, moving beyond the basic point-to-point web services communications to broader application of these technologies to enterprise-level business processes (Endrei, et al., 2004).

Competition and the need to provide value-added services has certainly promoted the use of ICT in logistics since easy contact is facilitated between firms and consumers leading to many more potential customers and service providers. With the growing numbers of service providers offering goods and services using ICT, it is desirable to come up with scalable and integrated ways for service providers to reach their customers, for customers to reach the service providers, and to enable the introduction of new services and offers efficiently. The effective use of ICT in logistics depends on the capabilities of customers to the obtain data they need to make informed decisions quickly and easily. This is best done through intermediaries or brokering services.

3.3 Logistics brokering services

According to Bichler & Segev (1999), traditional physical markets are often brokered by intermediaries, or parties that facilitate transactions by providing brokering services. Logistics brokering services are important because they provide a central marketplace and are in a key position to provide many essential third party services. In the logistics industry, brokering services provide the following benefits to customers and service providers with respect to conducting business.

- *Cost and time saving associated with searching for products and services*: it may be expensive for service providers and service customers to find each other. A brokering service could collect information about the service providers and pass the information to the customers.

- *Complete selection and qualified information*: this is especially important when a customer wants to make a choice of the service provider or the service they require. The brokering service can bring more information from other sources since they act as intermediaries.

- *Better pricing*: this is true in the case where a service broker can have better knowledge of what a customer is willing to pay for specific services. The consolidating capability of the

brokering service leads to better bargaining positions for both the customer and service provider.

- *Establishing confidence*: this is necessary when customers need to rely on a service provider's reliability and reputation. The customer may refuse to pay after receiving a service or the service provider may deny responsibility for incomplete service delivery. The brokering service can endorse the distribution of responsibility to all parties, and minimize bad transactions by selecting the best service providers and avoiding bad customers.

- *Privacy protection*: the brokering service may be a necessary intermediary when either one of the service customers or the service providers want to remain anonymous.

These benefits of brokering services in logistics as presented by Bichler & Segev (1999) form the basis for the emergence of new intermediaries whose capabilities are shaped by the technology employed. This is further supported in the work of Cunden & van Heck (2004) which states that the Internet-enabled technology has not only extended the traditional market mechanisms into the electronic realm, but also in areas where no market mechanisms have existed. The use of Internet technology has also meant that the buyers and sellers do not necessarily have to physically gather in one place. Further, Turban et al. (2006) observe that electronic markets are most useful when they are able to directly match buyers and sellers. Electronic markets serve to reduce the search costs, thus allowing consumers to find sellers offering low prices. In the long run, this may reduce the margins for sellers yet it may also lead to an increase in the number of transactions that do take place (Turban, et al., 2006). Besides their functionality in electronic markets, there are several other dimensions that play a role in the implementation of a logistics brokering service.

- *Provisioning*: this relates to the nature of the content of the trading entity, online information, physical goods, or virtual goods.

- *Information gathering*: this represents the way in which a brokering service is given access to information of market participants. The brokering service either gathers information to create a catalogue of services before the user requests for them, or dynamically after receiving the user request.

- *Payment*: this determines if the broker is paid for the services. From the user's point of view there are two main categories, namely one-stop-shopping where the user pays only to the broker and separate billing where the end user pays separate bills to the broker and the service providers. In other situations the service providers pay the broker. Moreover, the broker can be paid per usage or per transaction.

- *Ownership*: this determines if the mediator is the owner of the content or not. The distinguishing factor between a broker and a seller is the ownership relationship with the mediated good. A broker is supposed to mediate information about trading objects, but not own them. The seller is supposed to have selling rights on the traded object, and hence trades the goods.

- *Technology*: this determines the underlying techniques used to provide brokering services. This may also include the establishment of brokering services on the Internet. Most brokers on the Internet concentrate on the aggregation of information from underlying electronic catalogues.

However, these dimensions are not enough on their own. There is a need to include the human aspects of the market, particularly in developing countries. The work of Cunden & van Heck (2004) presents a conceptual framework that depicts the potential influence that African growers may assert over the market makers given the adoption of IT. In this conceptual framework, Cunden & van Heck (2004) depict that the adoption of IT by African growers has high influence on the market makers and increases the geographical reach to buyers. Further, the geographical reach increases the potential to select the right buyer, and selecting the right buyer leads to successful and profitable trade agreements. Based on this conceptual framework, Cunden & van Heck (2004) observe that achieving the objectives of concluding profitable transactions against the confluence of all participants' interests ensures a successful business network. The winning formula must therefore incorporate stakeholder influence and bargaining power within the social institution of the market. As further stated in the work of Cunden & van Heck (2004), for the African growers economic value is measured in terms of reaching more customers and providing richness in information and customer services designed to conclude successful trade agreements.

We note that on average, logistics brokering services face the challenge of combining all the information within a single coherent structure through which customers can navigate readily. Current web-based technology makes it difficult to aggregate information from underlying electronic catalogues dynamically. The brokering service should provide a trusted conjunction of supply and demand processes, and the brokering can be regarded as the general mediation process between customers and service providers. According to Bichler & Segev (1999), brokering services consist of the following:

- mechanisms through which a supplier can express the ability to provide products and/or services, and through which a customer can express an interest in products and/or services
- mechanisms to aggregate information of registered electronic catalogues dynamically i.e. to enable users to get the appropriate view on the service provider domain

- mechanisms to support notification capabilities i.e. a service provider can supply a description of abilities to a broker for the purpose of propagating the ability to registered customers who have expressed an interest in the particular ability or vice versa

- mechanisms for bi-lateral and multi-lateral negotiations on products and services

In order to enable these mechanisms, considerable interest is currently being shown by a wide range of organizations in the deployment of services on the Internet using web services technology. The benefits that such services offer organizations seem compelling. They promise the ability to reduce the time and cost involved in developing, supporting, and integrating the internal information systems within a single organization. Web services are defined by Fensel & Bussler (2002) as software objects that can be assembled over the Internet using standard protocols to perform functions or to execute business processes. Lau & Rayman (2002) define web services as providing a distributed computing technology for integrating applications over the Internet. Using a definition based on their likely impact, Ismail et al (2002) define web services as business and consumer applications delivered over the Internet that users can select and combine through almost any device from personal computer to a mobile phone. By using the shared set of protocols and standards, these applications permit disparate systems to 'talk' to one another, i.e. share data and services, without requiring humans to translate the conversation.

Two key concepts underlie web services: service oriented architecture and open standards. In service oriented architecture (SOA), applications can be accessed as services over a network, such as the Internet or a private intranet or extranet. Organizations can create or build applications to

support their business processes by selecting their required services from those available over the network. The services are called up and run each time the application is executed. This concept is similar to distributed, component oriented architecture, but the use of open standards enables services distributed across the entire Internet to be accessible, not just those within the organization.

The four key standards developed by the World Wide Web Consortium (W3C) that underpin web services are Extensible Mark-Up Language (XML), Universal Description Discovery and Integration (UDDI), Web Services Description Language (WSDL), and Single Object Access Protocol (SOAP). Each of these is defined below.

- *XML*: this is at the heart of web services. It is a standard used to describe data that allows different information systems to exchange data regardless of the underlying programming language or operating system. A developer or user applies tags to each element of data to be passed between applications, which identify the meaning of each piece of data. These tags or meta-data are transmitted with the actual data and used by the target application to decode the meaning of each piece of data that is received.

- *UDDI*: this is a specific type of directory that contains structured information that describes a web service. It is aimed at individuals or organizations that want to publish web services they have or user organizations that want to identify and locate services that are available. UDDI repositories contain four types of information: the business entity that developed the service, including address and other contact details; a description of business service undertaken by the module; a list of categories that describe the service; and one or more binding templates that give technical information about the service.

- *WSDL*: this is a language that is used to describe what the particular web service will do. It separates their description from the data format and concrete protocol, which act as bindings. The information includes how to invoke the service, including the port type (an abstract collection of operations); the operations that the port supports; the structure of the input and output messages.

- *SOAP*: this defines a means for communicating with web services over the Internet by describing the message layout specification. It provides a one-way as well as a request-and-reply mechanism (Remote Procedure Call (RPC)) using XML messaging over HTTP, thus avoiding conflicts with firewalls. SOAP enables communication between the service requestor and the service directory.

An organization describes its application/service in WSDL in terms of functionality and programming language. This description is stored in a UDDI repository where it can be accessed by other applications requiring this service. The user sends a SOAP message to the UDDI requesting a particular service. The UDDI provides the URL of the relevant service and the user connects with the service. The service application is run and the required response passed to the user over SOAP. All communication is in XML and therefore independent of application language or platform.

It is expected that the maximum benefit from web services will derive from their ability to allow organizations to develop flexible information system links with those of their trading partners, and to be able to do this rapidly and at a relatively modest cost. Such links are referred to as “loose couplings”. As organizations use web services to develop such flexible linkages, they are likely to find themselves developing links with a greater number and wider range of organizations. For such interactions to proliferate and become one-to-many, or even many-to-many connections requires the facilitation of independent third parties. Such third parties will be required to help users and

providers of web services to find and connect with each other and to provide a trusted and regulated environment in which to carry out business. The enabling activities of matching users and providers of web services are critical to the widespread adoption of web services for inter-organizational integration. The development of services based on service oriented architectures (SOA) is becoming the prevailing style, and this strengthens the role of web services.

3.4 Service Orientation and Service Oriented Architectures

In the previous section, we discussed the fact that businesses have to have an ability to change quickly whilst reducing costs. Using service oriented architecture we can realize the benefits of ICT to help organizations succeed in the dynamic business landscape of today. Service orientation is one way to build distributed systems. The concept of service orientation is defined by Papazoglou & Georgakopolous (2003) as the computing methodology that utilizes services as fundamental elements for developing applications, which views everything, from a mainframe application to the printer to the shipping dock clerk to the overnight delivery company, as a service provider. Separation between interface and implementation is fundamental to the service concept (Papazoglou & Georgakopolous, 2003).

The concept of creating flexible services using SOA, where services are provided and used as required, is rapidly gaining traction. Businesses are looking to SOA as the best way to leverage their IT assets and to provide the agility needed to be competitive in today's economy. SOA provides the basis for this infrastructure. The goal of SOA is to enable organizations to realise business and technology advantages through a combination of process innovation, effective governance, and development of a technology strategy that revolves around the definition and reuse of services (BEA Systems, 2005).

In general, a SOA represents a uniform means to discover and access distributed services that invoke functionalities which produce desired effects with measurable expectations (Oasis Open, 2005). The services hide their implementation details but have associated service descriptions to provide the service consumer with sufficient information to understand the technical and business requirements for invoking the service (Oasis Open, 2005). According to Endrei et al. (2004), a service consumer does not have to care about a particular service it is communicating with because the underlying infrastructure will make an appropriate choice on behalf of the consumer.

3.4.1 Principles of service oriented architectures

Service oriented architecture is an approach to software design ("architecture") where applications are assembled from reusable components ("services"). It is an architectural approach that makes it feasible and practical to build business applications through a collection of loosely coupled services (Kelly, 2005). A service is a software building block that performs a distinct function, such as retrieving customer information from a database, through a well-defined interface, which is basically an electronic description of how to call a service from other programs. Using SOA, the software is organized into loosely coupled modular components. Loose coupling is significant because it underlies the flexibility behind SOA, and it basically means that services can be linked together dynamically at run-time, independent of how the services are actually implemented.

An important consequence of loose coupling is that organizations can build open, heterogeneous services that can run anywhere on a network and they are not restricted to a specific hardware or software platform, or programming language (Kelly, 2005; webMethods, 2005). SOA approaches enable organizations to build applications by assembling discrete application components and orchestrating reusable business or presentation services to increase IT productivity, agility, and business flexibility greatly. The orchestration of services is defined by Sadiq & Racca (2004) as the

sequencing of services to fulfil a business task or process. In a SOA, services exist as two distinct elements, a well-defined service interface and the service implementation. The service interface describes how to call the service, specifying among other things, where the service is located, and the format of input/output parameters. The service interface is what provides another program with the information it needs to make a request to the service and get a response. The service implementation is the actual code that fulfils the functionality of the service. It is the logic that resides on a computer somewhere on the network and is executed when called. Unlike the service interface, the service implementation is inherently platform-dependent.

SOA defines services using a service-based approach. A service-based approach to IT changes the way in which functionality is developed and delivered. Functionality is considered, factored, and deployed once for use at all levels, yielding the associated benefits of reduced cost, faster delivery and IT responsiveness to the needs of change (BEA Systems, 2005). SOA also considers the manner in which functionality is made available as services, and the way in which those services are managed and monitored. The benefits of SOA are wide and varied. On the business side, continual process improvement and business-oriented delivery of functionality through services is made possible by increased collaboration between business and IT stakeholders. On the IT side, key factors to consider include improvements in delivery capability through incremental deployment, the reuse of services for faster deployment, standardization, benefits in skill portability, and lower skill set requirements in a standardized environment. A common platform for service deployment yields reliability, scalability, and performance (BEA Systems, 2005). Some of the characteristics and benefits of using SOA approaches, taken from webMethods (2005) are shown in table 3.2.

SOA Characteristic	Business Benefits
Loosely coupled	• Increases organizational agility; allows companies to easily assemble and modify business processes in response to market requirements • Provides competitive advantage by offering greater flexibility in the way computer systems can be used to support the business • Lowers implementation costs by increasing reusability; services can be shared among multiple applications • Increases IT adaptability; changes are integrated more easily
Modular approach	• Enables incremental development, deployment, and maintenance • Decreases development effort by reducing complexity • Over time, accelerates deployment of new application functionality; process becomes mostly assembly (of existing services) versus new development
Non-Intrusive	• Allows existing investment in IT assets to be leveraged • Lowers risk and development effort; avoids need to rewrite and test existing applications
Standards-based	• Platform independence allows companies to use the software and hardware of their choice • Allows companies to engage in a multi-source strategy, reducing the threat of vendor lock-in • Reduces complexity and fragmentation resulting from use of proprietary technologies • Lowers training requirements; increases labour pool
General purpose technology	• Delivers economies of scale; same technology can be applied to address a broad range of business problems

Table 3.2: Characteristics and benefits of SOA (Source: webMethods, 2005).

In a SOA, applications are not built as standalone monolithic silos. Instead, business-relevant services are either built new or layered on top of existing applications. SOA provides the framework to re-architect IT infrastructure, eliminate redundancy, and accelerate project delivery via consolidation and reuse of services. Ultimately, the value proposition is that SOA helps companies to be more agile and to do more with the resources that they already have.

Throughout the years, the core technology advancements that have been used to resolve IT problems have brought us to where we are today. Endrei et al. (2004) discusses these core technologies in five categories: object-oriented analysis and design; component-based design; service-oriented design; interface-based design; and layered application architectures. According to Larman (2002), the essence of object-oriented analysis and design is described as considering a problem domain and logical solution from the perspective of objects, i.e. things, concepts, or entities. In object-oriented analysis, such objects are identified and described in the problem domain, while in object-oriented design they are transitioned into logical software objects that will ultimately be implemented in an object-oriented programming language. With object-oriented analysis and design, certain aspects of the object (or group of objects) can be encapsulated to simplify the analysis of complex business scenarios. Certain characteristics of the object(s) can also be abstracted so that only the important or essential aspects are captured, to reduce complexity.

Endrei et al. (2004) observe that component-based design is not a new technology, but rather one which has naturally evolved from the object paradigm. In object-oriented analysis and design, fine-grained objects were initially marked as a mechanism to provide "reuse", but these objects are at too low a level of granularity and there are no standards in place to make widespread reuse practical. Coarse-grained components have become increasingly a target for reuse in application development and system integration. These coarse-grained components provide certain well-defined functionality from a cohesive set of finer-grained objects. In this way, packaged solution suites can also be encapsulated as "components". Components can be seen as the mechanism used to package, manage, and expose services (Endrei, et al., 2004).

The work of Allen & Frost (1998) describes a component as an executable unit of code that provides black-box encapsulation of related services, and can only be accessed through a consistent, published interface that includes interaction information. Allen & Frost (1998) further state that a component must be capable of being connected to other components, through a communication interface, and to a larger group of components. According to Endrei, et al. (2004), a service is generally implemented as a coarse-grained, discoverable software entity that exists as an instance and interacts with applications and other services through a loosely coupled, message-based communication model.

In the discussion on interface-based design, Endrei, et al. (2004) observe that in both component and service design, the design of the interfaces is done in such a way that the software entity implements and exposes a key part of its definition. Therefore, the notion and concept of "interface" is important for successful design in both component-based and service-oriented systems. Endrei, et al. (2004) further observe that object-oriented technology and languages are great ways to implement components. While components are the best way to implement services, one has to understand that a good component-based application does not necessarily have to make a good service-oriented application. The key to making this transition is to realise that a service-oriented approach implies an additional application architecture layer, the service layer, on top of the component layer and object/class layer to provide more coarse-grained implementation of consumer applications (Endrei, et al., 2004).

A graphical demonstration of how the technology layers can be applied to application architectures to provide more coarse-grained implementations as one gets closer to the consumers of the application is shown in figure 3.3. The right hand side of the figure is an addition adapted for this research to show the hierarchy of the services architecture using material from the case study presented in chapter 2.

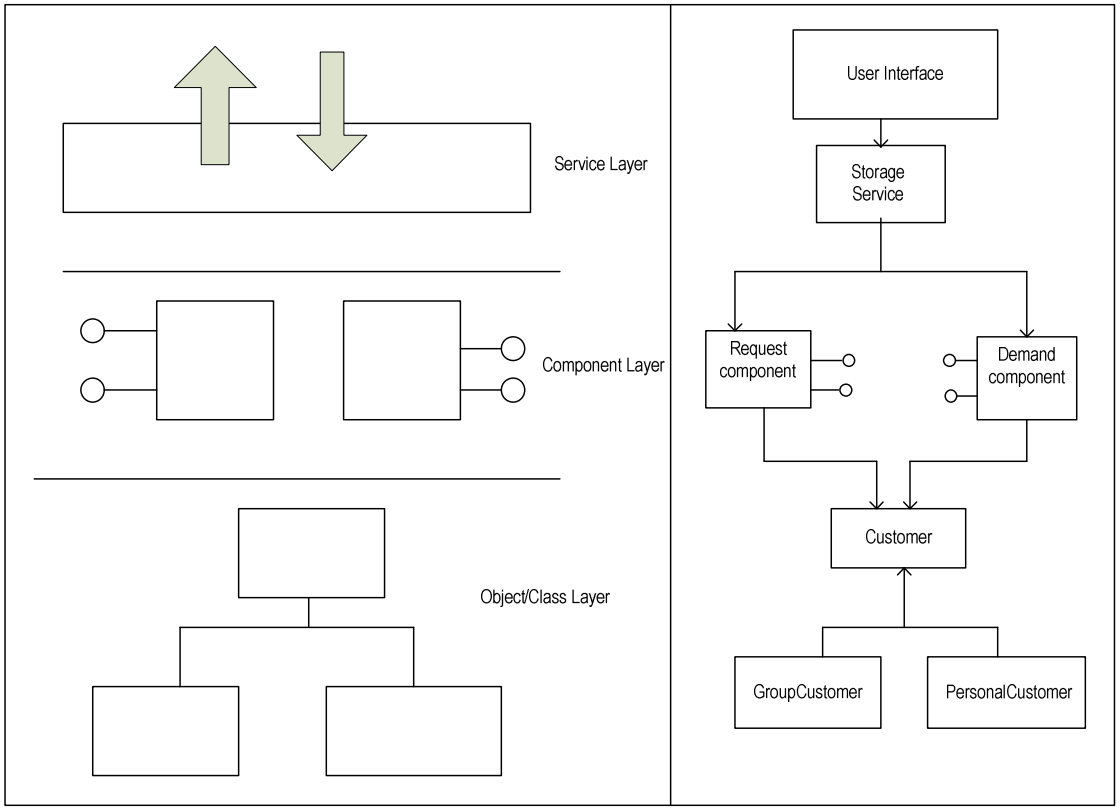


Figure 3.3 Application implementation layers: Services, components, objects (Adapted from: Endrei, et al., 2004)

From the diagram presented in figure 3.3, we see that access to the services is via a user interface. The user gives access to service components at the service layer, which when invoked provides access to service components that implement business logic. The object/class layer provides the technical implementation of the services, and is found at the lowest level.

According to Microsoft (2004), services are suitable to expose an external view of a system, while the internal reuse and composition is done using traditional component design approaches. To developers and solution architects, service orientation is a means to create dynamic collaborative applications. By supporting dynamic runtime selection of capability providers, service orientation allows applications to be sensitive to the content and context of a specific business process, and to incorporate new capability providers over time (Microsoft, 2004).

A key concept of SOA is that of a service. In general, people and organizations create capabilities to solve or support the solution of problems they face in the course of their business. SOA is conceived as a way of making those capabilities visible and supporting standard means of access so the existing capabilities can be reused or new capabilities can be readily substituted to improve the solutions. A service is a means to access such capabilities. To use a service, it is necessary to know it exists, what is accomplished if the service is invoked, how to invoke the service, and other characteristics to allow a prospective consumer to decide if the service is suitable for their current needs and if the consumer satisfies any requirements of the service provider to be permitted access. According to Endrei, et al. (20004 and Mahmoud (2005), such information constitutes the service description.

Endrei et al. (2004) observe that SOA is comprised of elements that can be categorized into functions and quality of service. The architectural stack and elements that might be observed in a framework for structuring the SOA are shown in figure 3.4.

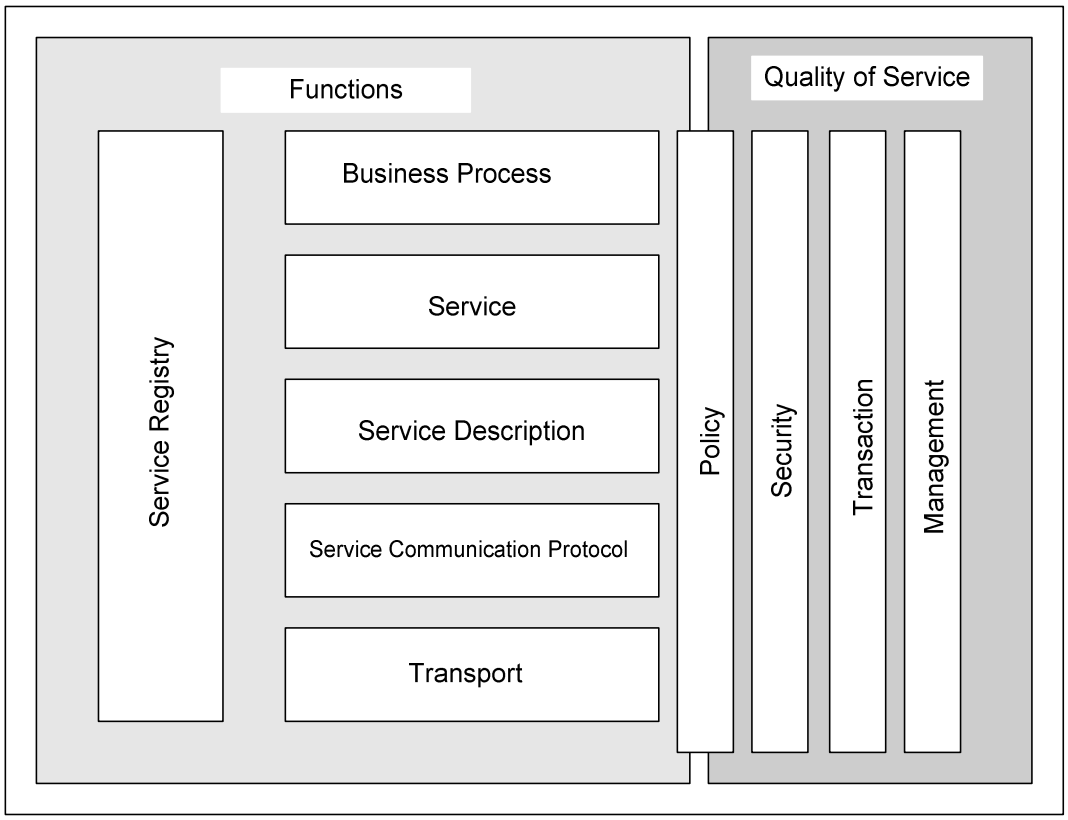


Figure 3.4: Elements of a service-oriented architecture (Source: Endrei, et al, 2004).

The architectural stack presented in figure 3.4 from Endrei, et al. (2004) is divided into two halves, with the left half addressing the functions of the architecture and the right half addressing quality of service. These elements are described in detail as follows:

The **functions** part of the architecture includes elements for:

- *transport*: the main mechanism used to move service requests from the service consumer to the service provider, and service responses from the service provider to the service consumer

- *service communication protocol*: an agreed mechanism that the service provider and the service consumer use to communicate what is being requested and what is being returned

- *service description*: an agreed schema for describing what the service is, how it should be invoked, and what data is required to invoke the service successfully

- *service*: describes an actual service that is made available for use

- *business process*: a collection of services, invoked in a particular sequence with a particular set of rules, to meet a business requirement. Business processes could be considered as

services in their own right, which leads to the idea that business processes may be composed of services of different granularities.

- the *service registry*: a repository of service and data descriptions which may be used by service providers to publish their services, and service consumers to discover or find available services. The service registry may provide other functions to services that require a centralized repository.

The **quality of service** part of the architecture includes elements related to:

- *policy*: a set of conditions or rules under which a service provider makes the service available to consumers. There are aspects of policy which are functional, and aspects which relate to quality of service; therefore we have the policy function both in the functions and in the quality of service area.

- *security*: the set of rules that might be applied to the identification, authorisation, and access control of service consumers invoking services

- *transaction*: the set of attributes that might be applied to a group of services to deliver a consistent result

- *management*: the set of attributes that might be applied to managing the services provided or consumed

Using these elements, services are accessed to achieve particular effects. An important reason for the scalability and reliability attributes of SOA is that the distinction promotes independence between service participants. SOA is an architectural style for building software applications that use services available in a network or on the web. SOA and web services are two different things, but web services are the preferred standards-based way to realize SOA. SOA is usually realised through web services (Mahmoud, 2005).

3.4.2 Service oriented architecture and web services

The advent of web services and SOA offers potential for lower integration costs and greater flexibility. An important aspect of SOA is the separation of the service interface, the what, from its implementation, the how. Such services are consumed by clients that are not concerned with how the services will execute their requests. SOA is basically a collection of communicating services. The communication can involve either simple data passing or it can involve two or more services coordinating some activity. Some means of connecting services is mandatory.

Web services provide the tools and infrastructure for the carrying out of business over the Internet, and provide a distributed computing approach for integrating extremely heterogeneous applications over the Internet (Endrei, et al., 2004). The World Wide Web Consortium's (W3C's) Web Services Architecture Working Group defines a web service as a software application identified by a unique resource identifier (URI), the interfaces and bindings of which are capable of being defined, described, and discovered as XML artefacts. A web service supports direct interactions with other software agents using XML-based messages exchanged via Internet-based protocols.

The technology of web services is widely accepted as the connection technology for service oriented architectures. Web services are self-contained, self-describing, software systems designed to support interoperable machine-to-machine interaction over a network. This interoperability is

gained through a set of XML-based open standards, such as Web Service Description Language (WSDL), Service Object Access Protocol (SOAP), and Universal Description, Discovery, and Integration (UDDI), details of which are presented in section 3.3. These standards provide a common approach for defining, publishing, and using web services. Web services essentially use XML to create a robust connection (Barry, 2003; Endrei, et al., 2004). SOA uses the find-bind-execute paradigm, in which a service consumer performs dynamic service location by querying the service registry for a service that matches its criteria. If the service exists, the registry provides the consumer with the interface contract and the endpoint address for the service.

Over the years, organizations have made extensive investments in system resources, both hardware and software-related, and have an enormous amount of data stored in legacy systems, which makes it impractical to discard existing systems. It is more cost effective to evolve and enhance such systems, and SOA provides a cost effective solution to this (Mahmoud, 2005). SOA presents an approach for building distributed systems that deliver application functionality as services to either end-user applications or to other services (Endrei, et al., 2004). SOA involves interaction between three kinds of participants: the service provider, service discovery, and the service requester (Ferris & Farrell, 2003; Mahmoud, 2005). These interactions are presented in figure 3.5 taken from Endrei, et al. (2004), which illustrates the entities in a SOA that collaborate to support the find, bind and invoke paradigm.

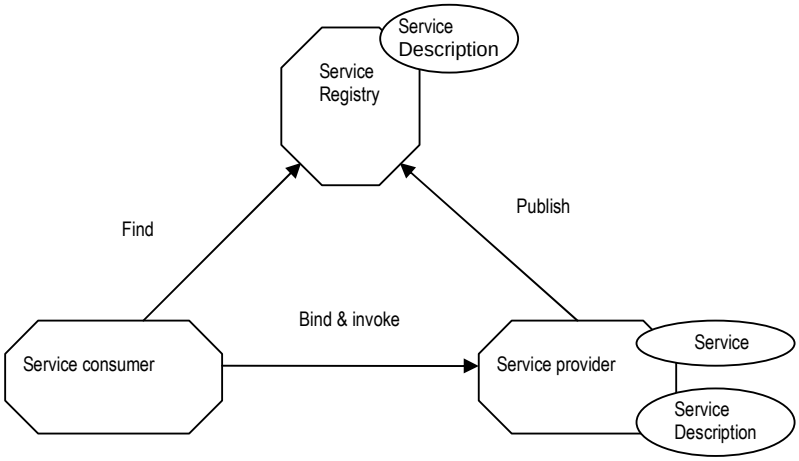


Figure 3.5: Collaborations in a SOA (Source: Endrei, et al., 2004)

The roles for each of these entities in a SOA as presented in figure 3.5 are:

- *service consumer*: an application, a software module or another service that requires a service. It initiates the enquiry of the service in the registry, binds to the service over a transport, and executes the service function. The service consumer executes the service according to the interface contract.
- *service provider*: a network-addressable entity that accepts and executes requests from consumers. It publishes its services and interface contract to the service registry so that the service consumer can discover and access the service.

- *service registry*: the enabler for service discovery. It contains a repository of available services and allows for the lookup of service provider interfaces to interested service consumers.

Each entity in the SOA as shown in figure 3.5 can play one (or more) of the three roles of service provider, consumer, or registry. The operations in a SOA are:

- *publish*: to be accessible, a service description must be published so that it can be discovered and invoked by a service consumer

- *find*: a service requester locates a service by querying the service registry for a service that meets its criteria

- *bind and invoke*: after retrieving the service description, the service consumer proceeds to invoke the service according to the information in the service description

The artefacts in a SOA are:

- *service*: a service that is made available for use through a published interface that allows it to be invoked by the service consumer

- *service description*: a service description specifies the way a service consumer will interact with the service provider. It specifies the format of the request and response from the service. This description may specify a set of pre-conditions, post-conditions, and/or quality of service (QoS) levels.

In addition to the dynamic service discovery and definition of a service interface contract, a SOA has the following characteristics: services are self-contained and modular; services support interoperability; services are loosely coupled; services are location transparent; and services are composite modules, comprised of components. SOA-based applications are distributed multi-tier applications that have presentation, business logic, and persistence layers. Services are the building blocks of SOA applications. While any functionality can be made into a service, the challenge is to define a service interface that is at the right level of abstraction (Mahmoud, 2005). Once a web service is discovered, the client makes a request to a web service. The web service processes the request and sends the response back to the client. Web services offer a standardized approach to application-to-application communication and interoperability. They provide a way for applications to expose their functionality over the web, regardless of the application's programming language or platform. Web services let developers reuse existing information assets by providing standard ways to access middle-tier and back-end services, and integrate them with other services.

In SOA, services map to the business functions that are identified during business process analysis. The services may be fine- or coarse-grained depending upon the business processes. Each service has a well-defined interface that allows it to be published, discovered, and invoked. An enterprise can choose to publish its service externally to business partners or internally within the organisation. A service can also be composed from other services either using workflow techniques or by calling lower-layer web services from a web service implementation (Endrei, et al., 2004). Composability is one of the main features of current enterprise business services. The majority of the benefits of SOA are realized when existing services are assembled into composite enterprise solutions. Service composition allows us to create solutions on top of existing services (Manolescu & Lublinsky, 2004).

3.5 Service composition

The platform-independent nature of web services creates the opportunity for businesses to develop their own business processes by using and combining existing web services. By selecting and

combining the most suitable and economical web services, business processes can be generated dynamically in the changing business environment (Orriens, et al., 2003). Service composition requirements differ from those of mainstream component-based software development, given that in place of access to documentation or code the service developers and users only have access to WSDL rudimentary function descriptions. Services execute in different containers, separated by firewalls and other trust barriers. According to Arsanjani (2005) a service composition can aggregate service functionality from services that provide distinct portions of functionality to satisfy a business process by creating a loosely coupled flow between loosely coupled services. Arsanjani (2005) describes the main reasons for the creation of composite services as usage simplicity, the creation of composite services, both encapsulating participating services and enforcing the rules of their invocation can significantly simplify their usage; and improved reusability, new unplanned solutions can often be assembled from available services. In addition, availability of services suggests new solutions that might otherwise not be considered and which often can be created inexpensively and quickly with the development or enhancement of relatively few services. In their work, Orriens, et al. (2003) discuss service composition elements, illustrated graphically in figure 3.6, and followed by an explanation of each of the elements.

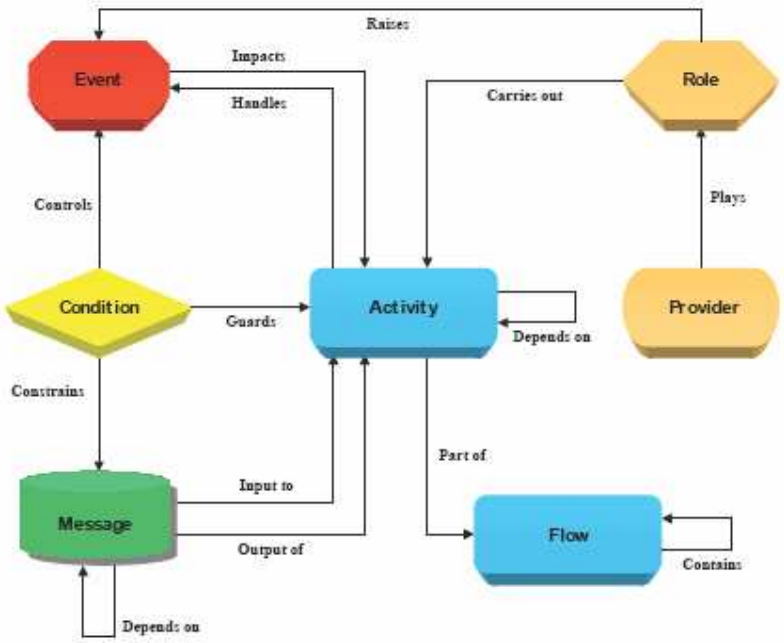


Figure 3.6: Architecture for a service composition (Source: Orriens, et al., 2003)

The architecture presented in figure 3.6 can be directly linked to the service layer in figure 3.3, and relates to the collaborations in a SOA presented in figure 3.5. The elements of the architecture are derived by Orriens, et al. (2003) based on the argument that the best way to design a business process is to analyse its role in the business. The composition elements are discussed as follows.

- *Activity*: an activity represents a well-defined business function. Each activity is associated with a role that is responsible for its execution. An activity may also be related to messages, defining its data prerequisites.

- *Condition*: the behaviour of a business process is governed by business rules, which are statements that define or constrain some aspect of the business and are intended to assert

business structure or to control or influence the behaviour of the business. Business rules are expressed in service composition in the form of conditions.

- *Event*: events in a service composition represent business events. A business event is an occurrence of some sort. Events have an impact on business processes, influencing their behaviour. They can trigger new activities or change the result of running activities.

- *Flow*: flow is used to express the choreography of complex activities, such as business processes. Possible types include sequential, parallel, conditional and iterative flow patterns. A service composition can contain one or more control flow elements.

- *Message*: we utilize messages to represent information exchanging behaviour of a business process in a composition. Messages are associated with the composition as a whole, expressing the interactions of the business process with the outside. They are also linked to activities to model the distribution of information within the process.

- *Provider*: the people and resources participating in a business process are depicted in a composition as providers. A provider describes a concrete web service.

- *Role*: roles define the expected behaviour of participants in the business in an abstract manner i.e. without providing any specifics of the resource or person responsible for actually performing the task. In the context of service composition, these provide abstract descriptions of the services involved in the composition.

Peltz (2003) identifies a number of important technical requirements that must be addressed when designing business processes involving multiple web services running over a long duration. These include: an ability to invoke services in an asynchronous manner, vital for achieving reliability, scalability, and adaptability since the business process can invoke services concurrently; orchestrated web services that are long running must manage exceptions and transactional integrity, given that resources cannot be locked in a transaction that runs over a long period of time; web services orchestration must be dynamic, flexible, and adaptable to meet the changing needs of a business. The quality of the composed service is dependent on that of the weakest link: the service that provides the lowest quality of service. Arsanjani (2005) further states that re-configurability of services and components is a key factor in achieving maximum flexibility and business agility, which can be done by exploiting web services standards and applying novel methods and techniques for composition.

Service composition requirements differ from those of mainstream component-based software development, whereby the service developers and users have access only to rudimentary WSDL definitions (Milanovic & Malek, 2004). Services execute in different containers, separated by firewalls and other trust barriers. Composition correctness requires verification of the composed service's properties such as security or dependability. Web service composition is a highly complex task. The work of Su, et al. (2005) identifies three main sources of this complexity:

- one, the number of services available over the web has increased dramatically during the recent years, and one can expect to have a huge web service repository that needs to be searched

- two, web services can be created and updated on the fly, thus the composition system needs to detect the updating at runtime and the decision should be made based on the up to date information

- three, web services can be developed by different organizations, which use different concept models to describe the services. However, there is no unique language that can be used to define and evaluate web services in an identical manner.

These three sources of complexity make building composite web services with an automated or semi-automated tool critical. The aim of this research is to provide software tools that can be used to compose services from service provider databases over the web, applying the technologies discussed in this section.

3.6 Engineering the ICT-enabled logistics brokering services

According to Bullinger et al (2003), the principal challenge faced in many organizations is the need to offer continuously improved services while fulfilling the needs and expectations of customers. Many service providers are hindered by the fact that their present business processes are not designed to enable services to be efficiently developed. Difficulties are frequently encountered because the new services created are not clearly defined, which results in considerable impediments caused by the absence of transparency and quality problems (Bullinger, et al., 2003). To develop ICT-enabled logistics brokering services, we vouch for the development of services that can be composed from existing services through the use of software tools. These software tools should enable the users to capture and reuse service processes in such a way that developing services to meet current and future business needs is made simpler. The studio-based approach and its suite of tools is the main contribution of this research, the starting points of which we present in this section.

In order to develop the suite of tools, we need to apply appropriate methods for designing the ICT-enabled services. Tax & Stuart (1997) provide a way of defining new services based on the extent of change to the existing service system or based on the operational process and participants in the service system. These two elements of the service concept represent the operational blueprint that communicates to the customers what they should expect to receive. According to Menor et al (2002), any changes to the service concept that requires different competencies from the existing operations can be considered a new service. Menor et al (2002) define a new service as an offering not previously available to a firm's customers resulting from the addition of a service offering or changes in the service concept that allow for the service offering to be made available. The work of Menor et al (2002) and that of Tax & Stuart (1997) vouches for the use of the term 'new service development' when referring to the creation of services that respond to customer needs.

Over the past few years, an ongoing transformation of market structures and competitive situations has been observed in many service markets, compounded by the consequences of modern ICT that is setting new standards in electronic processing and sale of services, particularly over the Internet. This phenomenon led to the rise of the term 'service engineering' in the mid nineties in Germany and Israel, parallel to the concept of 'new service development' used in America. Service engineering is defined by Bullinger et al. (2003) as a technical discipline concerned with the systematic development and design of services using suitable procedures, methods, and tools. In contrast to new service development, which is strictly marketing-oriented, service engineering adopts a technical-methodological approach, attempting to utilise existing engineering know-how efficiently in the area of traditional product development to develop innovative services (Bullinger, et al., 2003).

When applying systems engineering methods in the logistics services sector, it is imperative to note that the interactive elements used to deliver a logistics service are the essence of the service offer because the interaction process is typically an integral part of the service. The development of such

services is usually far more complex, conceptually, than the development of a tangible product, and requires a wider set of variables to be brought into play for service development. According to Cowell (1984), when developing a service we need to first define the core service attributes and thereafter define the service delivery systems, bringing together people, processes, and facilities. Edvardsson & Olsson (1996) present in their work that service development can be broken down into three activities:

- service *concept* development
- service *system* development
- service *process* development

The service concept is the description of the customers' needs and how these are to be satisfied. The service system represents the static resources required for the service, i.e. the staff, physical and technical environment, the organization, and the customers. The service process is the chain of activities that must occur for the service to function. Further, the ability to deliver services via the Internet has had an impact on the methods that are used to design services. The proliferation of service-oriented architectures is increasingly transforming ICT services into e-services: intangible products provisioned by the Internet, involving multi-enterprise transactions offering value in return for payment or something else (Gordijn & Akkermans, 2001). Towards this end, software engineers must first understand an e-service before they can build effective systems to support it. According to (Gordijn, et al., 2006), e-service design faces two major complexities:

- one, a group of enterprises working together provides the e-service rather than just a single company. This lack of single point of authority often results in complex decision making, and the participating enterprises frequently lack a shared understanding of the e-services.

- two, information systems design for supporting the delivery of e-services becomes intertwined with business designs: developers need to understand which enterprises and end customers are involved, what their commercial interests and motivations are, which things of economic value are exchanged between enterprises, and which constellations of enterprises deploying an e-service are likely to be profitable.

As a consequence of these complexities, the provisioning of ICT services often requires firms with different resources, e.g. financial support and consumer base, etc., and capabilities, e.g. telecommunication, payment, etc., that co-operate to create value for end users of the services (Faber, et al., 2003). Designing services is a complex undertaking because different requirements, e.g. technical, user, organizational and financial, need to be accommodated and balanced. Design choices in one domain, e.g. the technical domain, may affect those of the other domains, e.g. the user domain. The inter-relatedness of design choices complicates the design of viable services.

According to Faber, et al. (2003), service development needs to balance these requirements, and the interests of actors involved. Actors may originate from different industries each with their own peculiar business logic, because no single partner has formal authority over another partner. Every adjustment has to be discussed and jointly agreed upon, and therefore the success of a service is dependent on the commitment of all partners involved. Faber et al. (2003) propose a high level conceptual framework consisting of four inter-related design domains: the service, organization, technology, and finance.

In their work Faber, et al. (2003) further state that the central issue in service design is 'value'. A provider intends and delivers a certain value proposition and a customer or end-user expects and perceives a certain value proposition. The organizational design describes the value network that is

needed to realise a particular service offering. A value network consists of actors possessing certain resources and capabilities, which interact and together perform value activities to create value for customers and to realise their own strategies and goals. The technology design variables include the technical architecture, describing the overall architecture of the components required to deliver the service: the backbone infrastructure; access networks; service platforms; devices providing access to the service; applications running on the technology system; data transferred over the networks; and technical functionality offered by the technological system. In the finance domain, a design of the financial arrangements between the different actors in the value network is given, which shows how the value network intends to capture monetary value (Faber, et al., 2003).

Van de Kar & Verbraeck (2007) present a service systems framework that distinguishes a number of different aspects that need attention when designing service systems. In agreement with the work of Edvardsson & Olsson (1996) and Faber, et al. (2003) they state that we first need a service concept, which is the strategy that a service uses to create value for its customers. Secondly, an appropriate organizational network should be in place that supports the distributed service production from an inter-organizational point of view. Thirdly, as we look at services supported by ICT, a technical architecture should be provided, to structure the software, hardware, and netware that enable the delivery of the service. Van de Kar & Verbraeck (2007) state that the technical architecture and inter-organizational network determine the service concept that can or cannot be realised given the organizations that take part in the service system and the limitations of the technical architecture that is available to deliver the service. In addition, the organizational network and technical architecture also heavily determine the actual service delivery. The service design process can start at any of the 3 aspects, during which choices have to be made concerning trade-offs between each of the aspects. The framework is presented in figure 3.7.

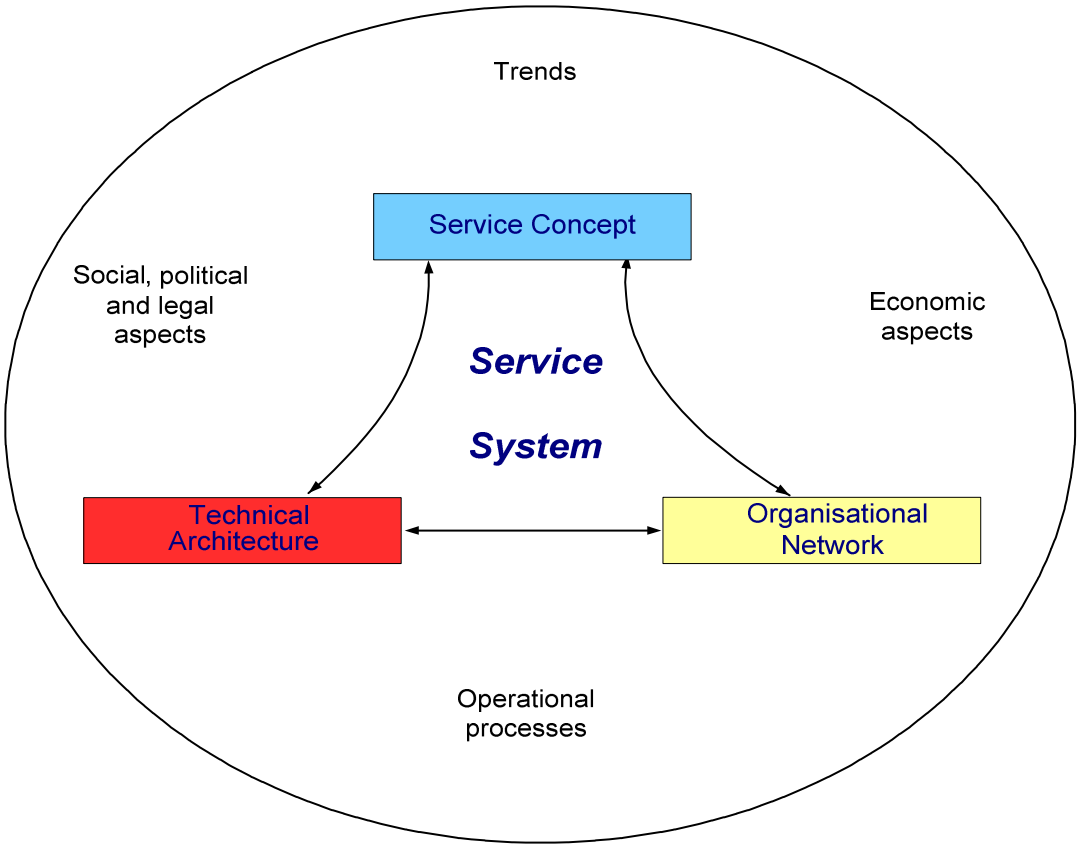


Figure 3.7 Aspects of a service system (Source: van de Kar and Verbraeck, 2007)

As can be observed from figure 3.7, the service system is positioned in an environment or application domain that might be dominated by other issues such as trends, politics, privacy, legal limitations, operational processes, and ethical considerations. The aspects that have to be taken into account depend on the system boundaries. Designers choose the system boundaries based on the relevant issues in the specific application domain of their service system, e.g. logistics brokering service. The financial and economic aspects of the service system are also important, and therefore the pricing model for the customer is considered as a part of the service concept (van de Kar & Verbraeck, 2007).

We used ideas taken from the work of van de Kar & Verbraeck (2007), Faber et al. (2003), and Edvardsson & Olsson (1996) to design and engineer the logistics brokering service system by defining the service concept, organizational network, and technical architecture. Based on the service systems framework presented in figure 3.7, we developed a suite to support the logistics brokering business processes. To support the effective development of ICT-enabled logistics brokering services, there is need to come up with software tools that capture and reuse service processes in such a way that developing services to meet current and future business needs is made simple.

3.7 Reflections

The purpose of this chapter was to present and discuss the relevant principles in ICT service development and the impact of ICT on logistics services, as obtained from a review of the literature. We presented the current trends regarding the development of ICT-enabled services with the aim of exploring how these trends, especially service oriented architectures (SOA), can be put into the context of developing ICT-enabled services for use in rural areas of developing countries. We provided a theoretical background in the domain of ICT-enabled logistics and ICT-enabled services to help us define the relevant concepts for the suite to facilitate logistics brokering services that meet local user needs. In chapter 4, we present the details of a suite that facilitates ICT-enabled logistics brokering services in rural areas.

Based on the case study findings presented in chapter 2, we state that the ICT-enabled logistics brokering services in rural areas should be achieved through the interaction of a human service broker. This is because from the rural areas in which we carried out our study, we learnt that people tend to work better with people who are familiar to them. Consequently, the type of applications needed to facilitate the local service brokers in delivering logistics services will tend to be complex, and developing such applications requires a more flexible approach than the more formal, structured applications. We studied SOA with the aim of putting the principles into practise by developing ICT-enabled logistics brokering services.

The provision of software tools to facilitate end-to-end service development within a suite helps to reduce the complexity related to development of services and improves the adoption of good service engineering practise. Further, the selection of appropriate methodologies for applying the suite is essential for the effective development of ICT-enabled logistics brokering services in rural areas. Based on the issues identified through the case study findings presented in chapter 2 and the theoretical overview from the literature presented in this chapter, we reflect that:

- to be effective, we need to come up with a way through which we can capture user requirements for the development of a logistics brokering service system that can be supported by a suite of tools. This is particularly difficult in rural areas, but for the services to be accepted they have to reflect local user needs. We prefer to use group support tools for

the user requirements elicitation exercise, as presented in Briggs et al, 2003 and den Hengst et al, 2004. The studio and its suite developed based on the services identified through the requirements elicitation process should enable the broker to apply the principles presented in section 3.3 of this chapter. We present a discussion of the requirements elicitation process in sub-section 4.2.2.

- adoption of the concept of SOA and aspects of web services in the development of ICT-enabled logistics brokering services greatly improves reuse of existing service components. We need to provide an environment through which integrated sets of software tools can be used to create business processes. The software tools should support the concept of reuse to develop services, and provide an interface that supports the user's way of working, to create their own service processes manually, either afresh or from existing services that are available remotely. Hagel (2002) presents justification for achieving flexibility by developing loosely coupled services using service oriented architectures.

- the suite should provide services that implement the business logic of each service component defined in a self-contained manner. We achieve the design of services by using the service systems framework from van de Kar & Verbraeck (2007). The services developed capture all the components presented in this framework, namely the service concept, organizational setup, and technical architecture. The service broker should be facilitated to access and process data from proprietary service provider databases in a distributed manner.

- object modelling provides a means of modelling the roles and interactions of stakeholders in a service. The suite should facilitate the development of services that meet local needs and closely emulate the current way of working in the logistics business processes within the rural areas. We also need to provide guidelines on how to use the suite to develop logistics brokering services.

Overall, we reflect that ICT-enabled services are currently developed with the inherent assumption that they are run and used on relatively stable and wired infrastructures, probably connected over relatively high bandwidth and reliable communication channels and power supply. Such assumptions do not work very well for service delivery in rural areas especially in cases where the long distances and rough terrain make it uneconomical to offer services over stable, wired solutions. We need to provide tools that enable service requests that do not run for a long time and use asynchronous communication protocols.

We considered the introduction of a suite to support distributed service development, and to support the development of logistics brokering services that take advantage of technology that already exists in the rural areas. As a general functionality, the suite should facilitate ICT-enabled logistics brokering services that can be delivered and used without the service broker, logistics service provider, and customer being in physical proximity. Such services should be robust, reusable, flexible, adaptable and reliable.

It is the elements presented in this section and their underlying ways of implementation to facilitate the development of ICT-enabled logistics brokering services, which form the basis of our contribution to scientific theory.

4. A Suite for Logistics brokering Services

4.1 Introduction

In this chapter, we discuss the design and development of a suite for facilitating the development and composition of ICT-enabled services. We use the domain of logistics brokering services in rural areas as a real world system, derived from the case study presented in chapter 2, to conceptualise and develop the suite. The logistics brokering services supported by the suite are designed based on the service systems framework developed by van de Kar & Verbraeck (2007). We first provide context for the ICT-enabled logistics brokering service system and present the challenges that need to be addressed. We then present the requirements for, and discuss the design of, the suite.

4.2 Context for the suite

The findings from the exploratory case study presented in chapter 2 led us to the conclusion that using a suite could provide opportunities for improving the development of ICT-enabled services in rural areas. From the case study, we observed that the introduction of software tools to support the development of services required a mechanism capable of handling the local environmental issues. The purpose of this research was to come up with a studio-based approach for improving and facilitating the development of ICT-enabled logistics brokering services in rural areas. The studio, through its suite, should facilitate the local service brokers (Infopreneurs™) to fulfil the local logistics needs of customer in the rural areas they serve. In this section, we provide answers to the second research question:

> *How can the current issues in the development of ICT-enabled services be contextualised to improve and facilitate ICT-enabled logistics brokering services in rural areas of transition countries?*

This question is directed at applying the ideas obtained from the literature with regard to the main issues in the current practise of developing ICT-enabled services, together with issues in logistics brokering services. The question is answered by providing context for, and designing, a suite using frameworks and methodologies taken from the literature as discussed in chapter 3. To put the suite into context, we developed a logistics brokering service system that was proposed after the exploratory case study presented in chapter 2. A general analysis of the case study findings led us to conclude that to provide ICT-based interventions to solve logistics problems in rural areas of South Africa, we need to bear in mind that the rough terrain conditions and a sparse population reduce the possibility to exploit fast connections for information transfer especially if they require wiring. We considered the bandwidth issue to be transient as explained in chapter 2, and this led us to propose the use of distributed service delivery using ICT in this low-bandwidth environment. The logistics brokering services could be delivered by taking advantage of the widely available mobile phone infrastructure and technology devices.

We learnt that there was a large amount of logistics-related data available in various proprietary databases, and that so far very little had been done to provide shared access for stakeholders to access and manipulate the data to provide better and more coordinated logistics services in rural South Africa. The suite, the requirements for which are presented in this chapter, is built around the challenges faced by local service brokers in delivering logistics services. A major challenge faced in an attempt to coordinate rural logistics service processes, as observed through the case study and through discussions with rural logistics practitioners, relates to the identification and location of small volume freight and passenger movements. Service brokers in rural areas do not have access to

information regarding who delivers what services, when, to whom, and how they deliver them. Another challenge is related to setting up service scheduling mechanisms that cost-efficiently coordinate the transportation of goods and people from geographically dispersed locations. Considering that the logistics brokering services should be focused on consolidating freight volumes, the work of Naudè, (2005) suggests that possible solutions should involve setting up storage facilities, with or without refrigeration, for goods until economically viable loads are available to transport.

Further, challenges arise in relation to how the service broker can best provide logistics services using ICT-based interventions to enable the consolidation and synchronization of service demand and supply. This should be done in such a way that operational inefficiencies are eliminated and translated into cost savings that enable logistics service providers to deliver financially viable services (Ittmann, 2004). A summary of challenges to the development of logistics brokering services obtained from the case study is presented in figure 4.1.

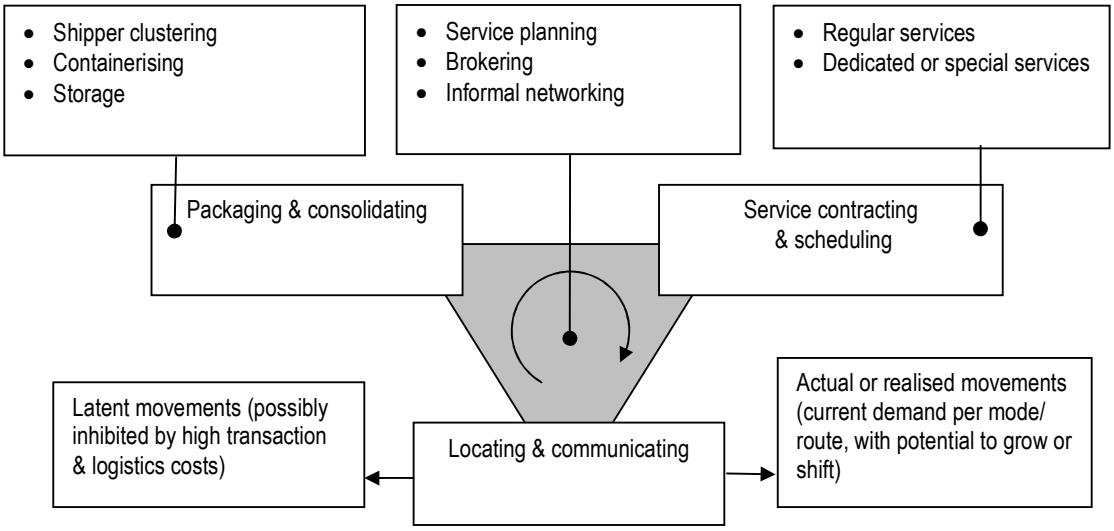


Figure 4.1 Triad of rural logistics technology challenges (Source: Naudè, 2005)

The knowledge gained from the rural logistics practitioners was used to identify the functionality required from the suite. The rural logistics practitioners observed that the introduction of ICT-enabled logistics brokering services should capture and address the three cornerstones presented in figure 4.1, namely: *packaging and consolidation, service contracting and scheduling, and location and communication* (Naudè, 2005). Addressing these three cornerstones raises questions related to identifying the need for logistics services, and facilitating actual delivery of the services.

In this thesis, we state that there is a need to facilitate the service brokers in: determining the demand for logistics services in a given area; determining the current logistics service supply situation in the area; categorizing the service demand and supply based on characteristics such as volume, frequency, etc.; matching the service demand to available supply, which may be local or remote; and communicating the results of a service match to the concerned parties, that is, informing the customers that a match for their service request has been found and informing the logistics service providers that they are required to deliver a service. These items have to be included in the design of the logistics brokering services suite to provide effective facilitation for services that meet the challenges of logistics service delivery in rural areas.

4.2.1 Designing the logistics brokering service system

As confirmed through the case study work presented in chapter 2 and from Ittmann (2004), most logistical, marketing and related services in rural areas are unreliable, ineffective and/or very expensive, thereby marginalizing and excluding most SMEs from 'mainstream' supply chains. The main features of the logistics situation in rural areas as we observed through the case study are: low and seasonal demand for logistics services, long distances from amenities, sparse population, high incidence of poverty, limited trip-making, and under-development of the transport industry. The concept of an ICT-enabled logistics brokering service system is considered to be part of a wider set of means for improving transport provision and coordination in rural areas. Using the logistics brokering service system is expected to provide a better and more efficient transport service to the public while at the same time making it more rewarding for the logistics service providers.

The case study findings and interviews with rural logistics practitioners revealed that the lack of transportation is an acute problem in rural areas because of *inter alia*, the long distances from main roads, sparse population, the need to transport high volumes of low value goods, e.g. maize, and low volumes of high value goods, e.g. grapes and honey, and the high incidence of chronic poverty (Green et. al, 2004). Trip making, especially motorised and long distance, is generally limited with mini buses, referred to as taxis, and pick-ups, 'bakkies', being the main means of transport. Due to the low demand for logistics services and their affordability, the transport industry is not well developed and is currently in an over-supply situation. Consequently, the taxi operators are fighting an uphill battle for survival, the transport needs of the people are poorly served and transport is expensive, among other issues (Green et. al, 2004).

The concept of an ICT-enabled logistics brokering service is conceived as a way of tackling some of the transport related issues and improving rural transport provision and coordination. The motivation for developing such a brokering service system is that transportation in rural areas can be improved, and users assured of better information and predictability of services, through a centre that enhances both mobility and access to service information (Green et. al, 2004). Once developed, the logistics brokering service system is expected to provide a better, more efficient transport coordination service to the rural public. The better and more efficient transport coordination services would be reflected in the ability to obtain information regarding the available transport services, and information on when to expect the next service.

The logistics brokering service system was conceptualised as a centralised information, booking, scheduling, and coordination service for all public transport concerning both passenger and freight services where appropriate, with an ability to 'package' key logistics service needs utilizing already existing services and assuring the transport users of better information and predictability of the transportation services. The brokering services will be delivered from a central office such as an MPCC. They can also be delivered and accessed remotely using ICT-enabled equipment such as mobile phones, PDAs, PCs, etc., which are currently widely available in the rural areas. A consequence of a more efficient and accessible ICT-enabled logistics brokering service is that new or additional transport-related services can be developed and offered in a distributed manner. These might include offering trips for rural dwellers and farm employees, taking small volumes of produce to markets for emerging farmers or other small scale producers, acting as a feeder service for passengers disembarking from trains or long distance buses, taking tourists to less accessible destinations and even parcel delivery services, as suggested by Green et al. (2004).

Despite some inherent technical problems such as limited bandwidth for data delivery, intermittent and unreliable infrastructure conditions, e.g. power blackouts, signal loss, etc., it should be noted that focal centres in most rural areas of South Africa are 'equipped' with suitable ICT systems and

persons that can provide such logistics brokering, plus other, value-added, services. This is especially so in areas where the Infopreneur™ model is in place. Further, the services do not need to be hosted within the rural environment, and can be placed in locations where there is stable power supply and consumed from a distance by the rural folk. The minimum improvement that the logistics brokering service should achieve is the direction and coordination of trips and the provision of information through the utilization of ICT-enabled services that are either custom-made or supplied by external service providers to deliver value-added services to customers.

We learnt through the case study that one of the main challenges when developing services for rural areas is to come up with user-centric ways of defining and developing services. With the aim of developing a service system that solves the problems mentioned in section 2.3 and the context presented in this sub-section, we determined the requirements for developing a logistics brokering service system using field user requirement elicitation sessions and concepts adapted from group support systems (GSS) tools. For this research, we did not use the technology based tools but instead we adapted ideas from the tools known as thinkLets, which are defined in Briggs et al. (2003) as units of analysis that enable us to produce more predictable and repeatable results. We followed steps similar to those applied and presented by den Hengst et al. (2004). The characteristics of rural areas dictate that the steps used to encourage user participation should provide an appropriate method with which to effectively gather user requirements. Findings from the joint user requirements elicitation exercise form a basis for the development of the use case models that were used to design and develop the logistics brokering service system.

4.2.2 Joint user-centric requirements elicitation

According to den Hengst et al. (2004), the main challenge in designing services is eliciting user requirements. Den Hengst et al (2004) state that participants in a requirements elicitation process should be chosen carefully through purposive sampling, by selecting them from specific user groups. Preferably, the requirements elicitation groups should consist of participants who are not too familiar with each other. The participants do not have to find solutions to problems but they are required to provide suggestions for service designers. Further, when eliciting user requirements we can benefit from a group setting where we have carefully chosen the users who will participate in the group sessions, and the techniques needed to support creativity. In their work, den Hengst et al. (2004) state that group sessions that are not facilitated by GSS should ideally have between five and twelve participants.

GSS are designed to improve the efficiency and effectiveness of group sessions by offering a variety of tools to assist the group in structuring activities, generating ideas, and improving communication (Nunamaker, et al., 1991). Towards this end, Briggs et al. (2003) propose a unit of analysis, called a thinkLet, which is an approach that can be applied in group settings to produce more predictable and repeatable results while generating ideas. A thinkLet describes in detail how a certain activity can be realized. Briggs et al. (2003) identify seven basic activities that form a group process: *divergence, convergence, organization, elaboration, abstraction, evaluation and consensus building*. The sessions were based on the overview presented in table 4.1, which was adapted using the concept of thinkLets presented in Briggs et al. (2003). For the exercise to be successful, we followed six steps: *introduction; problem analysis based on current experiences; solution generation based on the experiences; demonstration of future or possible scenarios; redefinition of solutions based on the scenarios; and a general description of how the service will be used in reality*.

The details of the amount of time each activity took, the name of the thinkLets used, the resources (capability) that the participants required or had access to, the subject matter that was being handled, and the output of the activity are given in table 4.1. The Free brainstorm and divergence

are examples of divergence group processes, while Broom Wagon and Fast focus are examples of convergence group processes that were used in the study. For a detailed explanation of the thinkLets and their names, refer to the work of Briggs et al. (2003).

Duration	thinkLet/Activity	Capability	Subject	Output
5-10 minutes	Introduction	White board; PowerPoint slides	Introduction to the session and what we aim to achieve	Understanding of the aims of the group exercise
30-45 minutes	Free Brainstorm	A-4 sheets; pens	Logistics service brokering functionality	A4's with ideas about logistics service functionality
30-45 minutes	Fast Focus	A-3 list with logistics service ideas; blank A-3 sheet	Definition of logistics services	Clean non-redundant list of preferred logistics services on A-3 sheet
30 minutes	Broom wagon	A-3 sheet; items on a public list	Priority services for the logistics brokering	Prioritized list of brokering services worth extra attention
30 minutes	Presentation	A-3; whiteboard with list of ideas on service problems worth more attention	Example of how the services shall be used	Clarified ideas of each of the suggested services
30 minutes	Directed Leafhopper	A-3 sheets each with heading of a different service	Prioritize the services to be offered by the brokering service	List of user requirements organized by service
30 minutes	Presentation	A-3; whiteboard	Discussion of the brainstorm ideas on how the users of the services are expected to use it	Shortlist of service requirements to be developed into service use cases

Table 4.1 Repeatable requirements elicitation process

The aim of the group sessions was to formulate user requirements and to develop use cases for an ICT-enabled logistics brokering service system, and to validate the use cases among the end-users before developing the software tools to support the service system. The group sessions were also aimed at identifying needs for current and future ICT-enabled logistics service systems that would be able to interface dynamically with mobile technology, GIS and Location Based Services, and which could possibly be deployed in terms of a virtual private network. We learnt from the case study that one of the biggest problems faced in rural areas is the difficulty of defining what services are required by the community. We therefore had to adopt the most appropriate group-based method to assist us in overcoming this problem.

We first identified the actors based on an analysis of the main stakeholders in the rural transportation sector, and grouped them into four: *the rural logistics service practitioners, the logistics service providers, the target service customers (SMEs, farmers, etc.), and the service brokers (Infopreneurs™)*. Participants for the sessions were purposively selected and grouped according to their interests and roles in the service environment to ensure that we came up with a fully representative set of user requirements. The steps that were used in carrying out the group requirements elicitation exercise based on the process presented in table 4.1 are summarised in figure 4.2.

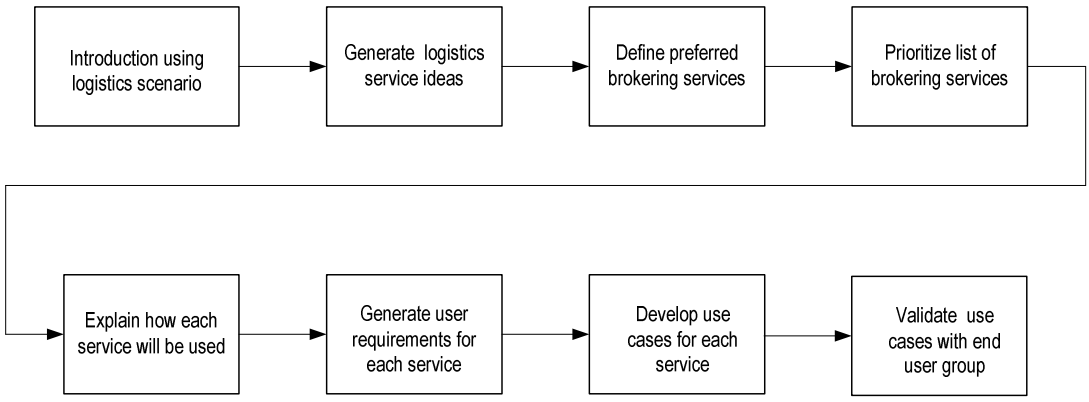


Figure 4.2: Steps followed in the group requirements elicitation exercise

Three separate group sessions followed by interview sessions and participatory observations were held with the stakeholders. The first session was held with a group consisting of rural logistics service practitioners from the CSIR; the second session was held with a group of rural logistics service providers; the third session was held with a group of small business owners and farmers in a rural area. Finally, an interview session was held with the Infopreneurs™, based at a municipality-sponsored MPCC, who will be expected to provide the logistics brokering services. The second, third, and fourth sessions were carried out in the rural areas of the Eastern Cape Province.

The group sessions took a similar approach, in which the participants were given a logistics service related context, and asked to explain how they would perform their activities to fulfil their logistics needs within the specific context. A summary of the steps taken to ensure that the ICT-enabled logistics brokering service system was defined in a user-centric manner as was possible is presented in figure 4.3.

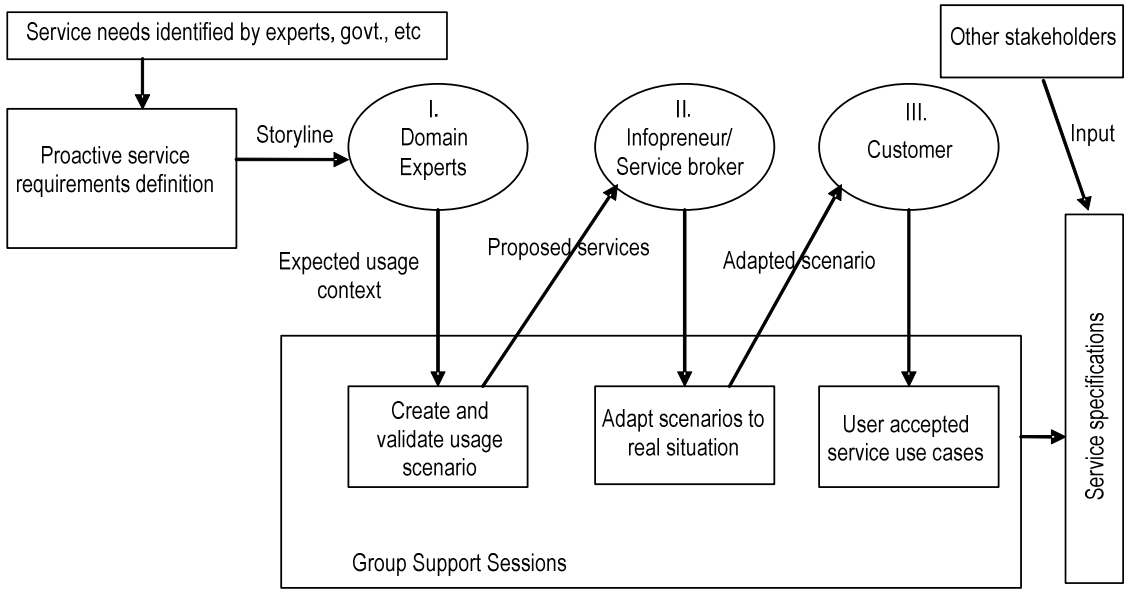


Figure 4.3: User-centric service specification for rural areas

In this work, the starting point of the user-centric service specification for the ICT-enabled logistics brokering service is a set of service needs identified by the rural development practitioners in

conjunction with the rural communities, as presented in figure 4.3. This is because as we learnt through the case study in chapter 2, the rural dwellers are unable to express their service needs clearly, and require some support from the practitioners. The service needs may also be derived from governmental policy. Based on these initial service needs identified, the rural logistics service practitioners were asked to come up with scenarios of possible services, and we asked them to use storylines to explain each of the potential services that might be developed. An example of the scenarios that were developed by the practitioners is given in appendix 3. The rural logistics service practitioners, as domain experts, then clarified how the services they defined would be used in real life. This was done using a manual adaptation of the thinkLets tool since we would not have access to electronic tools in the rural end-user environment yet we wanted to gather user requirements in what we felt at that moment was the most appropriate manner.

After the initial use cases were developed based on the experience and knowledge obtained from the rural logistics service practitioners, the models were run past the Infopreneur™ to determine whether the use cases were representative of the service needs in their areas. The reason for running the models past them was that they, the Infopreneurs™, were expected to deliver the logistics brokering services within the community. They are the end-users of the suite that was developed in this research. The use case models were adopted and refined based on the prevailing situation and information from the Infopreneur™, and new service ideas were also gathered. The adapted models were then run past the rural stakeholders that are expected to be customers of the brokering service delivered by the Infopreneur™. The rural stakeholders were expected to 'place' themselves in the use case and state whether it reflected the reality of the situation whenever they needed logistics services. After a few adaptations, the end-user accepted service use case models were then translated into service specifications, which were used to design the resulting service system.

It is worth noting that the output from the session with rural logistics service practitioners and the information that was collected from the other sessions with the Infopreneur™ and the rural stakeholders was used as input for the service design process. These findings were used to design the ICT-enabled logistics brokering service system. Details of the group composition, location, number and type of participants are presented in appendix 1. We now present details of each of the group sessions that were used to elicit user requirements.

Session 1: The rural logistics service practitioners

The session was based on the overview presented in table 4.1. As an introduction to the session, the participants were given a general talk about the topic of discussion, ICT-enabled logistics brokering service system, and the procedure we were going to follow with the aim of familiarising them with the goals of the session. After a brief explanation regarding the envisaged ICT-enabled logistics brokering service system, the participants were first asked to think of personal situations in which they thought such a service system would be used by the target customer group, rural communities. The general feeling was that the brokering service system would provide a solution to the transport problems that had earlier been identified. To assist in obtaining the experiences of the rural logistics service practitioners, we used the Free Brainstorm thinkLet, in which the session participants were asked to present their ideas in response to the question why they thought developing functionality for the brokering service would solve the problems that had been earlier identified.

Each participant had an A-4 sheet of paper on which they wrote their ideas on functionality of the brokering system, and these sheets of paper were circulated among the group after 30 minutes. We explained to the session participants that the ideas they were writing on each sheet of paper were expected to be original, or a reaction to the ideas already on the piece of paper. This resulted in a list of ideas regarding the problems faced when looking for logistics services, but all were on different

levels of abstraction that needed to be scaled and focused. To do this, we used the Fast Focus thinkLet to create more focus on the constraints (problems) that the participants, as the rural logistics service practitioners, had envisaged would be faced when the rural dwellers needed such logistics services, and how they overcame the problems. We then moved on to asking the participants to provide possible solutions to the problems they faced, and worked interactively to sharpen and re-define the solutions they provided. Some of the functionalities of the intended logistics brokering service were identified at this stage from a logistics service experts' point of view. Finally, we asked the participants to identify some of the (other) main functionalities they would desire to have in such a service system, and asked them briefly to explain how the functionality would be used by the customer.

Based on the list of focused ideas produced we then used the BroomWagon thinkLet in which we asked the participants to place a coloured sticker on a list next to the logistics service functionality they thought deserved more priority. This list was written on an A-3 sheet of paper. In the next activity, using the Directed Leafhopper thinkLet, the participants were asked to contribute ideas regarding the functionality required of each of the services that had been identified during the brainstorm session. We came up with a service flow chart which contained rudimentary use cases for the logistics services. The list of services that were identified by the rural logistics service practitioners is presented in appendix 1. From this step we developed initial use case models that acted as input and starting points for the other two sessions which were held with the logistics service providers, and the customers of the Infopreneur™ service.

Session 2: The rural logistics service providers

We begun the session by introducing the goal and structure of the session, and tried to make the participants as comfortable as possible using ideas presented in den Hengst et al (2004). This group of participants was purposively selected because of the role they play in the rural logistics service sector. They were made up of the owners of small light delivery vehicles (LDV), taxi operators, and personnel from a large trucking company. The owners of the LDVs in most cases doubled up as the drivers. The session followed the same procedure presented in table 4.1, except that in this case the starting point was the use case models, which had formed the output of the first session with the rural logistics service experts.

The use case models and diagrams developed at the end of the first session, situating the transport operators and showing their role in the service provision environment were presented on A-3 sheets. The context of the use case models was explained to the participants. We further explained to them that the rural logistics service practitioners had defined these roles in that particular manner. The participants were then asked whether they could relate their roles to the services identified in the use cases, what they thought their actual role should be, and to think of situations in which they would need to use the logistics brokering service. The participants came up with ideas regarding the roles they expected to play in utilizing and contacting the logistics brokering service. These did not vary widely from what the rural logistics service practitioners had presented. The best thing about this was that the findings came from a different user perspective.

We then asked the participants to think of the constraints, and problems, they faced when they needed to fulfil their logistics service provision needs, and how they overcame these problems. The purpose of this line of questioning was to enable us to come up with a list of problems faced from the logistics service provider perspective, whose solutions would be incorporated into the logistics brokering service system. We asked the participants to provide information regarding their current ways of overcoming the problems, and to provide what they thought to be possible solutions to overcome these and other problems in future. We worked iteratively to re-define and focus the solutions they provided. Finally, we asked the participants to identify some of the (other) main

functionalities they would desire from such a brokering service system, and how they would like the services to be delivered to them. In addition, we asked them to explain briefly how they would use the new functionality they had suggested when the service system is developed. The interview questions used to support the requirements elicitation exercise with this group are presented in appendix 1c. This step produced the set of service requirements for the logistics service provides. A set of use case models was developed capturing the service needs for this group of users.

Session 3: The small business owners and farmers

This group was considered to be the most important as they were seen as the direct beneficiaries of the logistics brokering service once it is developed and implemented by the Infopreneur™. The session followed a similar set up as presented in table 4.1, although due to the small size of the group and the fact that we carried out the session at the premises of one of the stakeholders, we made it an informal session. In this set up, the participants presented their ideas orally and we wrote them on sheets of A-4 paper, and repeated orally what we had written down to ensure agreement with all participants. The initial use case models developed in session 1 highlighting the place of this group of participants in the service delivery environment were used as demonstration. The interview questions used to support the requirements elicitation exercise with this group are presented in appendix 1a. The roles for this group of participants had been defined by the rural logistics service practitioners. The participants were taken through example scenarios of how they were predicted to use the brokering service.

As an introduction, the participants were first asked to think of situations when they needed transport services either for themselves or goods, from one location to another. This resulted in a list containing periods when they required transport. We then asked the participants to explain what they normally did when they wanted to fulfil those needs for logistics services. The purpose of using this line of questioning was to enable us to determine the current way of doing things. We did not intend to introduce ways that would make the participants uncomfortable. We then focused on the constraints and problems the participants faced when they needed to fulfil their transportation needs, and how they overcame the problems. We then asked the participants to try and provide possible solutions that they thought were better for solving the transport service problems they faced. We then worked iteratively with the participants to re-define the solutions that they had identified.

Finally, we asked the participants to identify some of the (other) main functionalities they would require from such a logistics brokering service system, and asked them to explain briefly how they would use the (new) functionality in the service. This step gave us the service requirements for the farmers and small business owners, who are the main customers of the logistics brokering service system.

Session 4: The Infopreneurs™

This was more of an interview and free discussion session and we carried it out in the office of an Infopreneur™, which had only three employees. We thought that this number was not large enough to warrant a formally organized group session. The aim of this session was to tap into the expertise of the people already involved in the direct delivery of a broad range of services to the rural communities. The assumption was that they were in a good position to know what would be an ideal service to be incorporated into the logistics brokering service system. This group of people, locally known as Infopreneurs™, are the ones who will provide and manage the logistics brokering service when it becomes operational. The details of the group composition are given in appendix 1a, while the interview questions used to support the requirements elicitation exercise with this group are presented in appendix 1b.

The participants were first asked to think of situations in which they envisaged that a brokered logistics service would be required by the rural communities. To give them some impetus, we asked the participants to identify some of the services that immediately came to mind as candidates for brokering, and especially those that would assist farmers and SMEs to move up the value chain. We wrote their ideas on A-4 sheets of paper. We then asked them, based on their experience and expertise, to focus on some of the constraints and problems they thought that the rural communities faced when they needed to fulfil their logistics service needs, and how the rural folk overcame these problems. We asked them to discuss how the rural communities solved these problems, and also encouraged them to provide (other) possible solutions to these problems. We also presented them with the use case models that had been prepared from the earlier sessions, to enable them to relate to the roles identified for them in the logistics brokering service system.

Considering that the Infopreneurs™ are expected to create income and volumes for themselves from delivering value-added services, we asked them to generate some ideas regarding how the payment and revenue models for such logistics brokering services should be set up. Some of the functionalities of the brokering service identified in the first session were presented, with the use case models to highlight the place of the participants in the service delivery environment to show them the roles they would play when the new service system was implemented. Finally, we asked the Infopreneurs™ to identify some of the (other) main functionalities they thought would be ideal for such a service system, and asked them to explain briefly how the functionality would be used. This step had more to do with the operations of the service than the detailed design. However, it was necessary to consider the step since it played an important role in the final requirements definition.

4.2.3 Discussion of the main findings

We now discuss the main findings from the joint user requirements elicitation exercise that had direct bearing to the development of the logistics brokering service system. These findings influenced the general design and development of the logistics brokering service system and formed a basis for deriving the requirements for the suite.

From the session with the rural logistics service practitioners, we learnt that they always faced the problem of working with rural communities that do not know what they want in terms of services or systems to support their services. This is further complicated by the fact that the rural communities are rarely able to put their service needs into proper words, hence the continued use of rapid application development methods. The importance of these findings is that they enabled us to carry out the elicitation exercise with the rural communities in a more detailed manner, and to determine what is required in the logistics brokering service system. The approach we followed in eliciting the user requirements among the end-users of the service system enabled us to achieve the desired result in a systematic and user-centric manner.

The logistics service providers expressed their interest in having and using the logistics brokering service system, on condition that they would not have to share information that they considered to be private. Most importantly, they were not willing to divulge any financial information and showed very little trust for third party solutions for handling their finances. They were willing to transport anything and anybody as long as they were paid directly for their services. They were also unwilling to divulge information about how they carried out their business processes. The implication of this finding is that when we develop the logistics brokering services, we would have to allow the logistics service operators to maintain their own service data, and only use what they expose publicly. Further, we learnt that the logistics brokering service system would only provide facilitation for the payment of services rendered, and that the service broker will not be a direct participant in handling the finances. The most that the Infopreneur™ would be expected to do with

the brokering service is to match service supply to service demand, to initiate the service delivery process, and to inform the parties involved of their obligations in the particular service delivery.
The small business owners and farmers expressed their desire to have a logistics brokering service system especially if they could communicate with it remotely, and if the service would provide them with up-to-date information regarding availability of transport, suppliers of goods and services, and market prices for their goods and produce. This group of subjects was also unwilling to share information about their business processes, and was very much against the idea of sharing means of transportation between themselves to reduce the amount of empty miles. We learnt from this finding that it is important to provide a catalogue service that enables the customers of the logistics brokering service system to obtain a list of service providers who may be able to fulfil their individual logistics service needs.

According to the Infopreneur™, logistics services presented themselves as suitable candidates for brokering. The Infopreneur™ and his staff suggested that although payment for services might be a problem given that people have very little expendable income or were based too far from the towns that had banks, the expected introduction of government-subsidised vouchers and debit card payment services using mobile phones would provide some solution to this problem. The Infopreneur™ and his staff stated that they would like to have access to a ranked list of logistics service providers in an area and be able to source markets for the service providers and link them with demand. They mentioned that trust is a major issue that needs to be overcome if this activity is to be successful. The Infopreneur™ and his staff also stated that they spent too much time looking for information instead of serving customers, and had to rely on material that was not necessarily the latest to provide market information. They expressed the desire to have access to GIS maps and services since this would give them up-to-date and pertinent information about customers in their catchments.

From the sessions held with the rural logistics service practitioners and an analysis of the documents they had prepared in support of setting up logistics brokering services in rural areas of South Africa (see Green et. al, 2004; Marais & Mayer (2004) in Appendix 3; and Naudè (2005)), we learnt that the logistics service supply and demand is spatially-specific and mobile in nature. The implication of this is that the logistics brokering service system could benefit significantly from the harnessing of GeoICT-enabled services, which could involve the utilisation of mobile phones and the tracking and dispatching of cell-phone equipped transport service providers. With the currently expanding cell phone and related ICT networks in the rural areas of South Africa, there is an exceptional opportunity to harness these developments in support of more coordinated and competitive rural supply chains. The delivery of logistics services could occur on a self-service basis, e.g. through the sending and receiving of text messages to and from the logistics brokering service system.

Overall, for the logistics brokering service system to be effective in the rural areas, it should enable stakeholders to determine the logistics service demand in a given area; establish availability of logistics service suppliers operating in the area; create a system that enables matching of the service demand to the service supply and communicating this information to the stakeholders; it should also support the initiation of service delivery, i.e. creation of route plans, service schedules, collection points, etc., as well as facilitate payment for services delivered.

Further, we felt that the joint requirements elicitation sessions were successful and we believe that the steps used in the requirements elicitation processes are repeatable and can produce usable outcomes in any rural area. This is because we were able to obtain end user views and opinions in a free manner since the participants were grouped with their own peers and there was no pressure from stakeholders who were higher up in social hierarchy. In rural areas, the power hierarchy is

very important and it can inhibit the free discussions that would otherwise be held when all the subjects are from the same social stratum. Based on the findings of the sessions, we were able to begin the design effort, in which we refined the initial use case models and class diagrams that were used to develop the software services. Through the joint sessions, we were able to identify key issues to consider in the development of logistics brokering services in rural areas. These formed the specifications for the suite and are presented and discussed further in section 4.4.

4.3 Design using the service systems framework

The basic purpose of this design exercise was to come up with a logistics brokering service system for rural areas. The service system was aimed at leveraging ICT to mitigate some of the logistics problems experienced in rural areas such as: the high amount of 'empty' miles driven; high shipment costs; the need to identify movements of goods and passengers; and the need to provide information on available logistics services in a given area. To design the logistics brokering services supported by the suite, we applied the service systems framework developed by van de Kar & Verbraeck (2007) to the findings we obtained through the joint user requirements elicitation exercise (see also section 3.6).

To develop an effective rural logistics brokering service system we needed to ensure that: the resulting services were *simple*; they were *cheap to develop and use*; they were *based upon existing ways of doing things*; they *solved real problems*; and they *created some sort of leverage*, e.g. "if I pay x for the service, I should get a benefit of 3x". Effectiveness is measured based on the ability to fulfil the rural user service needs. We recognized the need to facilitate ICT-enabled logistics brokering services that meet these challenges, as the rural service environment is highly complex and dynamic due to the informal nature of business transactions that take place. Based on an interpretation of the case study material and the findings from the joint requirements elicitation exercise presented in the previous section, the logistics brokering service system in rural areas should provide the following five distinct services.

- Services through which logistics service demand and supply can be *captured*
- Services through which the logistics service demands can be *consolidated and clustered*, e.g. according to type of goods, etc., to share available supply capacity
- Services for *matching* logistics service demand and supply
- Services for maintaining a *catalogue* of which service providers are doing what, when, where, for whom, how, and for whom; and information regarding service requests that recur
- Services for *communicating* with the service providers and service customers about the services they are expected to deliver and obtain

These five services should form the basis of the logistics brokering service system in rural areas. We applied the service systems framework of van de Kar & Verbraeck (2007) to design each of these services. We begin by presenting the service concept followed by the general organizational network and technical architecture which are common for all these services. The financial aspects of the logistics services have been left out in this research because we learnt that the logistics service providers preferred receiving direct payments for the services rendered, and that there is no standard way of determining the amount of money to be paid for a service rendered. The determination of the price is usually as a result of agreement between the customer and the logistics service provider. The Infopreneur™ acts only as a facilitator to link the service demand to supply, and initiating the delivery of the services.

Service concept

1. A service for capturing logistics service demand and supply

A board, modelled on the structure of a bulletinboard, is placed outside a focal point, e.g. the MPCC, on which logistics service demands are filled in. The service demands are either filled in directly or the person requiring the logistics service calls or sends a text message (sms) or email to the MPCC and requests them to make an entry into the bulletinboard for them. At regular and pre-specified intervals during the day, the Infopreneur™ scans the bulletinboard to check for any new service demands that have been placed, and updates the electronic bulletinboard on his PC with these demands plus those that have been received by phone or email. For practical purposes, this information needs to be filled in on the bulletinboard at least 24 hours in advance of the need of a transport or logistics service, with a maximum of one month ahead. The added value of this bulletinboard is that it provides a sort of one-stop-shop for gathering information from customers who need transportation and other logistics services.

On this bulletinboard, anybody needing to transport goods or any other logistics service is required to write their names and details such as date and time of the trip, the origin and destination, the product and its description, e.g. packaging, and quantity. To enhance the service, data will be supplied about the destinations that are travelled regularly with the assumption that these can be used to come up with a set of pre-determined collection points along the route, and that if a customer who needs transport is close to these points they do not have to go to the MPCC. The only requirement is that the details of the transport need are received by the Infopreneur™ 24 hours in advance. The basic premise behind this service is that there is a regular and unconstrained demand for transportation, given that people need to move products to and from some destination without any regular pattern considering that this is their normal way of doing things.

As an extra, the bulletinboard is also used by the logistics service providers who have unused capacity in their vehicles to or from a given destination on a particular day, or in their storage facilities. Using the same means as those for the people requiring transport or other logistics services, they enter the full details of their vehicle or store, the amount of space remaining, quantity and type of goods they can, or would like to, carry or store, and the route via which they will pass to get to the destination.

Based on the data collected from the bulletinboard and independent of the transportation mode, the Infopreneur™ transforms the transport demands into a service schedule depending on the destination and route followed, using data obtained from GIS service databases. The Infopreneur™ develops a route plan from origin to destination, which allows for goods or people to be picked up at various pre-determined collection points on the journey if necessary. The origin is always taken to be the focal point at which the MPCC is located, and on the return journey, this is considered to be the destination. However, the initial schedule is developed to cater for one-way journeys but can be scaled to cater for return trips. Based on the current way of doing things and indicating the service timings at each point, the schedule is initially prepared to reflect 3 main and currently existing categories per route.

- Regular, e.g. hourly, daily, weekly, etc.
- Dedicated, e.g. only to the Kei fruit market, for out-patients only, etc.
- Special, e.g. refrigerated transport, non-emergency ambulance service, school transport, etc.

Each of the demands is fitted into one of these categories, as per the information filled in on the board. The Infopreneur™ then clusters and consolidates the logistics service demands obtained from the bulletinboard and attempts to make a service schedule.

2. A service for clustering logistics service demands

As a way of determining the required capacity and utilising available capacity effectively, the logistics service demands need to be consolidated. The context of this service is derived from the existing situation, e.g. vehicle type, goods type, etc.; government regulations, carrying capacities and modes, etc.; and packaging quality requirements, e.g. containerisation. The purpose of this service is to cluster the logistics service demands to assist in the reduction of shipping costs and the amount of empty miles that would otherwise be generated to or from a destination.

This service clusters the demands based on attributes of the goods or people to be transported or goods to be stored. For example, if the goods are perishable, e.g. with same-day-to-market requirements, then they are given higher priority in transportation than goods with a longer shelf life. The quantity and weight of the goods and the packaging, e.g. boxes, bags, etc., is then used to determine the vehicle type that will be used to transport them. In case multi-modal transport is required, other services, e.g. those provided by the GIS databases, will be used to determine points at which the goods or people change from one mode to another. A service time schedule with a set of service collection points is developed based on the attributes of the goods or people to be picked up along the route, e.g. by light delivery transport vehicles and/or large trucks.

Considering the need to plan the available logistics capacity in an efficient manner, an assumption was made that the packaging of goods will be standardized. The implication of this assumption is that it will be possible to plan more accurately how much cargo can be carried in a given vehicle or stored in a given warehouse, and it would also lead to more efficient use of available capacity. For the transportation of goods, the customers are required to use one or several of the standard packages, e.g. mini-containers or small boxes such as the ones used in post offices, which are suitable for the particular goods. These packages will be obtained in advance either at the MPCC or at the collection point. They may differ based on their suitability to transport different goods, and can possibly be moved using both motorised and non-motorised transport. The packaging also needs to be affordable, secure, reusable, and compatible with mainstream containers and other relevant logistics standards.

After the service requests have been clustered and consolidated, there is need to match them to the available supply as advertised by the logistics service providers. The information about the service providers is obtained either from the bulletinboard or via the use of ICT to connect to the service provider databases.

3. A service for matching logistics service demand and supply

The Infopreneur™ maintains a detailed list of all logistics service providers who are in the catchment area of the MPCC who have transacted with them before, as well as those who are interested in receiving logistics service orders through the MPCC. The list is created when the logistics service providers voluntarily register with the MPCC and provide all the vital details of their vehicles e.g. type, e.g. ‘bakkie’, truck, mini van, etc., carrying capacity, e.g. 1 ton, etc., and body type, e.g. open, closed, refrigerated, etc. In the case of storage service providers, they provide details regarding the location of the store, its capacity, the kind of goods that can be stored, the dates it will be available, etc. The transport service providers also provide information related to their preferred routes of service, the charges per distance travelled, and the conditions under which they operate, e.g. one day a week. The service for matching supply and demand also has the ability to connect to the services offered by other logistics service providers, and can also be used to invoke services remotely via mobile phone, etc.

To assist the Infopreneur™ in determining the available transport for a given day, the transport service providers are required to update the MPCC with information about their vehicles daily. In

addition to this, the Infopreneur™ maintains a list of vehicle movements and is able to know when a vehicle is likely to be available. Using the available information, the Infopreneur™ is then able to make a detailed schedule by appropriately matching service providers to the service demands based on their availability. This information is then passed to the relevant transporters.

4. A catalogue service

The purpose of this service is to maintain information about the service providers and to keep a history of the service requests that have been handled through the Infopreneur™ office. The aim is to provide a proactive form of service delivery based on previous history. The service also provides for communication regarding the location and movement of goods and people. Among other functions, it records actual or realised movements in terms of the transportation mode, route, and destination. Each time goods or people are delivered to their destination, a record is made by the driver at the point of delivery, and this is entered into the database.

Using the data gathered in the database and the statistics that can be drawn from it, the service provides the Infopreneur™ with an ability to determine if there are any 'latent' movements, i.e. those that are not happening due to inhibitions such as high transaction and logistics costs, and he or she can work proactively to provide solutions.

5. A communication service

The purpose of this service is to communicate the details of a service match to the concerned parties. It also assists in initiating the payment for services that have been rendered, upon receiving information on a completed service delivery. Since there is no formal money-payment binding between the Infopreneur™ and the customers, each customer is expected to pay for the logistics services as per the conditions set by the service providers, e.g. in kind, cash basis, debit account, etc. The service informs the customers when and where to expect the logistics service and it also passes the relevant information to the service providers. As an extra, this service can be used to calculate the amount to be paid by each customer if this information is readily available from the logistics service providers.

In the context of this work, we assume that customers that are unable to pay either in full or in part for transport or other logistics services receive transport subsidy vouchers from the local government. These vouchers are registered with the Infopreneur™, and the service system assists in managing information related to the vouchers. The vouchers are handed over to the vehicle driver at the beginning of the trip, and presented to a local government office on completion of a trip in return for payment in full, after validation. The only requirement for using this service is that the transporters are registered with the MPCC if they want to participate in the voucher system. Their details and the voucher details are stored in the inTouch Africa® system.

If the mode of payment is by voucher, the driver presents the voucher to the receiving person to sign as proof of delivery, and the voucher is then presented for payment at the local government offices. The owners of vehicles that are registered with the MPCC all agree to the installation of an RFID tag that provides details about the location of the vehicle at any given time. The packaging, e.g. the mini-containers, also has identification tags the details of which can be used to show where the goods have reached in their transportation regime. These tags can be traced through the GPS mapping points already created by the CSIR, to provide a geo-referenced location for the goods or vehicles.

Organizational network

There are several actors involved in making the logistics brokering service viable. These are:

- the Infopreneur™: this is the actor responsible for setting up and running the service. He or she acts as an intermediary between the customers and logistics service providers, and is responsible for managing the service and creating business volumes for him or herself. The service users will be clients of this actor, and channel all their logistics service needs through the actor. The Infopreneur™ also provide human support to those who need access to the service but do not have the relevant know-how or devices. This actor is responsible for ensuring that the service works the right way, and delivers the relevant service schedules to the customers and logistics service providers. The Infopreneur™ does not incur any extra costs in addition to his or her normal operational activities, but is expected to generate some financial benefits through brokering the services.

- the customer: this is the actor for whom the logistics brokering service has been set up. They are responsible for requesting for the logistics service by sending their service demands through the Infopreneur™. In return, they receive the list of available service providers and service schedules from the Infopreneur™. These actors can be generalised to include the SMEs, farmers in rural areas, people requiring transport, and other organisations that present themselves as single entities to use the service. They pay for the services either through the use of vouchers, cash payments, or via direct debit from their bank accounts.

- the logistics service provider: this is the actor that provides the service system with information regarding their ability to meet the logistics service demands. For the transport service, the service provider is required to provide details of the destinations to which they travel. The role of this actor is to constantly provide accurate and up-to-date information regarding their logistics services. They receive route plans and service schedules from the Infopreneur™. They generate their revenue directly from the customer payments or through voucher payments from the local government. They are responsible for maintaining their own databases regarding the basic services they offer.

- the network provider: this is the actor who facilitates communication with the multi-purpose community centre either via mobile devices or Internet connections. The devices, e.g. mobile phones, computers, etc., make contact with the inTouch Africa® toolbox running at the MPCC, to which they either send or receive text messages. This group may be made up of several different operators, e.g. MTN, Vodacom, etc., and Internet service providers. Their responsibility is to ensure that the network is running at acceptable levels to enable the customers, service providers and the Infopreneur™ to conduct business effectively.

- the application provider is the actor who develops and provides the software systems on which the logistics brokering services are run. In this case, the Meraka Institute of the CSIR is identified as the main actor, since they currently provide the inTouch Africa® software toolbox and the related support and maintenance.

Technical architecture

The technical architecture for running the service system implements the current mode of working as the inTouch Africa® toolbox (see chapter 2 for details). We discuss this architecture using the three-tier model, i.e. presentation layer, business logic layer, and data layer, presented in van de Kar & Verbraeck (2007).

Data layer

The data layer consists of the database, or system data, containing information that has been entered either in a decentralised manner or locally, with changes being updated whenever a connection takes place. The information stored in this database includes details of the logistics service

providers in a given area, and information regarding services that have already been delivered through the MPCC. In order to implement the services, data from a number of web services needs to be coupled. Such services include those delivered by the logistics service providers, services obtained from GIS databases, GPS data, etc. The services use standard formats, e.g. XML and SOAP, to communicate with the web services and the messages are received in the presentation layer.

Business logic layer
The business logic layer is meant as middleware and is also called a server, known as the Builder in the inTouch Africa® toolbox, and it contains protocols, e.g. EJB, .NET, etc., that enable communication between the data layer and presentation layer. This layer addresses the main part of determining the service demand and supply by implementing the business processes such as creating route plans, creating service schedules, etc. It is in this layer that the matching of service demand to supply is carried out. The protocols, e.g. SOAP, that are used by the services provide for platform-independent data exchange take into account that the customers of the logistics brokering service either use mobile phones, PDA's or computers to interact with the Infopreneur™.

The communication between the server and the database uses standard connections that are currently supported by the inTouch Africa® toolbox. The communication between the server and the customer devices takes place over the normal network as provided by the network operators e.g. mobile phone networks for the mobile devices, dial-up networks for the computers, etc., and the customers pay for the normal network access as they already do The communication between the presentation layer and business logic layer uses XML. The software installed at the MPCC takes care of the communications that happen via mobile phone and email.

Presentation layer
This is also known as the interface layer, and its main purpose is to enable communication with the service end-users through their equipment such as mobile phones, PDA's, computers, etc. It describes how the service is presented to the users and how they should interact with the service. It receives its data from the server in XML format, and is visualized using software e.g. to show the route from origin to destination using GPS coordinate points linked to a GIS database, which were collected by CSIR. The software allows the Infopreneur™ to personalise the information needed for every service demand. The Infopreneur™ can access a menu on the interface by scrolling through the different functions.

The customer gets access to the services provided by the Infopreneur™ either with their mobile device, or other ICT-enabled equipment, by connecting to the computer at the MPCC. This is when the interaction with the service system begins. The main assumption is that the typical customer possesses a piece of equipment that can communicate remotely, e.g. mobile phone, PDA, etc., and that can communicate via an IP address system, e.g. computer connected to the Internet via dial-up, through which information can be routed. For customers without any of these devices, the Infopreneur™ handles their service requests manually and inputs them into the system. The mobile phone infrastructure, which is widely available in rural South Africa, is assumed to be up and running most of the time, even though it may face situations of poor signal or some periods of signal loss.

4.4 Requirements for the suite

In the previous chapters and earlier sections of this chapter, we identified the main issues and concepts to consider when designing a suite to improve and support the development of ICT-enabled logistics brokering services in rural areas. In section 4.2 we contextualized issues from the

case study and the literature to provide a basis for development of the suite based on the challenges identified. In the previous section, we designed the service system using ideas obtained from the literature. This section further builds on our theory that the use of tools improves the development of services, and we develop the requirements of a prescriptive suite that facilitates in providing solutions to the issues identified in the problem analysis presented in chapter 2 and through the joint requirements elicitation exercise. We provide answers to the 3rd research question.

> *What services should a suite for facilitating ICT-enabled logistics brokering services in rural areas of transition countries contain?*

This question is directed at defining a "blueprint" for a suite that can be used to facilitate the development of ICT-enabled logistics brokering services that meet local needs of the rural areas. We provide answers to this question by developing a suite that fulfils the requirements presented in this section, and implemented in a prototype as presented in chapter 5.

We observed from the case study presented in chapter two that to arrive at effective ICT-enabled logistics brokering services that fulfil local user needs, the brokering service needs to manipulate large data sets to extract information and ultimately decision support knowledge. This process of extracting information might involve selecting particular data from large sets and from multiple sources such as service provider databases. Currently, the logistics service providers, such as transporters and storage facility owners, offer basic services that are core to their business processes, and maintain their own service databases. Considering that the customers of the logistics brokering service may need a combination of different services to meet their service requirements, there is need to provide software tools to facilitate the development, assembly, and invocation of services from different service provider databases to present a complete logistics brokering service.

The development, assembly, and invocation of ICT-enabled logistics brokering services can be done using a suite, which is defined by Keen & Sol (2007) as a well chosen set of services and standards to support a decision making process. Keen & Sol (2007) state that such a suite must correspond to the key individual business processes. In the context of this thesis, the statement is interpreted to mean that the suite must correspond to the key logistics business processes in rural areas as identified through the case study. The suite must consist of an integrated set of services that link the individual business processes, and facilitates in solving the problems of unconsolidated freight and passenger movements and uncoordinated transport service delivery. Following on this, the suite for improving and facilitating ICT-enabled logistics brokering services in rural areas should provide functionality that covers the key business processes associated with the three cornerstones presented in figure 4.1, and the discussions presented in section 4.3 on what needs to be included in the suite. The key business processes are translated into the services of the suite.

The end-users of the suite, the Infopreneur™, need to be provided with an interface to the services of the suite that is simple but representative of the logistics business processes in rural areas. As stated by Keen & Sol (2007), the functionality provided by the services must be integrated and work with a consistent database. The services must be accessed through a common, interactive, intuitive and sophisticated interface; the services must be transparent to the non-technical user and the range of services should be consistent with the level of analysis and detail required. This forms the basis for deriving the requirements of the suite. The suite should facilitate the Infopreneurs™ in their quest to broker services for consolidating and coordinating logistics services in rural areas. Application of the suite should give the Infopreneur™ effective support through which dynamic and flexible ICT-enabled logistics brokering services can be developed and composed from other existing services. It should enable both automatic and manual user-driven integration of ICT-based

services even when the Infopreneur™ does not have knowledge of the participating providers' business processes.

The basis for the requirements of the suite developed in this research comes from the work of Keen & Sol (2007), which was also discussed in section 1.5. We learnt that effective support for decision enhancement in the development of services can be expressed using a combination of three U's: usefulness, usability, and usage. The *usefulness* of the suite addresses the value it adds to the decision-making process. The *usability* of the suite deals with the mesh between people, processes, and technologies. The *usage* dimension deals with how the suite is embedded in the decision process.

4.4.1 Usefulness

The concept of usefulness expresses the value that the suite adds to the decision-making process when developing services. The concept of the perceived usefulness of the suite is also based on the work of Davis (1989). It relates to the analytical models, the embedded knowledge, and the information resources available in a model or tool (Keen & Sol, 2007).

The findings from the case study, presented in chapter two, and the joint user requirements elicitation exercise presented in section 4.2 revealed that developing logistics brokering services for use in rural areas is very complex. Many of the SMEs operate in a complex and dynamic environment that is not supportive of long-term business relationships mainly due to economic issues, seasonality of service demand, trust-related issues and the ever-changing roles that a given actor can play in the delivery of a service. The suite should provide services that can capture both the logistics service demand and supply. The services should also capture the ever-changing roles and interests of stakeholders in each role. The roles of the stakeholders are not fixed (Keen & Sol, 2007). This can be translated into the following requirement for the suite.

Requirement 1: ***Capture both the logistics service demand and supply*** → the suite should contain services that facilitate capturing full details of both the service demand and supply in a given area. The suite should provide a means of classifying the logistics service providers according to the services they provide, and their service delivery capacities. In addition, the suite should provide services that enable matching of demand and supply.

We also learnt that there is a need to facilitate the development of ICT-enabled logistics brokering services in autonomous, heterogeneous, and dynamic environments such as those described in the case study, which generally exhibit limited bandwidth capabilities. Considering that the number of services to be composed may be large and continuously evolving, and that some service attributes may not be fully defined, approaches in which the development of services requires understanding and establishing interactions among service components at service-definition time are inappropriate for the suite of logistics brokering services. There is a need to focus on the service selection aspect, in which service providers can be selected based on their ability to fulfil a service when it is required during service run-time. This translates into the following requirement.

Requirement 2: ***Support distributed and dynamic selection of services during delivery*** → the suite should be platform independent, and contain services that enable rapid development and flexible adaptation of services during delivery. The set of services in the suite should facilitate creation of dynamic service process definitions and dynamic modification of service process instances while they are in execution (Casati, et al, 2000).

Unlike situations in which the service delivery infrastructure is stable, we do not pre-suppose the existence of a centralized powerful machine for the service composition in rural areas, but rather a

decentralized kind of architecture in which services are hosted in different locations. There is need to effectively combine services from different providers in such a way that mitigates infrastructure unavailability. This then translates into the following requirement.

Requirement 3: ***Support effective combination of service components*** → the suite should contain middleware services that alleviate infrastructure problems and effectively combine logistics services from distributed sources based on the consideration that communication infrastructure can experience unavailability.

In the challenging rural environment, service brokers have to devise means of creating and maintaining competitive value-added services for their basic survival. This means that it is very important to have a good knowledge of user behaviour and requirements to develop ICT-enabled logistics brokering services effectively. This would be more effective than developing services based on pre-configured user preferences. This translates into the following requirement.

Requirement 4: ***Support creation of flexible and adaptive value added services*** → the suite should contain services that can be used to identify ICT-enabled services from various service providers and flexibly assemble them depending on demand. The services should enable the broker to build logistics services from a range of domain specific and common services, e.g. transportation, or from services across domains, e.g. schedules, to create ever-changing value-added services.

4.4.2 Usability

Usability expresses the mesh between people, processes, and technology. Usability mainly depends in the interface between users and the supporting technology (Keen & Sol, 2007). The design for the perceived usability of the suite is also based on the work of Nielsen (1992).

We learnt through the case study that there is an inherent lack of trust among logistics service stakeholders in rural areas, leading to lack of transparency between operating partners. This makes it difficult to share information and services. This can be overcome by providing a user interface through which the Infopreneur™ selects services and composes them remotely without requiring details of the service provider business processes. The user interface would be used to couple ICT-enabled services by selecting from elements representing the different logistics service processes. This would enable user-driven integration of ICT-enabled services without requiring the service broker to have deep knowledge of the service provider business processes. This can be translated into the following requirement.

Requirement 5: ***Provide a graphical user interface for development of services*** → the suite should contain services that provide a front-end tool, user interface, to enable Infopreneurs™ to manually create their own business processes. The services of the suite should enable the Infopreneur™ to select and compose ICT-enabled logistics brokering services through a high-level coarse-grained user interface.

We feel that the existing service oriented architectures (SOA) and web service provision techniques are still inappropriate to cope with the requirements for service delivery in rural environments. Such environments face obstacles that hinder the seamless provision of ICT-enabled services due to technological limitations such as low bandwidth, poor connectivity, and risks of frequent communication and power failure. In addition to criteria such as monetary costs and bandwidth limitation, service delivery in such rural environments calls for service systems that adapt to different computing and user requirements. This would allow Infopreneurs™ to develop services that connect to larger industry-standard logistics services and management systems. This then translates into the following requirement.

Requirement 6: ***Allow for interfacing with industry standard logistics systems*** → the suite should contain services that enable the Infopreneur™ to adapt ICT-enabled logistics services to suit end-user contexts and connect to other partners in the supply chain. This should be done in a transparent manner such that the Infopreneur™ can connect to partners at different levels of the logistics network. The services of the suite should enable Infopreneurs™ to reuse and adapt existing ICT-enabled service components and business processes.

4.4.3 Usage

The concept of usage expresses the flexibility, adaptivity, and suitability of the suite of services to meet the organizational, technical and social context (Keen & Sol, 2007).

Through the case study and the joint user requirement elicitation exercise, we observed that it is very difficult in the logistics domain to develop services for use by stakeholders who do not trust each other and who believe that sharing of information gives undue advantage to their competitors. We also learnt that it is not a simple task to develop services when the stakeholders have very little, fragmented information and limited insight into services that can be used to improve their business processes. There is need to become acquainted in detail with local situations and to provide an overview of available services. In addition to requirements 2 and 3 that focus on the aspects related to the selection and combination of services, there is a need to focus on the flexible assembly of services to ensure that the service brokers are not bound to specific service providers. This is interpreted into the following two requirements.

Requirement 7: ***Support flexible development and assembly of services*** → the suite must contain services that correspond to different levels of locally used domain specific key business processes. Using the suite, the Infopreneur™ should identify and change the requirements of implementing a given business process.

Requirement 8: ***Provide guidelines for using the suite*** → the suite must be accompanied by a practical and usable set of guidelines that facilitate the Infopreneur™ to develop their own ICT-enabled logistics brokering service processes.

Specifically, the suite will be used to support ICT-enabled logistics brokering services in rural environments. The suite should provide services that support the consolidation of passenger and freight movements, and coordinate demand for logistics services. By providing services that fulfil these requirements, the suite is expected to facilitate the Infopreneurs™ in the effective composition and development of ICT-enabled logistics brokering services that meet needs of rural stakeholders.

4.5 Development of the suite

The suite is aimed at facilitating service development, so that (new) services can be developed from existing data sources and services. The suite is targeted at creating a framework for distributed development and manipulation of logistics services from services residing in remote databases. The use of ICT-enabled interventions in rural areas provides new capabilities that would otherwise not be possible. By using the suite, the Infopreneur™ is able to develop logistics services and business processes by assembling them from geographically distributed resources. The services are customised to meet specific user needs and solve the main problem of uncoordinated logistics services currently experienced in rural areas. The issue of facilitating distributed service development and decentralized service delivery is of importance in this work.

According to Papazoglou & van den Heuvel (2006), there is need to provide support that enables service developers to create business processes and web-enabled service composition by taking into account both technical and business concerns. To facilitate the development of logistics services in rural areas, taking into account both technical and business concerns, we prefer to use a suite based on the work of Keen & Sol (2007). The reasons for this preference are presented in chapters 1 and 2, and in the previous section. We apply a model that is used for the development of workflow systems from the work of Hollingsworth (1995) to design the logistics service business processes in rural areas.

The main issue surrounding development of the suite is the identification of basic logistics services in rural areas, organizing these services, and developing business processes from them in such a way that the resulting services can be delivered using ICT-based interventions. This is aimed at consolidating logistics service demand, and coordinating passenger and freight movements in the context of rural South Africa. The resulting services are developed from already existing services and can be delivered using the technologies currently available in rural areas.

As a starting point for developing the suite, we borrow from the work of Papazoglou & van den Heuvel (2006) which states that the development of services should focus on analyzing, designing and producing a service oriented architecture (SOA) that aligns with business process interactions between trading partners to accomplish a common business goal. The basic purpose of the suite is to provide functionality that facilitates the development of ICT-enabled logistics brokering services in rural areas. The services of the suite should allow the smaller logistics service operators to connect seamlessly to, and use the services of, larger logistics service operators. The overall concept is that by using the suite, the end user is able to create value-added logistics service processes. The services of the suite are derived from the findings of the case study and the joint requirements elicitation exercise, and correspond to the complex requirements of the transportation situation in rural South Africa. The suite enables us to assemble information from existing web services and data sources, and provides ICT-based interventions that enable development of services that:

- capture and maintain details of logistics service demand
- identify and maintain details of available logistics service providers
- categorize and prioritize the service demand and service providers available
- match the service demand to service supply
- create service schedules and provide information on available logistics services

The architecture of the suite is made up of these five main components, which were broken down and translated into services that closely match and provide functionality required to fulfil rural logistics service delivery needs. The services of the suite are considered to be logical in a completely technology-independent manner, and must collaborate to provide functionality of the suite. To put this discussion into context, we adapt the following steps from (Tewoldeberhan, 2005) as a basis for development of the suite.

1. Select appropriate approach to abstract services and map them into a conceptual model.
2. Represent the service elements in the chosen model.
3. Implement the service development and composition model.

We explain each of these steps in detail.

Select appropriate model to abstract services and map them into a conceptual model

The central idea of this step is to raise the level of abstraction by separating the fundamental service logic from particular service development and composition specifications. This allows for rapid development of services, which is what we aim to achieve given that we would like to facilitate the development of services that can run on limited-bandwidth environments. There are several approaches that can be used to model abstract services and we chose to use the unified modelling language (UML). This is because UML allows for development of technology-independent service definitions. We chose to use the workflow meta-model developed by Hollingsworth (1995), who describes a common model for the development of workflow systems. The reason for choosing the workflow model is that service development is in many ways similar to workflows e.g. concerning task structuring.

The workflow model developed by Hollingsworth (1995) identifies a basic set of object types appropriate to an initial level for the interchange of relatively simple process definitions. Using this model, the service development process starts by specifying services in an abstract manner based on user requirements, without specifying the workflow and the service providers. It then progresses from the abstract service specification to a model that can be implemented by applying basic business rules to arrive at the specification of the service elements. To implement the workflow in a service-oriented way as suggested by Papazoglou & van den Heuvel (2006), we used the information model developed by Orriens, et al. (2003). This information model is presented diagrammatically in figure 4.4 and is used to model the required service information as classes containing special purpose attributes. An explanation of each of the components is given after the diagram.

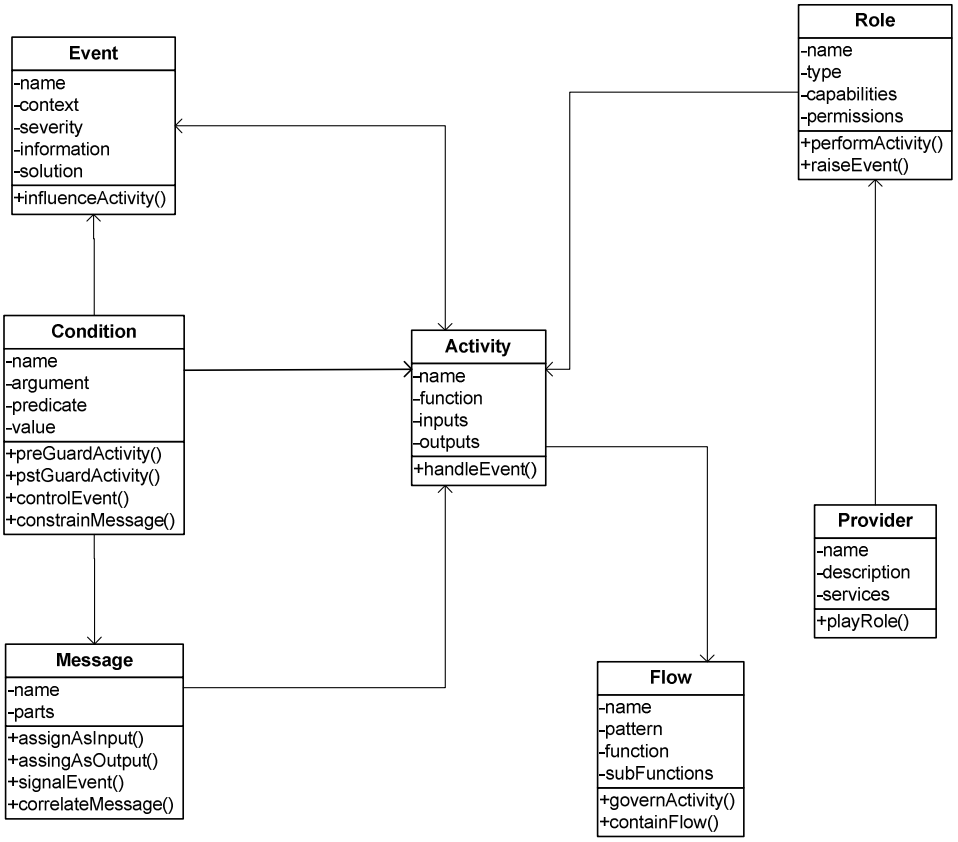


Figure 4.4 UML Class diagram of service development (Source: Orriens, et al, 2003)

The building blocks presented in figure 4.4 are derived from workflow technology as discussed by Hollingsworth (1995). Activity is an abstract class representing a well-defined business function; the Condition class constrains the behaviour of the composition by controlling event occurrences, enforcing pre- and post-conditions, and integrity constraints; the Event class describes occurrences during the process of service composition and its impact on an activity; the Flow class defines a block of activities and how they are connected; the Message class represents a container of information; the Provider class describes a party offering services; while the Role class provides an abstract description for a party participating in the service composition. We use these ideas to instantiate the classes and to implement the service development.

Represent the service elements in the chosen model

To represent the services required for development ICT-enabled logistics brokering services, we based our work on the information model created by Orriens et al. (2003) presented in figure 4.4, which comprises classes referred to as service composition classes, with instances of the classes referred to as service composition elements. Relationships between composition classes such as how to relate a service to a certain activity or how to relate a certain activity to a flow are determined on the basis of business rules from our domain of interest, which is rural logistics brokering services. The UML class diagram arising from this analysis and based on the theory of workflow is presented in chapter 5. The third step involved implementing building blocks for service development and composition.

Implement the service development and composition model

To instantiate the services within the context of the rural logistics services domain, preference was given to the use of an object oriented tool that supports XML parsing and processing. This choice was made because we wanted to support the development of platform-independent services. In terms of the software and language of implementation we preferred to use the object-oriented approach to design and develop the logistics brokering service system. We also preferred to base the design of the services on the commonly used UML meta-model using the earlier identified business processes. We preferred to use Java, an object-oriented programming language, to implement the services of the suite since Java is inherently platform-independent and contains an extensive collection of libraries to support the specification of distributed, web-enabled applications. Java contains a rich XML processing and parsing library (Maruyama, et al., 2002), and we wanted the suite to benefit from this library. Instantiation of the service development building blocks is presented in chapter 5, in which we also present the UML class diagram which represents a well defined business activity in the rural areas.

4.6 Conclusions

The logistics brokering service system that was developed for use in rural areas is presented and put into context in this chapter. The logistics brokering service system captures the requirements identified through the joint requirements elicitation exercise and the findings from the case study presented in chapter 2. We applied the service systems framework from van de Kar & Verbraeck (2007) to design the logistics brokering service system, and identified the requirements to be fulfilled by the suite in support of delivery of these services. We used the ideas presented in this section as a basis for further development of our theory and the suite for use in facilitating the logistics brokering services. We developed a prototype of the suite that implements the requirements identified in this chapter. We present details of implementation of the prototype in chapter 5.

5. Implementation of the suite

5.1 Introduction

In this chapter, we discuss the implementation of the suite in a prototype and provide details of its functionality in facilitating ICT-enabled logistics brokering services. To manage the development of services using the suite properly consideration should be given to the key actors involved in identifying and defining services, applying the suite in service development, and identifying end users of the logistics brokering services. We begin by discussing the main actors and activities involved in using the suite to develop services in a studio-based approach. We then present a complete overview of a prototype of the suite and explain how it was implemented, and discuss some of the important implementation considerations that were made. We finally reflect on use of a suite to provide answers to the research problem.

5.2 Actors in the studio-based approach

The suite developed through this research is for use in facilitating the development of ICT-enabled logistics brokering services, and the studio in which it is deployed should support all the actors involved in using the suite. The service environment which we presented in chapter 2 is inherently multi-actor, with the stakeholders having varying needs. In this thesis we distinguish the actors with respect to their roles within the logistics services domain in the rural environment, as identified through the case study. The following roles and responsibilities, though not mutually exclusive, were identified with respect to the support provided for stakeholders through the studio.

- *Logistics service practitioner*: this actor is responsible for gathering the service requirements and initial concepts required to design logistics services. In the studio-based approach, they have the responsibility of defining and validating the services of the suite to ensure that the relevant aspects of the domain are captured and that the suite facilitates the development of services within the domain. Through the case study material presented in chapter 2, we learnt that this actor is also responsible for implementing services in the rural environment.

- *Service provider*: this actor delivers the actual logistics services. They provide basic logistics services that are core to their business processes, e.g. transport services, and their main interest is profit. In the studio-based approach to the development of logistics brokering services, they are responsible for maintaining their own databases and ensuring that their services can be accessed by interested parties. As we learnt from the case study, this actor owns the service content, which is stored in proprietary databases.

- *Service customer*: this is the (remote) actor who requires logistics services, and is a customer of the logistics brokering service. The group of actors is made up of SMEs and other rural stakeholders who want to receive logistics services that enable them to link seamlessly to the national supply web. In the context of the studio-based approach, this actor is responsible for requesting logistics services that are delivered through the suite, and receiving services that fulfil their transport service needs.

- *Service broker*: this is the main end-user of the suite, locally referred to as an Infopreneur™. This actor creates and delivers bundles of value-added services that are requested and are relevant to local rural needs. In the process of service delivery, this actor creates business volumes and income for themselves. In the context of the studio-

based approach, this is the actor who will use the suite in actual service development in real life settings. This actor provides feedback to the logistics service practitioners and software developers regarding whether the suite facilitates in logistics brokering services that meet local needs.

Considering that the roles and responsibilities identified may be complementary and not mutually exclusive, in the context of this research the stakeholders require an environment that can bring as many of them into service development as is practical. This is because we want to capture the ideas and values of all them. A studio provides such an environment and according to Keen & Sol (2007), a simulation model or planning document can never adequately and dynamically include the perceptions and priorities of all the parties, nor can a mathematical formula easily incorporate their trade-offs. The studio-based approach establishes a guiding framework for handling the decision process, to provide a common reference point for framing the discussion, and to cover the values and issues of all the stakeholders.

The studio enables actors in the service development process to focus on relevant service design issues by setting the context of the decision space; enabling the service developers to treat context-specific issues from various points of view; and helping them to identify opportunities and evaluate business values of their decisions through the use of analytical models (Keen & Sol, 2007). A studio to support the needs of the stakeholders should contain a suite that enables them to develop and test the logistics brokering services. In addition, the studio should provide guidelines on how to use the suite to develop logistics brokering services that solve the main problems presented in chapter 2 and the challenges presented in section 4.1. The ability to allow for multi-stakeholder interaction in the development of logistics brokering services is an important issue for this research considering that in the rural areas services that do not represent the way of working are unlikely to be well received by the rural folk.

5.3 Developing services using the suite

To facilitate the actual development of ICT-enabled logistics brokering services in rural areas using the studio-based approach, the suite should be based on real life activities that can be used to improve and provide solutions to the logistics problems faced in rural areas. The suite should enable the user to carry out the following activities.

- *Capture service demand and supply*: this activity is used to store and maintain demand and supply details for logistics services in a given area. The idea behind this is that before one can introduce a logistics service, there is need to confirm that there is actually a need for the service, to find out how the service will be delivered and by whom, and to determine which specific (new) services will have to be developed.

- *Consolidate service demand and supply*: this activity must be central since one of the biggest problems faced in rural areas is the high incidence of ‘empty’ miles travelled by transport operators, leading to uneconomical use of the available logistics service systems. This also leads to high transaction costs, which can be lowered if logistics services are shared. This activity also involves grouping together logistics service demands that are closely related, e.g. in terms of origin and destination, type of goods, etc. This is helpful in determining the kinds of freight that can be transported or stored using the same logistics resource, and in determining how much space is available.

- *Coordinate complex movements and inter-modal transfers*: in the case of a single transport mode and single destination, there are usually fewer coordination problems. The importance

of this activity becomes apparent when one considers the fact that rural dwellers are unable to link up economically to the national logistics service systems because of the limited capacities of the logistics systems available to them. Goods or passengers that need to be transported from several origins to several destinations using different transportation means tend to raise problems. The situation is further compounded by the lack of capability among the rural logistics service providers to transport or store large volumes of produce economically. It becomes economically sensible to create service schedules using ICT-based interventions to plan and coordinate the movement of goods and passengers.

- *Match demand and supply*: this activity is important for ensuring that the service demand in a given location is matched to the available supply. The available supply may be either sourced locally within the environment, or from remote locations, and this adds further impetus to the need to develop ICT-enabled interventions. In some cases the matching of service demand to supply may not necessarily be a one-to-one match, and therefore the use of ICT-based interventions would greatly improve the situation since it is possible to use service providers who have a larger capacity but are based in further off areas.

- *Maintain catalogue of service providers*: the importance of this activity is that it enables the service broker to know which service provider does what, when, where, for whom, and how. When you have a catalogue of service providers in a given location, it becomes easier to contact them whenever the need arises. The maintenance of the catalogue acts as a reference point for the identification of service suppliers, and will add value to the services provided by the broker since they are able to satisfy customer enquiries much more efficiently.

- *Communicate and facilitate service delivery*: this activity is important for ensuring that a service demand has been matched to a supplier and the concerned parties have been informed. Through this activity, the service provider is informed of the service they are required to perform, and they are able to confirm their ability to deliver the service. The customer requesting a service is given details concerning the service they requested and the service provider who will deliver the service. These details include items such as the time of service delivery, the schedule, etc. This activity supports communication both to and from the service broker.

The use of ICT-based interventions to support these activities is of great importance in the delivery of goods and services to and from various supply chain partners. The interventions are expected to make logistics service providers in rural areas more competitive since they will be driven to think beyond the idea of moving cargo and passengers from one point to another, as customers demand more value-added services. The software services implemented in the suite are aimed at providing a simple and easy means to facilitate ICT-enabled logistics brokering services that fulfil activities presented in this sub-section.

5.4 Overview of the suite

The basic principle behind design of the suite is that it should use existing services and technology, while allowing the end user to develop services and extra functionality when required. We define a service as a function that is well-defined, self-contained, and does not depend on the context or state of other services (Endrei, et al, 2004). Services are what you connect together using web services, which is the technology that facilitates the connections. A service is an endpoint of a connection. The suite was developed in such a way that the services contained in it can function in a loosely-coupled manner.

The goal of this part of the work was to develop a suite that could make use of existing technologies to provide ICT-enabled solutions for rural logistics problems by meeting the requirements presented in section 4.4. The main challenge we faced in developing the suite lay in the fact that although there are several existing technologies that can be used for dynamic service development, many of these technologies provide only partial solutions to service development on infrastructure, geographical conditions, and service environment problems found in rural contexts. These are conditions that were not necessarily anticipated when the technology was designed. This provided justification for developing the suite based on the rural area context to facilitate the service brokers in developing logistics brokering services that meet local user needs. The services of the suite were developed based on the UML class diagram presented in figure 5.1.

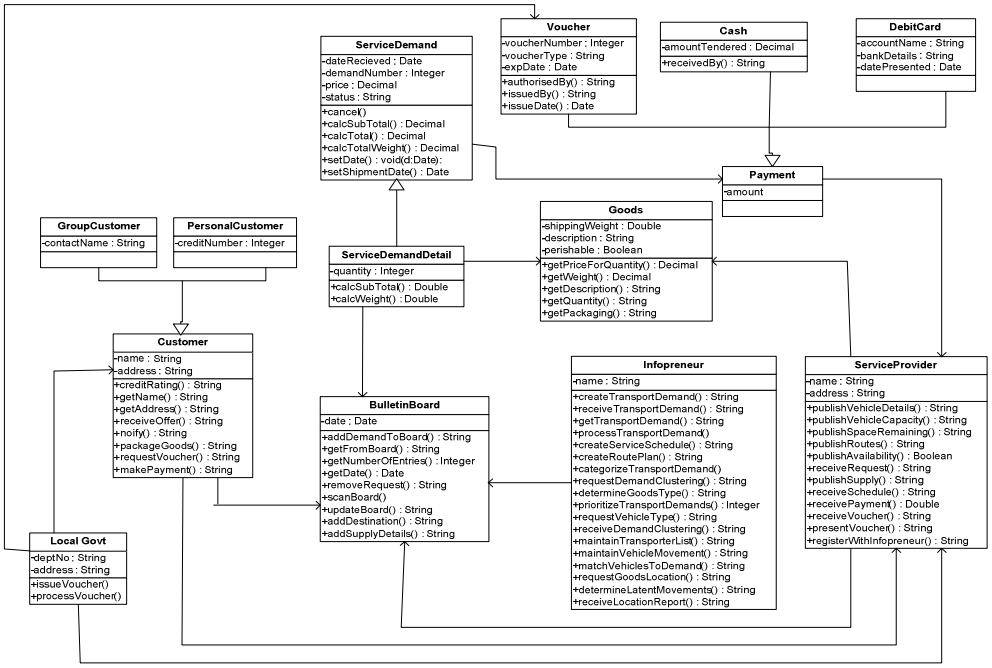


Figure 5.1 UML class diagram for the logistics services suite

5.4.1 Services of the suite

The UML diagram presented in figure 5.1 was used as a basis for implementing the suite, and towards this end we developed a prototype that provided functionality for the development of logistics brokering services. Following on the design evaluation methods presented by Hevner et al. (2004), we used functional (black box) and structural (white box) testing throughout the development of the suite to ensure that the suite was working correctly. The aim of the black box testing was to determine the functionality of the suite in relation to its requirements as identified in section 4.4, without going into the details of the implementation. Integration testing was also carried out on the individual components, in which we combined the different software modules and tested them as a group. The white box testing method was used to design test cases to determine whether the software would produce the required output. We distinguish the following 9 sets of services implemented in the prototype: *bulletinboard* services, *catalogue* services, *control* services,

matching services, *communicator* services, *handler* services, *GUI* services, *parsing* services, and *logger* services. The UML class diagrams that implement the functionality of the suite as fulfilled in the prototype are presented in appendix 4. The services are described in more detail as follows.

Bulletinboard service

This service contains a set of classes used to handle the modification of contents of the bulletinboard. On the service provider side, the service handles the broker communication for making announcements to the service provider and displaying announcements received from a broker in standard output format. The service is also used to return previously matched service demand and service supply details from the bulletinboard at the broker, according to a given date. The service enables retrieval of service demand and supply items from the bulletinboard, allows the broker to add and remove service demand and supply from the board, and allows the broker to retrieve specific service demand and service supply items from the bulletinboard. The service handles broker communication for registering new, and deregistering existing, service providers.

Catalogue service

To support distributed service invocation from many participants, the suite needs to locate appropriate services for specific tasks. The catalogue service contains a set of classes that allow service providers to register with the broker and receive unique addresses. It allows on-line services to be registered with the broker so that they can be found and accessed during service composition. Through this service, the broker obtains references to services they wish to use, as it allows names to be associated with service provider references. The catalogue service holds all the properties of service providers, and is used to retrieve database keys of the service providers. The service retrieves the endpoint URL where a given service provider can be reached, retrieves the name of the service provider, and the type of service delivered by the service provider. It is also used to set and retrieve the availability status of the given service provider.

Matching service

This service contains a set of classes for matching service demand to service supply. The matching service holds all common properties of matches that are found on the bulletinboard, and retrieves the match type, sets the match state, and retrieves the match state of a given service demand. The service uses a demand matcher to find and process service requests from the bulletinboard, and is used to find and initialize the match finder. The service holds all the possible service demand and supply matching states for the matching engine. It creates a match state service object of the given type, and retrieves the value of the match state, and retrieves a new match state.

The demand matcher handles matching of service demand to service supply. It does this by attempting to find matching service provider details for the given bulletinboard item, and commits a list of matches belonging to the given service request item on the bulletinboard. The local match service holds all the properties of a match found from service provider details on the bulletinboard, retrieves the details of the service request being matched on the bulletinboard, retrieves the service request details which matches the criteria of the source detail of the local match from the bulletinboard, retrieves information regarding whether the local match has found a target service supply on the bulletinboard, and retrieves details of the local match if it is successful. An example of the *DemandMatcher* method used to process a transport service demand is presented below:

```
/** Class which handles the matching of demand to supply */
public class DemandMatcher {
/** Creates a {@link DemandMatcher} which handles the matching of demands on supplies */
       public DemandMatcher() {
       }
/** Attempts to find matching supply details for the given {@link BulletinBoardItem}.
     * @param item the {@link BulletinBoardItem} to find matches for.
     * @pre item != null.
     * @pre item.getServiceType().equals(ServiceType.DEMAND).
     *
```

```
     * @return a list of {@link Match}es */
        public ArrayList<Match> findMatch(BulletinBoardItem item) {
                assert item! = null;
                assert item.getServiceType().equals(ServiceType.DEMAND);
                ArrayList<Match> matches = new ArrayList<Match>();
                Vector<Integer> usedSupplies = new Vector<Integer>();
                Vector<Integer> usedServices = new Vector<Integer>();
                ServiceCategory category;
                Period period;
                // Traverse all details and call specific routines
        for(BulletinBoardItemDetail detail : item.getDetails()) {
                category = detail.getServiceCategory();
                period = detail.getPeriod();
                if(category.equals(ServiceCategory.TRANSPORT)) {
        TransportDemandMatchingHandler tdmh = new TransportDemandMatchingHandler();
                        LocalMatch localmatch = tdmh.findMatch(detail, period, usedSupplies);

                if(localmatch.getState().equals(MatchState.MATCHED)) {
                        matches.add(localmatch);
                }
                else {
ClientTransportDemandMatchingCommunicator tdmc = new ClientTransportDemandMatchingCommunicator();
                RemoteMatch remote match = tdmc.findMatch(detail, period, usedServices);
                        matches.add(remotematch);
                        }
                }
        }
        return matches;
        }
```

The match type provides details of all the possible types of matches that can be made by the brokering system, and is used to retrieve a new match type. The remote matching service holds all the properties of a match which are found by targeting remote service providers for service demands that could not be matched directly from the service provider details on the bulletinboard. This service retrieves, from the bulletinboard, details of the service demand that is being matched remotely, sets details of the service demand that is being matched from the bulletinboard, and sets the criteria of the source detail of the remotely matched service request on the bulletinboard.

Control service

The set of classes implemented in this service deploy and undeploy the ICT-enabled logistics brokering services. The classes provide functionality for checking the properties of each service before it is booked, and maintains a status check of running services. The control service is responsible for ensuring that all services are running as expected, and contains middleware responsible for managing disconnections to the service caused by intermittent infrastructure conditions. This service consists of protocols that are aimed at minimizing the effects of infrastructure failure on service composition and delivery.

This service is made up of a collection of interfaces and classes used for developing and composing logistics brokering services from existing web services. It consists of the basic functional units of the business processes and the business logic and solution strategies used to arrive at the brokering of a service. These functional units include classes that carry out the identification and location of service providers, registration and deregistration of the services provided, and checking of service providers to see whether they are still available. This is the core service of the suite, and is made of two distinct sets of classes: one for service demand and one for service supply. The demand service implements all properties of a service demand. The bulletinboard consists of either one or more service demand details. This abstract service partly implements the need for capturing service demand details according to the interface. It sets and returns the period for the service demand, in addition to setting and returning the database key for the service demand.

The supply service implements all the properties of a service supply. It is an abstract service which implements the properties of a service supply, given that every bulletinboard item consists of either one or more service supply details. This abstract service partly implements the need for capturing service supply details according to the interface. This service describes the capabilities and

availability of each service provider by giving details of the kind of goods that can be transported based on information obtained from the service provider databases.

Communicator service

This service is made from a set of classes that handle communication between service providers and the broker. The client communicator handles the broker communication for communicating service demand details that have been matched to a given service provider. The classes in this service commit service demand details from the bulletinboard which are sent to relevant service provider databases. The service also handles broker communication for finding service demands that can be matched at a service provider, and attempts to match service demand to service providers using details on the bulletinboard.

The matching communicator handles communication on the service provider side for committing service demand match details from the broker. The demand communicator handles the communication for finding service demand matches at the service provider's side, and checks if a service provider can process a service request within the given parameters such as date, location, etc. An example implementation of the *BrokerServiceCommunicator* method is given below.

```
/**
 * Class which handles the broker communication for (de)registering a service provider */
public class BrokerServiceCommunicator {
/** Creates a {@link BrokerServiceCommunicator} which handles the broker communication for
(de)registering a service provider */
        public BrokerServiceCommunicator() {
                sh = new ServiceHandler();
                log = Logger.getLogger( BrokerServiceCommunicator.class );
        }
        /** Registers a new service provider at the broker.
         * @param config the configuration file to parse and register at the broker.
         * @return boolean true if registration is completed, false on error */
        public boolean registerService(DataHandler config) {
                log.debug("Webservice BrokerServiceCommunicator invoked :: registerService()");
                if (config == null ) {
                log.error("In service registration:");
                log.error("No data handler with configfile received");
                return false;
         }
         else return sh.registerService(config);
        }
        /** deregisters an existing service provider at the broker.
         * @param config the configuration file to parse and deregister services at broker.
         * @return boolean true if deregistration is completed, false on error */
        public boolean deregisterService(DataHandler config) {
        log.debug("Webservice BrokerServiceCommunicator invoked :: unregisterService()");
                if (config == null ) {
                log.error("In service unregistration:");
                log.error("No datahandler with configfile received");
                return false;
         }
         else return sh.unregisterService(config);
        }
        private ServiceHandler sh;
        private Logger log;
}
```

The broker communicator handles the registration and deregistration of new and existing service providers. The client communicator service is responsible for announcing messages to the service provider from the broker.

Data handler service

The group of classes in this service are responsible for the running of services, obtaining invocation details of the discovered services, and for handling communication between the deployed services and the database layer. The service contains handlers for inserting and removing service endpoints, opening and closing service connections, executing queries, and getting the required services from service providers. The configuration handler, which is also provided by this service, contains properties used by a service provider to specify their services. This service allows for efficient data access and processing, by ensuring that only the necessary data is transferred from the data layer.

The service uses database handlers to provide generic linkage over the JDBC connector. It contains data type definitions and acts as a repository of process definitions. The service handles database (dis)connection by opening new connections to service provider databases, and closing open connections at the end of processing. It is responsible for database communication services for the management, registration and deregistration of service providers in the database, and for retrieving the full details of service providers fulfilling given criteria.

```
public class ServiceHandler extends CommonHandler {
/**
 * Creates a {@link ServiceHandler} which handles database communication for service management.
 *
 */
	public ServiceHandler() {
		log = Logger.getLogger (ServiceHandler.class );
	}
	/**
 * Registers a new service provider in the database.
 * @param config the configuration file to parse and register in the database.
 * @return boolean true if registration is completed, false on error
 public boolean registerService(DataHandler config) {
	log.debug("Starting registration of service");
	try {
	int service_id = getServiceID (service_name, service_type, service_endpoint,
	service_available);
	//Check if we have a valid service_id
	if(service_id == -1) {
	log.debug("Service does not exist, attempting insert!");
	//Insert service its name, type and endpoint
	Connection conn = openConnection();
	Statement stat = conn.createStatement();
	String sql = "INSERT INTO service(service_name, service_type, service_endpoint,
	service_available)" + "VALUES (service_name + service_type + service_endpoint +
	service_available')";
		log.debug(sql);
		stat.execute(sql);
	/**
	 * Deregisters an existing service provider from the database.
	 * @param config the configuration file to parse and deregister from the database.
	 * @return boolean true if unregistration is completed, false on error
	 * /
	public boolean unregisterService(DataHandler config) {
		log.debug("Starting unregistration of service");
		try {
		int service_id = getServiceID (service_name, service_type,
		service_endpoint,service_available);
		//Check if we have a valid service_id
		if(service_id != -1) {
			log.debug("Service does exist, attempting remove!");
			//Delete service its name, type and endpoint
			Connection conn = openConnection();
			Statement stat = conn.createStatement();
		String sql = "DELETE FROM service" +" WHERE service_name = '" + service_name +
	"AND service_type = '" + service_type +  " AND service_endpoint = '" +
		service_endpoint + "AND service_available = '" + service_available + "'";
			log.debug(sql);
			stat.execute(sql);
		//Delete service properties
		Node property;
		for (int i=0; i<service_properties.getLength(); i++) {
		property = service_properties.item (i);
		sql = "DELETE FROM" +
		((property.getAttributes()).getNamedItem("name")).getNodeValue() + " WHERE
		service_id='" + service_id + "'";
		log.debug(sql);
		stat.execute(sql);
			}
		stat.close();
		closeConnection(conn);
		}
		return true;
		}
	private Logger log;
	private ConfigHandler cxh;
}
```

The bulletinboard handler is responsible for database communication for modifying contents of the bulletinboard. The matching handler is responsible for database communication for matching service demand and supply and vice versa. It also provides a service for marking service demand and service supply details from the bulletinboard with the given state in the database. The matching

handler is also responsible for database communication for matching service demand to supply, registering local or remote matches in the broker's database, retrieving details of the database key for the service demand or service supply item from the bulletinboard, and checking if we can flag a service request or service supply item from the bulletinboard as matched, so that it does not have any unmatched details contained in it.

GUI service

This service is made from a collection of classes that provide an interface to facilitate access to the software platform by users of the suite. A standard browser-like interface is employed to provide the user interaction with the services of the suite. The browser-like interface is used because it leverages the most widely available Internet environment and is convenient for quick development of services. The classes that provide the web-enabled graphical user interface for the suite are contained in the GUI service. The broker frame implements the bulletinboard through which users of the suite can add and remove service demand and service supply details.

This service initializes the bulletinboard, reviews bulletinboard history, and eventually allows the broker to process service demand. The GUI service uses JPanel, which is a Java service that is used to implement the bulletinboard. It initializes a refresh timer and the menu items on the bulletinboard.

Logger service

The logistics brokering services suite contains a logger service which is based on Java's logging mechanism. The value of this service is that output, debug information, warnings, etc. produced by objects in the suite can be captured and used to improve the development of services. It is not for direct use by the service broker.

Parsing service

The configuration handler is used to handle parsing of XML configuration files. XML is a platform independent, human readable language. The service retrieves details such as the name, type, endpoint, availability and properties of a service given in the configuration file. The configuration loader provides functionality for creating services that load configuration properties from the configuration file, and returns the endpoint of the broker from the configuration file. This enables service providers to communicate and publish their service supply details with the broker.

We implemented these services of the suite in a prototype to facilitate in the development of logistics brokering services, with the purpose of mitigating some of the problems identified in the case study analysis presented in sub-section 2.1.3. For the suite to provide adequate support to the service broker, it must consist of the distinct set of services that were discussed in this sub-section.

5.4.2 Suite functionality in detail

The prototype was designed to facilitate the Infopreneur™ in performing their daily tasks in the delivery of logistics services. A schematic overview of the functionality of the suite as implemented in the prototype is presented in a data flow diagram in figure 5.2. The numbers1 to 6 in the circles represent the main service functionality of the suite, and we explain how they are directly related to the services of the suite discussed in the previous sub-section.

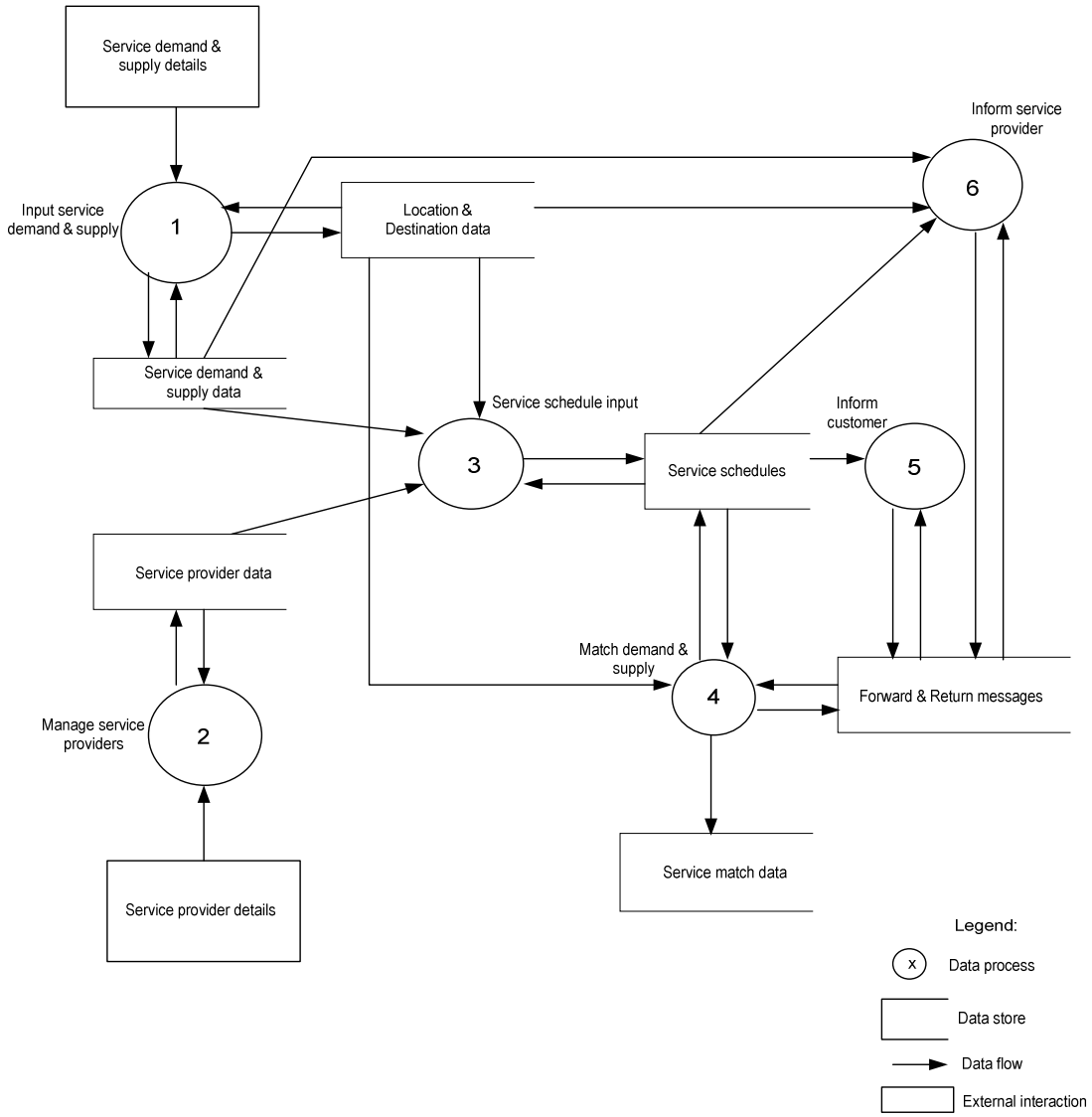


Figure 5.2 Data flow diagram of the suite functionality

We chose to use the data flow diagram instead of the UML functional analysis techniques to present the functionality of the suite because we wanted to show the data flows between the service components by partitioning them into functions. The intention of this was to show the functional partitions of the suite, since this would help to clarify the functions of the services implemented in the suite. The functionality of the suite as seen in figure 5.2 is broadly divided into four categories, which is delivered through the services discussed in sub-section 5.4.1. The four functionality categories implemented in the prototype are:

- the service demand and supply *capturing* functions
- the service demand and supply *matching* functions
- the message *handling* functions
- the logistics service provider *management* functions

Each of the four categories of functionality is discussed in more detail as follows.

Service demand and supply capturing functions

The service demand and supply functions deal with registering the data that is needed before the logistics brokering process can be started. This group comprises functions that are included in processes 1 and 2 in figure 5.2, namely: input service demand and supply, location and destination data, and manage service providers. The data concerning service demand and supply is obtained from the bulletinboard, while the location and destination data is obtained from the service provider databases.

From an end-user perspective, the Infopreneur™ is dealing with a single service from a single point of contact, even though the actual service composition is done in a distributed and collaborative manner. The core platform offering the logistics services stays at the logistics service providers' sites, and the Infopreneur™ only accesses services that are exposed by these providers without the associated maintenance and update challenges. A standard graphical user interface is deployed to provide the Infopreneur™ with a means of interaction with the functionality of the prototype. To run the prototype, the Infopreneur™ needs to set up a Tomcat server on the machine on which the web services are deployed.

Through the user interface, the Infopreneur™ is able to input service demand and service supply details collected from the physical bulletinboard placed outside their office. These details are stored in an electronic bulletinboard that is modelled on the same principle as the physical one. Using the prototype, the Infopreneur™ can input details related to three types of logistics services: packaging, storage, and transport. The required service demand details include information ranging from the dates the service is required, the times, the required capacities, the origin and destination for transport service requests, to the type of goods being handled. The prototype was limited to these three types of services for testing purposes, and these were the most commonly occurring service requests observed during the case study. The demand and supply functionality requires the service demand and service supply information to be input by the Infopreneur™ using forms presented on a screen such as the one shown in figures 5.3 and 5.4.

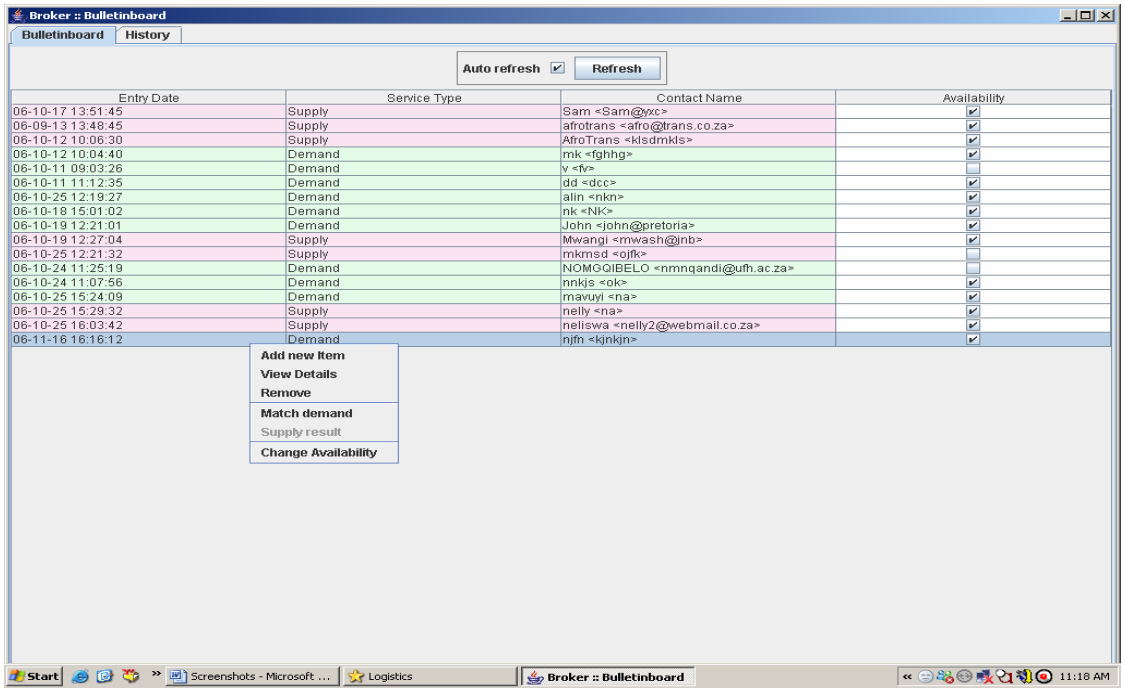


Figure 5.3: The broker's service demand and supply input screen

The functionality for gathering the location and destination data is implemented in a straightforward manner. The coordinates of a location are obtained from a database containing information on the locations, and the destination information for transport services is obtained from service provider databases or from the information published on the bulletinboard. Information regarding the location of a storage facility or details of the packaging services is also obtained from the service provider databases.

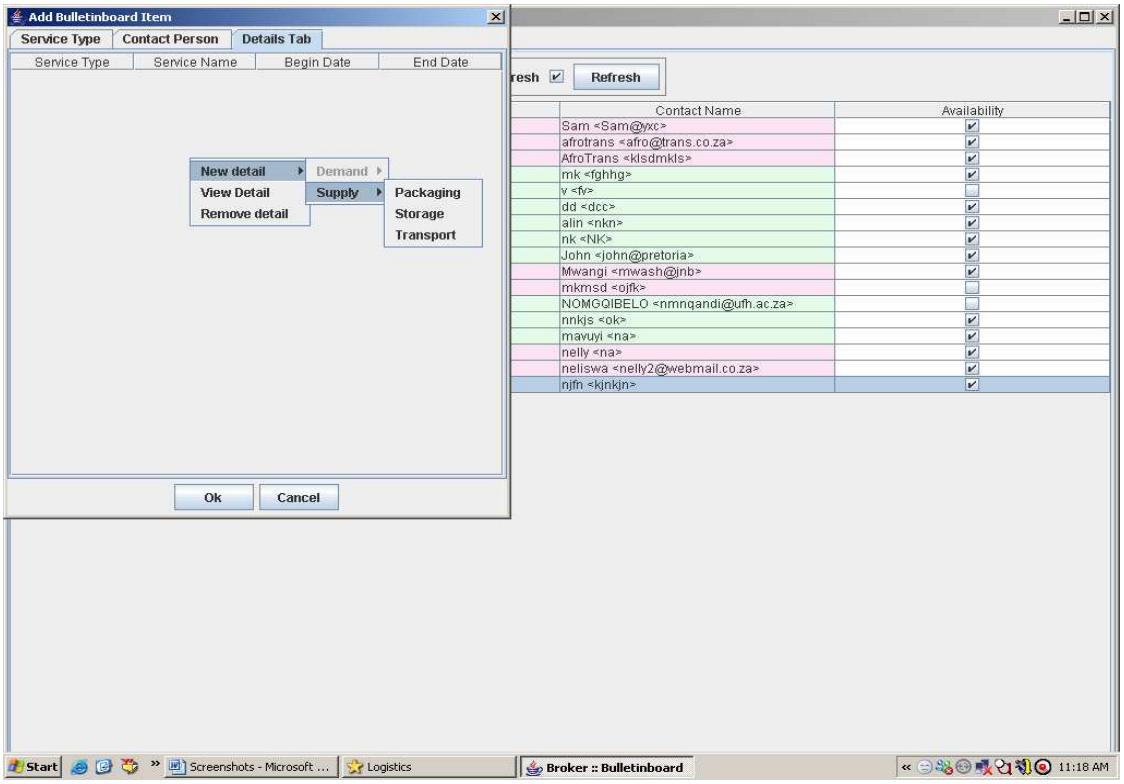


Figure 5.4: Adding service demand or supply details to the board

The demand and supply capturing function also implements services that enable the Infopreneur™ to locate, register, and maintain logistics service providers. The services enable the broker to connect to web services that have been exposed by logistics service providers that the broker can contact or obtain services from. Given that the prototype is developed based on web services technology, it uses endpoints to resolve the locations of the logistics service provider databases. In the implementation of the prototype, the service provider databases are stored locally on one computer, which also runs a Tomcat server to emulate a real life situation.

Service demand and supply matching functions

These functions comprise the processes 3 and 4 in figure 5.2, and use the service schedules and service match data. In order to schedule a service demand and to match it to a service provider, the Infopreneur™ needs to go through details of the available schedules from service providers before searching for service providers who can be matched to the service demands. The result of the service scheduling process is the assignment of service demands to service providers based on the time schedules and destinations they travel to in the case of transportation. In the case of storage or packaging services, the match is done based on availability of space or packaging capacity.

In general, the logistics service request data are entered by the Infopreneur™. For transport service demand requests, this data comprise the origin and destination, the times the service is required, the type of goods to be transported, the type of vehicle required to perform the transportation, e.g. open

body, refrigerated truck, etc., and other relevant information regarding the transport service demand request. The transport service demand is then matched to a given service provider who fulfils the criteria. When all details of the service demand have been agreed upon, the service will be scheduled. Once the service has been matched, information is sent to both the service provider and the customer demanding the services informing them that there is a match. This match is then processed and committed to the database at the Infopreneur™ site, and is placed in the history file.

The algorithm used to match demand and supply works at two levels: in the first instance, it attempts to look for service providers who can match the service demand directly from the local bulletinboard. This is known as a local match. In the second instance, if the service providers whose details are on the bulletinboard are unable to meet the requirements of the service demand request, the algorithm performs a remote search by connecting to service providers with a web presence. It is possible that not all components of the service demand request may be matched, and the Infopreneur™ is given feedback regarding this.

If a service demand request has been matched, i.e. there is a service provider who can deliver the service, the Infopreneur™ can choose to process and commit the service match. Doing this will remove the service demand entry from the bulletinboard and place it on the history file. At the same time, a message will be sent to the service provider informing them of their obligations to deliver a given services, while the customer will receive a message informing them that their service demand has been successfully matched. The two parties are also given details of their obligations. Figure 5.5 shows the results of a demand that has been successfully matched to supply.

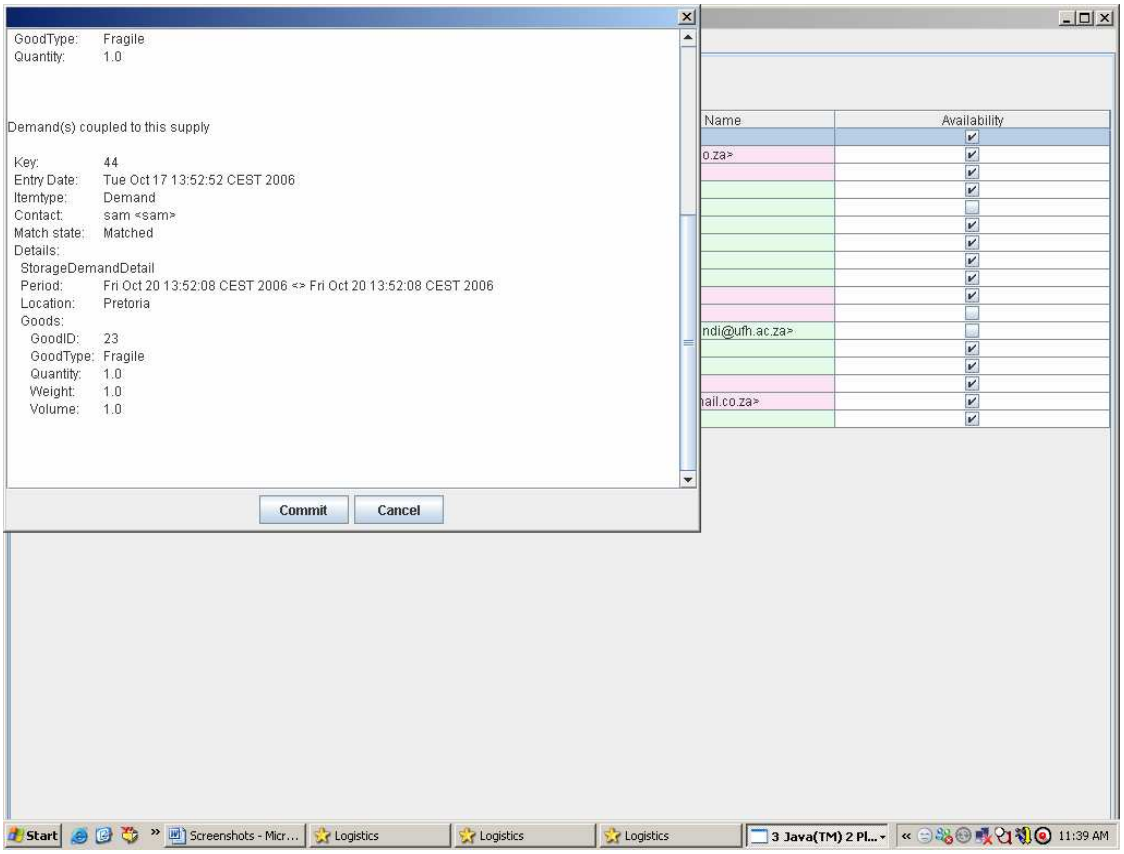


Figure 5.5: A matched service demand ready to be committed

The history file is used to store information related to service demand requests and service supply offers that have been processed from the bulletinboard by the Infopreneur™ in the recent past.

Message handling functions

The message handling functions are implemented in data processes 5 and 6, shown in figure 5.2. Once a service match has taken place, the service provider is informed of the service that is required of them, and at the same time a message is sent to the customer informing them of the service provider who will deliver the service they had requested. These messages contain details of the relevant trip information such as times, destinations, capacity, etc., and are dependent on the service required, e.g. transportation, storage, or packaging.

The messages sent to the service providers and customers are known as *forward messages*, while those that are returned from either the customer or the service provider confirming their agreement with the service match are known as *return messages*. A message such as the one shown in figure 5.7 is received after processing a service match, and it is sent to the service providers giving them full details of the service they are expected to provide. If the components of a service request are unmatched, the Infopreneur™ will receive a message and transmit it to both parties just as is the case with a matched service request.

Logistics service provider management functions

The logistics service providers send information to the Infopreneur™ through the service components 5 and 6 in figure 5.2 regarding their availability to provide services at any given time. These functions are implemented through services that allow logistics service providers to register their services with the server on the Infopreneur™ side such that their services can be found when the matching algorithm searches in remote service provider databases. Each exposed service provides an endpoint, and the individual service provider is responsible for maintaining their availability status and databases. The Infopreneur™ is able to update the bulletinboard with details of the service provider's availability and this is taken into account when the matching algorithm processes the service requests. A screenshot of service provider registration functionality is presented in figure 5.6.

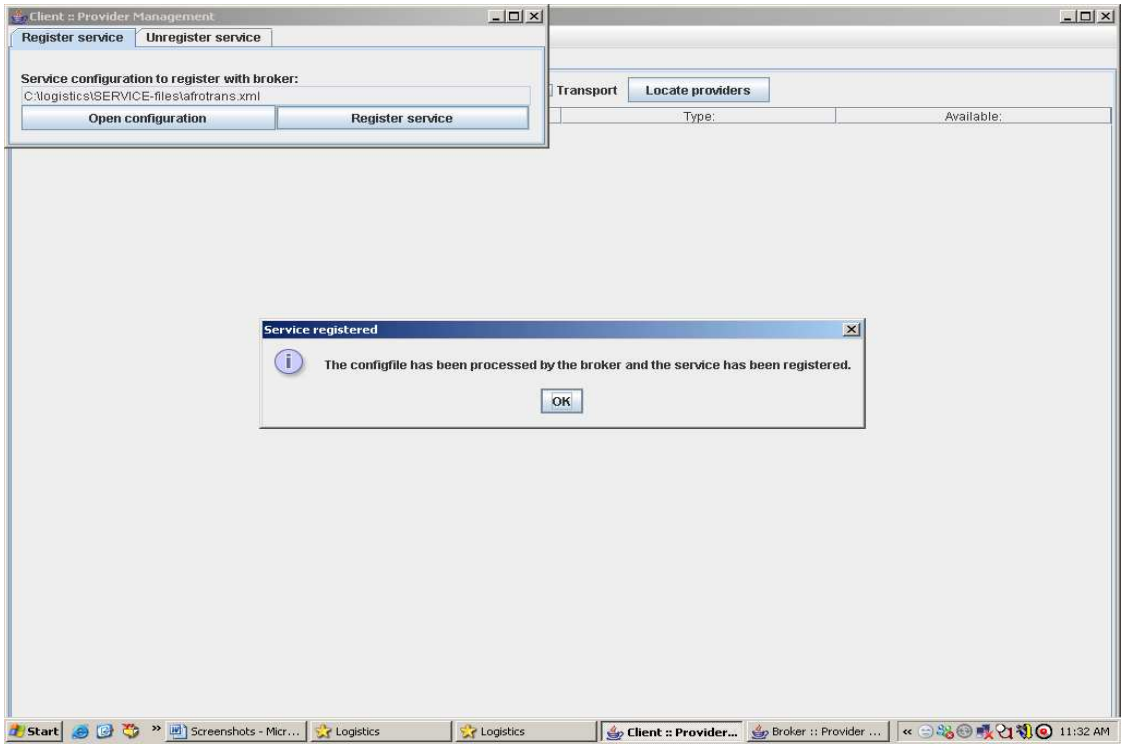


Figure 5.6: Registration of service providers at the broker

The functions of the suite as implemented in the prototype presented in this section were used to facilitate service brokers in developing logistics brokering services that fulfil local user needs. In essence, the implementation of the prototype as presented in this chapter fulfils the requirements of the suite presented in chapter 4. The functions of the prototype were tested on the end users in a case study, the details of which are presented in chapter 6.

5.5 Suite implementation considerations

In this section, we review some of the other implementation decisions that had to be made during the development of the suite. A prototype of the suite was developed using Java programming language, based on the UML class diagram presented in figure 5.1. For the purpose of creating a server on which to host the services, the Axis HTTP server was used as the web server for handling customer requests and keeping track of the services that were running at any given time. Apache Tomcat, an implementation of the Java Servlet technology, was deployed as the Java Servlet server for purposes of running the prototype. For persistent storage of data and results regarding the service providers and service customers, Oracle 9i with Java Database Connectivity (JDBC) was used as the database management system. The services presented in section 5.4 were all implemented in the prototype where they were developed in a loosely coupled manner using service-oriented design and modelling.

The prototype allowed the logistics service providers to expose and register their services with the service broker. The Tomcat server was used to deploy the web services at the broker side, and it was where the service providers could register their services through the service registry we created. The registry contained information about the service providers as well as details of whether their services were running or not. Each time the prototype invokes a function to search for logistics service providers' information is obtained from this registry. For practical and demonstration purposes, the service broker and logistics service providers' systems were both run on the same machine. The choice for using this approach to demonstrate the system was governed by the fact that the areas in which we were going to test the prototype did not necessarily have a stable or regular access to the Internet with which we could access remote service provider databases. There was need to demonstrate how the prototype performs the function of remote service invocation. We emphasize that this choice was made only within the context of demonstrating the functionality of the prototype.

The prototype was developed in a way that captured the essential characteristics of the logistics system in rural areas. Each of the services was developed as a separate, loosely coupled, component with the purpose of providing services only when required. The choice for doing this was motivated by the fact that the prototype was required to interface with and use some of the functionality of the existing inTouch Africa® software suite, as well as to use the services exposed by remote service providers. The inTouch Africa® suite is the one that is currently used to deliver services in rural areas, and once the functionality of the prototype is accepted by the users, the logistics brokering functionality would be incorporated into this system. It was therefore very important to ensure that the prototype supported loose coupling of services.

The functionality for matching service demand to supply was implemented in such a way that it enhances the use of local logistics service providers, and only invokes remote logistics service providers when a match is not possible from the local bulletinboard at the service broker. The algorithm first goes through the bulletinboard to see if any of the service providers who have offered to supply the service are able to meet the conditions set, and if not it connects to remote service provider endpoints. This was done to determine whether local matches to service requests

could be made, to make use of the available service supply within the region. This choice was also made for the purposes of reducing complexity in developing a matching algorithm.

Further, the prototype consists of two separate applications: the application for capturing and maintaining the service demand and supply details; and the logistics service provider application that takes care of the logistics service providers registering their services and responding to service offerings. These applications are executed simultaneously and independently of each other using service orientation and web services technology. The applications were developed in Java, using libraries for web services, and provide access to an Oracle database management system.

For the purpose of utilising the service supply available, and to create a service schedule, we chose to use a rule of exclusivity when checking which freight could be combined and transported using the same vehicle. We created categories that prioritize the cargo, i.e. high, medium, and low, and capture the fact that some freight cannot be transported together. In the prototype, the cargo that cannot be transported or stored with other cargo falls under the category “dedicated”. As well, some vehicles are categorised as “exclusive”. If two types of cargo fall under the dedicated category or the vehicle type is “exclusive”, then a match will not take place. For example, it is not possible to transport cattle in a refrigerated truck since these two are mutually exclusive. A piece of code from the class that implements these goods prioritization conditions is presented below.

```
public class CargoType implements Serializable
{
	/**
	 * @param cargoTypeID of the cargo type
	 * @param parent the parent of the CargoType
	 */
public CargoType(final String cargoTypeID, final CargoType parent, final String name, final String
description, final boolean dedicated, final CargoType[] excludedTypes)
	{
		super();
	}
	public boolean isCompatible(final CargoType type)
	{
		/** Equality */
		if (this.equals(type))
		{
			return true;
		}
/**
 * If the types are both dedicated they won’t match, or one gets explicitly excluded */
if (ArraySetUtil.contains(this.excludedTypes, type) || ArraySetUtil.contains(type.excludedTypes,
this))
		{
			return false;
		}
		/** Both root, they are not equal */
		if (this.parent == null && type.parent == null)
		{
			return false;
		}
		/** Find common father */
		final CargoType[] thisHierarchy = this.getHierarchy();
		final CargoType[] typeHierarhy = type.getHierarchy();
		int order = 0;
		while (thisHierarchy[order].equals(type) && order < thisHierarchy.length &&
		 order < typeHierarhy.length)
		{
			order++;
		}
		/** Fix order index */
		order--;
/**
 * If no dedication found above the mutual order the cargo can be transported together
 */
if (order <= this.getDominantDedicationOrder() && order <= type.getDominantDedicationOrder())
		{
			return true;
		}
		return false;
	}
	public boolean isCompatible(final CargoType[] types)
	{
		for (final CargoType type : types)
		{
```

```
                        if (!this.isCompatible(type))
                        {
                                return false;
                        }
                }
                return true;
        }
        private CargoType[] getHierarchy()
        {
                if (this.HierarchyCache == null)
                {
        /** Get the order */
        final List<CargoType> hierarchy = new ArrayList<CargoType>();
        for (CargoType parent = this.parent; parent != null; parent = parent.parent)
                        {
                                hierarchy.add(0, parent);
                        }
                this.HierarchyCache = hierarchy.toArray(new CargoType[hierarchy.size()]);
                }
                return this.HierarchyCache;
        }
}
```

The user interface of the prototype was implemented in a straight forward manner. As can be seen from the screen layouts presented earlier in this chapter, data entry is done using fill-in screens accompanied by pop-up menus from which to select the data entry item required. Once the data is entered into the system, the user has to confirm before it is committed to the database. The fill-in forms simplify data entry, and take the format of a physical bulletinboard such as the one that would be placed at the MPCC. The structure of the menus and fill-in forms was considered to be suitable for the prototype demonstration purposes since the aim was to present the users with a means to capture service demand and service supply, and match the two.

5.6 Conclusions

We started this chapter with a discussion of the actors and support provided when using a studio-based approach to deploy the prototype to improve and facilitate the development of ICT-enabled logistics brokering services. Based on the findings of the exploratory case study presented in chapter 2 and the theoretical framework presented in chapter 3, we stated that using a studio built around the challenges faced in logistics brokering services in rural areas would provide better support to the service brokers.

We presented some arguments in chapter 4, and explained how we derived and modelled the suite for deployment within the studio. Furthermore, we presented a set of requirements for services that must be contained in the suite, focusing on the three dimensions of usefulness, usability and usage. These requirements distinguish the studio-based approach from traditional service development approached since it enables us to create a balance between the three Us and to develop a suite that focuses on composing services from autonomously deployed services. The focus of the suite is to provide a loosely-coupled set of services to facilitate logistics brokering in rural areas.

6. Testing the suite

In this chapter we describe the test procedures carried out on a prototype of the suite to evaluate the utility of the suite in its application to logistics service brokering with rural South Africa as the area of study. The tests to evaluate the utility of the suite were carried out in an action research project. The suite resulting from the requirements defined in chapter 4 consists of software services for use in developing ICT-enabled logistics brokering services in rural areas. The prototype of the suite was developed as part of the overall objective of this research, which was to develop a studio that supports and improves the development of ICT-enabled logistics brokering services in rural areas. The aim of carrying out the tests was to evaluate the utility of the suite in facilitating the development of logistics brokering services that fulfil local needs. We also aimed to evaluate whether the suite is useful in supporting joint development of ICT-enabled logistics brokering services. We carried out the tests at rural sites gather information on the usefulness, usability, and usage of the suite in facilitating the development of logistics brokering services.

The case study-based testing approach was selected because we were introducing an artefact that provided facilitation for the development of logistics brokering services in rural areas. Following on the work of Hevner et al. (2004) we tested the suite in a controlled environment to evaluate its usability among the end users. For this, we needed to involve the stakeholders in empirical testing procedures to gather direct feedback on their experience in using the suite to develop logistics brokering services. This was carried out in two ways:

- in a test setting: to evaluate whether the functionality implemented in the prototype facilitates logistics brokering services from the logistics service practitioners' point of view

- in the daily work setting of the Infopreneurs™: to evaluate whether the prototype facilitates the day-to-day logistics brokering services delivery from the end-user point of view

The overall reasoning behind carrying out the tests was that the use of a suite would provide and improve the level of support offered to the Infopreneurs™ in their daily work activities of delivering logistics services. The support for logistics brokering services is offered through the application of the suite. Carrying out the tests on the application of the suite in a real life setting led us to provide answers to the fourth question of our research:

> *How can we use the suite to provide support for ICT-enabled logistics brokering services in rural areas of transition countries given their characteristics?*

This question was answered by fulfilling the activities presented in this chapter.

6.1 Background for the tests

Testing of the prototype was considered necessary to ensure interoperability, performance, and availability of the software services when developing logistics brokering services. Based on the work of Iyer et al. (2005), we identified two important steps that were of immediate relevance to this work and that were used to create the tasks and scenarios used in the testing procedure. These two steps were:

1. **Identification of the business workflows**: this process depends strictly on the business scope of the product. Key areas or workflows that represent the broader use of the product need to be identified, and should include both end-user and administrative workflow applicable to the production environment. We interpreted the product in the statement from

Iyer et al. (2005) to refer to the suite. This step was operationalised in the test case through identification of typical business workflows that take place when logistics service requests are made in a rural environment.

2. **Identification and creation of the necessary data**: this process closely follows the business scenarios that have been identified for testing. To cover the majority of the user base for the product, categorizing the data size into small, medium, and large is usually helpful. This can be accomplished by creating the basic content to cover the business workflow and building up the volume needed for small, medium, and large data sets. Typically, the basic data content could be used for functional testing while larger data sets could be used for system/integration testing.

   This step was operationalised in the case study by carrying out functional testing of the prototype among the logistics service practitioner using rural logistics scenarios. The purpose was to gather information on the potential application of a suite in handling service development needs in real life. To carry out the test effectively, we categorized the logistics brokering services into two broad categories: *simple services* i.e. brokered from one service provider and *complex services* i.e. brokered from more than one service provider. We also identified situations in which services could be brokered without interaction with a suite.

To carry out tests on the prototype with the stakeholders, the environment was a location in rural South Africa. This area was familiar to us given that it is where we got the initial user requirements for building the logistics brokering service system, and would therefore provide a good test environment for the services implemented in the suite. The aim of conducting the test in this environment was to study the utility of a suite in facilitating the development of ICT-enabled logistics brokering services. In carrying out these studies we were aiming to learn about the situations under which application of a suite would provide valuable support to the Infopreneurs™ in their daily work activities. We also aimed to learn whether the use of the suite actually improves the development of logistics brokering services. To carry out the actual tests, we adapted theories from previous research related to technology testing from the work of Davis, 1989; Venkatesh & Davis, 2000; Nielsen, 1994; and Hevner et al. 2004.

6.2 Theoretical basis for the test procedures

We built procedures for testing the prototype on the concept of the 3 U's taken from Keen & Sol (2007, which states that the *usefulness* aspect addresses the value that a suite adds to the decision-making process in the development of services, the *usability* aspect addresses the mesh between people, processes, and technology, while the *usage* aspect addresses how the suite is embedded in the decision process while developing logistics brokering services.

For measuring usefulness, we tested the application of the prototype in a real life situation by gathering information about how the functionality, embedded knowledge, and information resources implemented in the prototype facilitated the Infopreneurs™ in their work activities. The aim was to test how useful the functionality was for meeting the need for logistics brokering services in rural areas.

To measure usability, we carried out tests on how the prototype could be accessed concurrently and in a distributed manner, and how similar the prototype was to its conceptual blueprint. The aim of conducting these tests was to get both objective and subjective measures regarding what the users perceived about the concept of using a suite in logistics brokering, and whether they were capable of using it to develop logistics brokering services. We also studied whether the prototype supported

joint development of services, and how it contributed to the efficiency and satisfaction of the end users in achieving their specific work-related goals, in line with the work of Bevan & MacLeod (1994). The conceptual blueprint for the suite was agreed on with the stakeholders during the requirements elicitation exercise (see chapter 4), and it represented the typical business processes that a suite for handling logistics services in rural areas must possess.

To measure usage, we carried out tests on the prototype considering issues like how independent the technology was, how stable the prototype was, how open it was, and how reliable it was in handling the user needs. The tests carried out in this context were aimed at helping us to learn the important issues that need to be taken into account when using a suite to provide and improve the service development support.

6.2.1 The test plan

We tested the prototype in a case study in rural South Africa. Various instruments were used to test the 3 U's in the application of the prototype in the development of ICT-enabled logistics brokering services, measured on a 5-point Likert scale. Using validated items from prior related research (see Davis, 1989; Nielsen, 1992; Bevan & MacLeod, 1994; Endsley, 1988; Briggs et al., 2003), we applied the following theories.

- *Situation awareness rating technique*: this technique was used mainly to test the perceived **usefulness** of the suite in supporting the service brokers at work. The concept of perceived usefulness of a system is defined by Davis (1989) as the extent to which a person believes that using the system will enhance their job performance. We chose to use the theory on perceived usefulness because it enabled us to study whether using the prototype demanded more cognitive resources from the broker, such that they would actually prefer to use manual interventions in certain instances to perform their work. Details of the way we applied this technique are presented in sub-section 6.2.2.

- *Usability engineering lifecycle*: the usability theory behind this cycle is that it is nearly impossible to design a system right the first time. The theory presents the most basic elements in usability engineering as empirical user testing combined with iterative design (Nielsen, 1992). The concept of usability engineering was used to test perceived **usability** of the suite in the case study environment. We used the associated theories on usability of user interfaces from human computer interaction as presented in Nielsen, 1992; Nielsen, 1994; and Bevan & MacLeod, 1994. This enabled us to assess how the end-users applied the prototype for naturally occurring tasks. More details are presented in sub-section 6.2.3.

- *Satisfaction*: theories related to measuring the effectiveness, efficiency and satisfaction of using the suite were applied to test perceived **usability** and actual **usage** aspects of the prototype. Specifically, we used the satisfaction attainment theory and associated instruments from Endsley (1988) to assess effectiveness and efficiency of application of the prototype in the work activities of the end-users. We used ideas presented in the work of Briggs et al. (2003) to assess the satisfaction with which users of the suite achieved specified goals in carrying out tasks while using the prototype. The details are presented in subsections 6.2.3 and 6.2.4.

To put the test plan into practise, we used the following research instruments.

- *Observation*: this instrument was employed to make direct observations on the **usage** of the prototype in the naturally occurring logistics brokering tasks. The observations were taken

by the researcher as an observer, looking at how the subjects under study dealt with service demands and whether using the prototype to perform tasks occurred naturally.

- *Questionnaire*: this instrument was administered at the end of the prototype testing exercise. All the test subjects were required to fill in questionnaires related to the measures on usefulness, usability, and usage of the prototype in developing logistics brokering services.

A combination of the instruments and theories led us to carrying out the following practical steps:

- testing the functionality of the prototype with logistics service practitioners by creating a set of tasks directly derived from logistics brokering service scenarios in the rural environment in which the Infopreneurs™ work. The tasks were grouped into two broad areas: simple tasks related to logistics brokering services from a single service provider; and complex tasks related to logistics brokering services resulting from combining services from more than one logistics service provider.

- offline filling of questionnaires by the test subjects. The questionnaire was administered after the test subjects had been introduced to the prototype, and given a chance to use it on their own in fulfilling work activities. The aim of administering the questionnaire was to gather information related to the subject's experience of using the prototype.

- after the prototype testing session, brainstorming and general discussions over problems and possible solutions were carried out.

6.2.2 Testing usefulness

Logistics brokering services in rural areas require a lot of information regarding the local situation. With the help of a suite, information can be better generated, managed, and the resultant communication improved. This would lead to lowering of the cognitive load required to develop logistics brokering services in rural areas. We used a self-reporting method through a questionnaire to obtain individual user assessment of the amount of effort required to use the suite to develop logistics brokering services. One of the theories we used to test the perceived usefulness of the suite is situation awareness.

Situation awareness is a concept defined by Endsley (1988) as the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future. In other words, situation awareness involves perceiving critical factors; understanding what those factors mean, particularly when integrated together in relation to a person's goal; and an understanding of what will happen with the system in the near future. According to Endsley (1996) several methods have been established for the measurement of situation awareness, mostly involving the creation of a simulation of the system under consideration. Situation awareness can be measured directly through either objective or subjective means.

For the purpose of this study, we applied subjective means of measuring situation awareness to obtain data from the subjects while using the prototype. This was a conscious choice based on the fact that subjective measures are easier and less expensive to administer, and would still provide the required result. We employed the Situational Awareness Rating Technique (SART) developed by Taylor (1989). This technique enables system operators to rate system designs on the amount of demand on attentional resources, supply of attentional resources, and understanding of the situation provided. It considers the operator's perceived workload i.e. supply and demand on attentional

resources, and their perceived understanding of the situation as measures of usefulness of the system.

6.2.3 Testing usability

According to Bevan & MacLeod (1994), the usability of a product is a function of the context in which the product is used, and the characteristics of the context, i.e. the tasks, the user, and the environment, are as important in determining usability as the characteristics of the product itself. Changing any relevant aspect of the context of use may change the usability of the product. According to Nielsen (1992) there is need to carry out usability studies to assess how real users use a system for naturally occurring tasks in their real world working environments, since this can lead to insights not readily available from laboratory studies. In this study, we tested the usability of the suite among the Infopreneurs™ using the theory presented in Nielsen (1992), which requires end-users of a product to apply it in their work practise.

In the tests we asked the Infopreneurs™ to perform logistics brokering service tasks at a broad individual level and at group level thereby requiring them to collaborate to achieve the service goal, i.e. concurrent development of logistics brokering services using the prototype. The purpose of these tests was to obtain measurements related to joint development of logistics brokering services using a suite, and to study whether the way of working with a suite supported the context of the Infopreneurs™ work activities.

In carrying out the usability tests, we focused on the context of use as the central part of the study. Given this context, we were concerned with attributes that had influence on the perceived usability of the prototype in tasks performed by its users. According to Bevan & MacLeod (1994), when measuring usability, it is important that the conditions for the test are representative of important aspects of the overall context of use. In this study, we based the usability tests on what we considered to be the most important task-related attributes such as the type of users, their skills and knowledge levels in performing the task, the kind of tasks they were to perform, and their environment i.e. organizational, physical and technical. The purpose of carrying out these tests was to measure user performance, user satisfaction, and the cognitive workload when using a suite in logistics brokering services.

6.2.4 Testing usage

We tested the usage of the suite by assessing the levels of satisfaction among the subjects while working with the prototype. From the work of Bevan & MacLeod (1994), we learnt that measures of satisfaction describe the perceived usability of the overall system by its users and the acceptability of the system to the people who use it and to the other people affected by its use. Measures of satisfaction may relate to specific aspects of a system or may be measures of satisfaction with the overall system, and can provide useful indicators of the user's acceptance of the system. We used these measures to test the usage of the prototype based on the scenario and tasks set for the logistics service practitioners, and the real life work logistics brokering activities carried out by the Infopreneurs™.

To put this into the research context we used Satisfaction Attainment Theory (SAT), which is a causal theory that was originally proposed by Briggs et al. (2003) to explain mechanisms that could give rise to satisfaction and dissatisfaction responses when using group support systems. In SAT, a list of questions is developed to measure the satisfaction of the participants in a group process. For this research, we adapted the ideas from Briggs et al. (2003) and developed a set of questions that were directly related to usage of a suite in actual service delivery to measure the perceived value achieved by the users, and the satisfaction they got from using the prototype in performing the

tasks. We tested whether the prototype supported the Infopreneurs™ in addressing the key challenges of logistics service brokering in their locations. We tested whether the prototype could be used in the Infopreneurs™ daily work environment, and whether it fitted within their service delivery context.

6.3 Methodology for testing the suite

To assess the functionality of the services implemented in the suite, we needed to get attitudes from logistics domain practitioners who could assess the suite as a tool to support the development of services in rural areas. A test was carried out with a group of rural logistics service practitioners, building on the theories presented in section 6.2. The test was followed by two separate field studies carried out in groups among Infopreneurs™, based on the issues and challenges identified in chapter 2. The prototype was used in research sites that reflected the situations which we would like the results to generalise, that is, rural areas in which application of a suite for logistics brokering services would improve the delivery of services. The criteria used for selecting the case study sites were:

- typical rural area characterised by low levels of service delivery. The reason for this criterion is that the use of a suite to develop ICT-enabled logistics brokering services in such areas is expected to improve the level of logistics service delivery through the bundling of different services together to maximise use of resources. The services do not have to be hosted locally within the environment, but can be accessed remotely.

- an area in which logistics brokering services would definitely play an important role in improving the delivery of logistics services. The reason for using this criterion was that the freight volumes to be transported to and from the rural areas are very low and the average size of the loads can be increased through the use of brokering services that support the consolidation of service demand and supply. This offers the chance to improve the efficiency of logistics service delivery.

- areas in which ICT-enabled services have begun to be implemented as a means to support and improve service delivery. For this research, we chose areas in which the inTouch Africa® toolbox is implemented and used, since the ability to use the toolbox in the rural setting implied a familiarity with using ICT-enabled interventions for service delivery. This was considered important since the prototype is ICT-enabled.

- areas in which local service brokers are available. For this research, we chose areas in which the Infopreneurs™ were available. The Infopreneurs™ are the local service brokers who will be delivering the logistics brokering services as part of their portfolio of services. They are familiar with operations of the inTouch Africa® toolbox in which the logistics brokering services functionality is to be incorporated. The logistics brokering services will be delivered through the Infopreneurs™ office, and they are the end-users of the suite.

- areas in which logistics brokering services have shown the possibilities of playing a key role in the service delivery activities of the local service brokers. For this study, the choice of location with Infopreneurs™ was based on the fact that such areas had clearly shown the need for logistics brokering services.

The rural logistics service practitioners were used to test functionality of the prototype, to obtain feedback regarding whether the prototype provided utility that would actually facilitate the development of logistics brokering services. During the test they were introduced to the complete

functionality of the prototype, and given the chance to carry out logistics brokering service tasks using it. Based on their experience with the prototype and knowledge of the environment in which the prototype would be applied, they suggested the sites in which we carried out the tests on application of the prototype in real life.

Using the criteria presented, we identified two rural sites on which to base the tests. The sites selected were involved in providing services to a range of rural locations, each with differing logistics functional areas, regional context, and differing interests in types of services delivered. In addition, we selected these rural locations because they were considered to be ready for, and in need of, the introduction of ICT-enabled logistics brokering services as a means for handling the problems that had been identified earlier through the exploratory case study. The main characteristics of the test sites are summarised and presented in table 6.1.

Characteristics	Site 1	Site 2
Service delivery context	Rural SMEs	Academic (university)
Logistics functional area	Transport	Transport
Type of service	Laundry; mail	Ticketing; transport scheduling
Personnel skills in ICT-enabled service delivery	Range from moderate to good	Range from moderate to good
Motivational factor	Pre-determined need for logistics brokering services	Services can be improved through logistics brokering

Table 6.1: Characteristics of the test sites

The two rural sites were ecologically different. The first site was chosen based on the fact that usage of ICT-enabled logistics brokering services had already been determined as being highly desirable given the location and prevailing conditions in the area. Selection of the second site was based on the idea that the nature of business carried out would improve greatly from the application of ICT-enabled logistics brokering services. In all the tests that were carried out, i.e. one with the logistics service practitioners and two with Infopreneurs™, questionnaires were administered after the subjects had actually used the prototype to develop logistics brokering services to meet local needs. The purpose of administering the questionnaire was to measure the subjects' perceptions of using the prototype in performing their daily work activities. We also wanted to test their experience in using the prototype. The questionnaires are presented in appendix 2.

6.3.1 Units of analysis

The main units of analysis for the case study and testing of the prototype were based on the functionality of the suite and its actual application in the development of logistics brokering services. The units of analysis are derived from the need to test real life application of a suite to assess whether it facilitates local service brokers in the development of services that fulfil local logistics needs. The units of analysis are presented below.

1. *The end-users of the suite*: taking this as unit of analysis was aimed at providing information regarding interaction of the users with the suite, and the support provided by the services of the suite in developing logistics brokering services.

2. *Application of the suite in the work process*: using this as a unit of analysis provided information on the multi-actor nature of the logistics service development network in rural areas, and the improvement in efficiency and effectiveness gained when using a suite to develop local logistics brokering services.

3. *Ability of the user to develop services in their daily work activities using the suite*: we mainly studied how the use of a suite would facilitate joint logistics brokering service development. We also considered observable results achieved from using the suite to deliver logistics services in real life situations.

4. *Agility of the suite in developing services*: this unit of analysis was mainly used to study the functional contribution of using a suite in developing logistics brokering services in the rural areas. The information gathered was based on functionality of the suite in facilitating the development of services that meet local needs.

The test carried out with the rural logistics service practitioners was designed to determine whether the services of the suite were representative of the rural logistics domain. The measures were taken on the 3 dimensions of usefulness, usability, and usage.

6.4 The data sample

The main subjects of our case studies were service brokers, known as Infopreneurs™, operating in the rural areas. The activities and services delivered by these Infopreneurs™ vary a lot and depend mainly on the location they are servicing. The initial tests for functionality of the prototype were carried out with the rural logistics service practitioners, after which the Infopreneurs™ were given the chance to use the prototype in actual service delivery activities. This was followed by an evaluation of the prototype based on the 3 U's. A summary of the steps that were used in testing the prototype is given in figure 6.1.

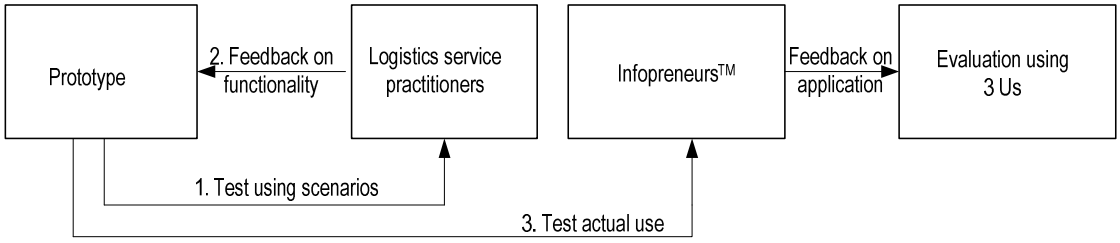


Figure 6.1: Steps in testing the suite

The results of the test with the rural logistics practitioners provided guidance on focusing tests among actual end users of the suite, the Infopreneurs™. The prototype contains appropriate services to support the Infopreneurs™ in rural areas to develop logistics brokering services irrespective of their remoteness to the markets. The purpose of the services implemented in the prototype is to support the development of ICT-enabled logistics brokering services in such a way that allows seamless operability between participants in the logistics value chain. The benefit of this is that the Infopreneur™ is able to develop logistics brokering services that allow rural communities to overcome barriers of remoteness, especially if participating organizations can share their knowledge.

The logistics brokering service system is enabled by ICT, with the aim of improving the current service delivery interventions in rural areas. Compared with the existing situation in which there are no logistics brokering services, the new service system is designed to assist in solving some of the logistics problems such as the coordination of low supply chain volumes and the consolidation of small freight loads. Currently, the service brokers are not in a position to determine the demand and

supply of logistics services within their regions, and information such as who is doing what, when, where, and unto whom is lacking.

The prototype introduces the functionality of a bulletinboard that is used to collect all information related to supply and demand for logistics services in an area. The prototype also provides a service for matching demand to supply that is used to consolidate logistics service demand by matching demand to supply either locally i.e. from the bulletinboard, or remotely i.e. from service providers exposing their services, as explained in chapter 5. It also provides cataloguing functionality and message handling functions for passing messages to and from the broker, in addition to providing functionality that allows logistics service providers to communicate their availability to deliver services. The prototype is modelled on out-bound logistics services, and is concerned with logistics brokering services for moving people and goods from the Infopreneurs™ area of operation.

6.4.1 Rural logistics service practitioners

Through the exploratory study and findings from the requirements elicitation exercise presented in chapters 2 and 4, we learnt that there was need to introduce ICT-enabled logistics brokering services as a means of solving some of the transport-related problems faced in rural areas. Based on the findings, a prototype implementing the logistics brokering service system was developed with the intention that, after successful testing, its functionality would be scaled up and introduced to the end users via the currently used inTouch Africa® application suite.

The subjects of this test were 6 practitioners involved in rural logistics service development and 2 practitioners in rural ICT-enabled services development. They were introduced to the functionality of the prototype and how it can be used to facilitate the development of logistics brokering services. In their normal work activities, these subjects are involved in performing various tasks related to the design and development of both ICT and non-ICT enabled logistics services for use in rural areas.

A two-hour training session was conducted to educate the subjects on the use of the prototype and its software environment, with the aim of demonstrating all the functionalities and services of the prototype. The demonstration was followed by an open question and answer session with the researcher acting as a facilitator to clarify the functionality of the prototype. The subjects were given an opportunity to air their views regarding what they thought of the software services and functionality of the prototype in handling the logistics problems earlier identified. The subjects were then given the opportunity to create their own logistics brokering services with the prototype based on scenarios developed from a rural environment. After the test exercise the subjects were asked to fill in a questionnaire on their experience with using the prototype to perform the task of logistics brokering.

6.4.2 Infopreneurs™

Site 1: Sterkspruit Infopreneurs™

The subjects of this study were 3 Infopreneurs™ operating in a highly active MPCC that is centrally located in a rural town called Sterkspruit. The MPCC provides all kinds of services ranging from disseminating government produced information to delivery of tele-centre services. At present, the Sterkspruit Infopreneurs™ service is mainly involved in delivery of the tele-centre services. All the subjects at this test site are ICT literate, and perform various activities related to the brokering of different types of customer services such as the selling of bank products, video recording, keeping catalogues of guesthouses in their municipality, and acting as a one-stop shop for servicing other community needs. The circumstances presented were ideal for testing the suite.

At the time of the study, the subjects were faced with the task of developing the transport services required by the laundry service in their region. Currently, the nearest laundry to Sterkspruit town is located in Bloemfontein, which is about 250km away. The vehicle that picks up or drops the laundry items travels to and from Bloemfontein twice a week regardless of whether there is any item to be picked or not. This results in empty miles being generated every week. A desire has been expressed for the development of a service that can inform the laundry services when they should send a vehicle, and also if they can piggy-back some of the other transport needs such as mail delivery. The biggest client for the mail delivery service would be the local municipality office, which has shown a need for a service system that they could use to schedule transport for the delivery of post between different municipality offices within the district. Using the functionality provided by the suite, some of the problems being faced can be alleviated.

The subjects were unfamiliar with the use and functionality of the suite. A one hour on-site training session was conducted to educate them on the software services of the suite and its functionality, showing how its application may benefit them in their normal working environment. After the introduction and demonstration, the subjects were given a chance to play with the suite and to familiarise themselves with how it could be used to support their work activities. Given that the suite would introduce a new way of working for developing ICT-enabled brokering services when fully implemented, the subjects were given continued access to the suite and allowed to use it in performing their logistics service tasks for the rest of that particular day. Whenever there was need for it, the subjects were allowed to carry out their tasks the way they normally do without the use of ICT-enabled support tools since the test was being carried out in the work environment with no control over the environmental variables. After the test, a questionnaire was administered to measure the subjects' experience in using the prototype to perform their logistics-related tasks.

Site 2: Alice Infopreneurs™

The subjects of this study were 3 practising Infopreneurs™, operating in a medium-sized community development centre based in the University of Fort Hare, a large university in the Eastern Cape Province. The Infopreneurs™ possess ICT skills and run a business that involves delivery of service bundles to their immediate community. The university is located in a rural town called Alice, with no major urban centres near it. The clientele of the Alice Infopreneurs™ service mainly consists of students who apart from having other needs, require transport services to and from main cities especially at the end of the semester or on long weekends and holidays. The university is located in a small town but many students come from far flung areas.

At the moment, when the students need to purchase a ticket for their trip home, they are forced to travel a very long distance to King Williamstown (over 50 kilometres) or to East London (over 70 kilometres), which are the nearest urban areas. This is an activity that takes a lot of money and time. The Alice Infopreneurs™ service has worked out a business plan that aims to change this situation. They have introduced a transport brokering service that attempts to solve the problems of their clients. In using this service, the day-to-day transport-related activities that the Alice Infopreneurs™ office carries out include gathering information about who would like to go to which city and using which mode of transport, details of what they would like to transport, and connecting the students to the transport service providers whenever they have a need to schedule the transport demand to transport supply. Their tasks are only related to ensuring that the students can make their bookings without having to travel a long distance.

Currently, the Infopreneurs™ use a manual system to perform this task, although they have the inTouch Africa® software toolbox installed on two computers used to perform their other mostly database-related activities. The intention is that if the suite proves beneficial to their operations, a complete suite for ICT-enabled logistics brokering will be built into the inTouch Africa® toolbox to

support them in their service delivery. The subjects had no prior knowledge on the operations of the prototype suite, and the purpose of introducing them to it was to give them an idea of how their transport brokering-related service tasks could be improved through the use of an ICT-enabled suite. We also aimed to study how the work of the Infopreneurs™ is facilitated through application of the suite in service development.

The subjects received two hours of training on the application of the suite in handling the logistics service requests they faced regularly. They were shown how they could improve their service delivery using ICT, through application of the suite. The introduction and demo were then followed by two hour hands-on practise session to familiarize them with the use of the suite in carrying out transport brokering-related tasks that arise as part of their daily routine. After using the suite the subjects were asked to fill in a questionnaire to measure their attitudes towards using the suite. All 3 subjects at this site participated fully in the study and provided usable responses on all measures.

6.5 Measurement scales

Theoretical constructs for measuring the usefulness, usability, and usage of the prototype were operationalised in the case study using ideas taken from the work of Keen & Sol (2007). The scales of usefulness and usage were measured using validated items from previous research adapted from the work of Davis (1989), while usability was measured using validated items adapted from the work of Nielsen (1994). We developed a questionnaire that required the subjects to respond to various items regarding the use of the prototype in ICT-enabled logistics brokering services. The questionnaire contained three parts: demographic information, closed-ended questions, and open-ended questions. A copy of the questionnaire is attached in appendix 2.

The closed-ended items were measured on a 5-point Likert scale on which the subjects filled in their responses ranging from 5 (Strongly Agree) to 1 (Strongly Disagree), regarding application of the prototype to develop logistics brokering services. This part of the questionnaire consisted of statements for measuring both the subjects' positive and negative attitudes. For the positive statements, we infer from a response of 5 (Strongly Agree) that the users of the prototype thought that the statement represented a positive perceived attitude towards the application of a suite in logistics brokering. For the negative statements, we infer from a response of 1 (Strongly Disagree) that the users were satisfied with an aspect of the prototype, and were therefore in disagreement with what was in the statement.

We used the 5-point Likert scale because previous research revealed that such a scale had been successfully used and validated in carrying out other technology related studies (e.g. Venkatesh & Davis, 2000). We also felt that the 5-point scale adequately represented the spread between the different responses, and was deep enough to enable the gathering of required information. The section of the questionnaire on demographic data of the subjects was intended to gather information that could show whether the subjects had enough ICT experience and knowledge to apply and make an assessment of the prototype. The logistics service practitioners were not required to fill in these demographic details. The data collected on demographics of the Infopreneurs™ is presented in table 6.2.

Item	No. of respondents
Gender:	
Female	6
Male	-
Experience in use of ICT-enabled services:	
Email	6
Web browsing	6
Voice (over mobile or fixed line)	6
Professionally working with ICT-enabled services	6
Other	-
General skill level in ICT usage:	
Low	-
Moderate	3
Good	3
Proficient	-
Education level:	
Matriculation	6
College diploma	-
Degree	-
Other	-
Experience with functionality of inTouch Africa®	
Little	1
Moderate	2
Good	3
Proficient	-
Understanding of local transport service needs	
Poor	-
Moderate	4
Good	2
Domain with most need for logistics brokering services	
Health	
Education	1
Agriculture	1
Small businesses	4
Other	-

Table 6.2: Demographic information about the Infopreneurs™

The questionnaire items were intended to measure perceived user attitudes on how the prototype facilitated the Infopreneurs™ in logistics brokering services. We measured these using self-reporting mechanisms such as the amount of time it took them to learn how to use the prototype, the amount of time it took them to perform the given task using the prototype, and whether they would have preferred to do the same task without applying ICT-enabled interventions. Observation was also used to complement the questionnaire and to study the actions and reactions of the subjects while working with the prototype.

The data presented in table 6.2 provides demographic information on the Infopreneurs™. They were all considered to possess the level of education required to perform the tasks required in the tests on the prototype. They all had matriculation qualifications, which is the minimum requirement for the Infopreneurs™ job. As can be seen from the table all the Infopreneurs™ had an adequate level of experience in using ICT-enabled services and were all able to work professionally with ICT, 50% of the Infopreneurs™ had good skills in using ICT while the other 50% had moderate skills. The implication of this was that we were able to rely on the findings obtained from the Infopreneurs™ to meet the objectives of the study. The prototype we were testing is designed for use in facilitating logistics brokering services, and to use it requires people to have at least moderate level of ICT knowledge.

Fifty percent of the Infopreneurs™ had a good working knowledge of the inTouch Africa® software toolbox, while the other 50% had low to moderate experience in using the toolbox. The implication of this was that we could gauge the attitude of the Infopreneurs™ on how using a suite would potentially add value to their daily work activities. They regularly use other functionalities provided by inTouch Africa® to deliver ICT-enabled services, and would be dealing with a familiar concept when the logistics brokering service functionalities are introduced to them.

The data in table 6.2 also shows that 60% of the Infopreneurs™ had moderate knowledge of the local transport needs, while the other 40% had good knowledge of the local transport situation. We took this to imply that we could rely on their local knowledge in making an assessment of how using the prototype facilitated their daily work activities. We then looked at the data collected in the second part of the questionnaire using closed-ended questions. The section of the questionnaire with open-ended questions was used to gather information on perceived attitudes of the subjects on various aspects of the prototype, and to collect valuable suggestions for improvement based on the user experiences in logistics brokering using the prototype.

We will now present the detailed procedure used to test the prototype, to measure the users' attitudes and perceptions, and to gather relevant information for this research. We used frequency scores to measure each of the responses, and abstained from using more sophisticated measurement techniques for determining the quality of responses by the subjects because:

- comparison could only be made with situations in which the Infopreneurs™ had experience in logistics brokering services without using a suite. There was no way of knowing whether the ability of the subjects to complete a task in a short time using the prototype would be considered a good or poor performance.

- the subjects were not chosen randomly. The rural logistics service practitioners were directly involved in rural service development, and were purposively selected because of their experience and knowledge in rural logistics services. The sites in which tests were carried out with the Infopreneurs™ were selected on the basis that they were the only ones with Infopreneurs™ already in place at the time of the study.

- the number of subjects involved was small, but was thought to be good enough to enable us to draw relevant conclusions that were of value to the research. From the work of Nielsen (1994), we learnt that increasing the number of subjects when testing the prototype would not necessarily provide more information than what the subjects had already provided. Nielsen (1994) states that what is important in such a study is that the subjects are the actual end users of the system that is being tested on them. The Infopreneurs™ were the end users of the suite.

Based on these reasons, we chose to use non-parametric statistical tests to analyse the data, since these tests would allow us to make various assumptions about the distribution of the responses given to the statements in the questionnaire. Siegel & Castellan (1988) define a non-parametric statistical test as one that is based on a model that specifies only very general conditions and none regarding the specific form of the distribution from which the sample was drawn.

6.6 Data collection procedures and tests on the suite

Although the demonstration, specific initial training, and introduction to the prototype were different in each research site, the process of application of the prototype and questionnaire administration was similar. The differences were mainly due to varying skills level among the

subjects which meant that in some cases more detail had to be included in the demonstration while in other sites this was not necessary. The subjects were first introduced to the prototype and given a brief demonstration of how it is operated and what results to expect. They were then given an opportunity to ask questions regarding application of the prototype. They were also given a chance to perform hands-on tests with the prototype, which enabled them to become more familiar with its functionalities.

After the rural logistics service practitioners had indicated that they were ready to perform the testing exercise they were presented with a local scenario and a set of tasks which, when completed using the prototype, would to result in logistics brokering. On their part, the Infopreneurs™ were either expected to use existing requests for transport services or to use the prototype in the actual delivery of logistics services as and when users came into their premises. At the end of the testing exercises, the subjects filled in a questionnaire regarding their attitudes and experience in using the prototype to carry out logistics brokering.

The questionnaires were distributed in hard copy, marked with the identifier of the location in which the test was carried out, the context, and the user category to keep track of responses and to ensure that the external validation of the research would not be based on biased information. To preserve privacy and confidentiality, the subjects were not required to indicate their names on the questionnaire, and were asked to place the completed questionnaires in a box so that the researcher could pick them up later without knowing who had filled in which questionnaire. This was considered to be adequate as a fairly low-level precaution for eliminating bias in the data collection procedure.

The purpose of administering the questionnaires after practical usage was to measure the subjects' experience in using the prototype for logistics brokering services. The subjects' attitudes and reactions to using the prototype were considered to be important since they would provide the kind of feedback required in assessing whether using a suite facilitated the Infopreneurs™ in developing logistics brokering services that met local needs. The Infopreneurs™ were expected to use the prototype to develop logistics brokering services under little or no supervision from the researcher, just as they would in real life situations. The responses to the questionnaires were intended to give usable information for this research on the dimensions of usefulness, usability and usage of a suite in logistics brokering. This would contribute towards fulfilling the overall aim of supporting the development of ICT-enabled logistics brokering services in rural areas.

6.7 Results

As reported in section 6.4, the purpose of carrying out the initial test case with the rural logistics service practitioners was to test the functionality of the services implemented in the prototype. We wanted to gather feedback regarding whether the services provide the required support to facilitate logistics brokering services in the rural environments. After the test with the rural logistics service practitioners, we carried out field tests with the Infopreneurs™ in their work environments to study the application of the prototype in actual logistics brokering.

According to Jamieson (2004) and Tastle et al. (2005), using the mean or standard deviation to analyse data on a Likert scale is not appropriate since response categories in Likert scales have a rank order, and the intervals between the values cannot be presumed equal. Further, Jamieson (2004) observes that Likert scales fall within the category of ordinal level measurement and recommends that for ordinal data, one should employ the median or mode as the measure of central tendency because the arithmetical manipulations required to calculate the mean and standard deviation are inappropriate for ordinal data where numbers generally represent verbal statements.

Ordinal data may be described using frequencies and/or percentages in each category (Jamieson, 2004; Blaikie, 2003). On how to use data on Likert scales Knapp (1990) advices that non-parametric tests should be employed if the data is clearly ordinal. Our data was considered to be ordinal.

To put the preceding discussions into the context of this work, the findings of the testing cases both for the rural logistics service practitioners and Infopreneurs™, are summarised in frequencies and presented in tables 6.3 - 6.8 based on the 3 U's. The numbers in the tables represent the frequency of responses to a given statement on the Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree); n is the number of subjects; $\bar{x}$ is the mean; σ is the standard deviation; and m is the mode, which refers to the most frequently occurring response. While the mean and standard deviation are calculated and presented in the tables, they are not used as the basis for the data analysis since the aim was not to compare the averages over several tests, nor to compare averages between a new and old situation. Instead the values are used to support the arguments regarding acceptability of the mode, and are given as indicators of the general spread of the responses obtained from the subjects. The data analysis is mainly based on the frequencies, *m*, as indicators of perceived attitudes of the subjects following on the work of Jamieson (2004) and Blaike (2003) who state that frequencies are appropriate to describe ordinal data.

6.7.1 Usefulness

In tables 6.3 and 6.4, we list the frequencies with which the two different groups of subjects responded to each of the 14 items of the questionnaire that were used to measure usefulness of the prototype. For the positive statements, we arbitrarily took the mode value of 4 (Agree) as the cut-off for a good result, since this is higher than the neutral value of 3 on the Likert scale that was used. For the negative statements, we arbitrarily considered a mode value of 2 (Disagree) as the cut-off for a good response. The value of the mean is also used to support the explanation for the mode if the mean is higher than the neutral value for the positive statements and if it is lower than the neutral value for the negative statements.

Usefulness	Logistics practitioners n=8							
	Answer							
	1	2	3	4	5	$\bar{x}$	σ	m
The suite presents me with an accurate model of what I need for my work	0	0	3	3	2	3.88	0.835	4
I am able to complete the task quickly using the suite	0	0	2	5	1	3.88	0.641	4
The suite is useful for me in creating my services	0	0	2	1	5	4.38	0.916	5
The suite supports my understanding of basic concepts of logistics	0	0	3	5	0	3.63	0.518	4
Too much effort is required in developing services using the suite	2	6	0	0	0	1.75	0.463	2
I can focus on important logistics issues and not distracted by details	0	0	1	3	4	4.38	0.744	5
The suite provides many elements such that I cannot concentrate on any	2	4	2	0	0	2.00	0.756	2
The messages I get and the log files enable me to develop services better	0	0	4	4	0	3.50	0.535	4
The suite does not really do what I want it to do when working with it	1	6	1	0	0	2.00	0.535	2
The suite provides me with a lot of useful functions for brokering	1	0	0	3	4	4.13	1.356	5
The software services of the suite correctly represent the situation in my area	0	0	0	6	2	4.25	0.463	4
I have enough knowledge and experience to fill in any gaps left out in the suite	0	0	1	2	5	4.50	0.756	5
In general, I do not see any added value in using the suite to perform the task	6	2	0	0	0	1.25	0.463	1
In general, I would prefer to carry out the same task without the suite	5	3	0	0	0	1.38	0.518	1

Table 6.3: Responses from logistics practitioner on usefulness of the prototype

Usefulness	Infopreneurs™ n=6							
	Answer							
	1	2	3	4	5	$\bar{x}$	σ	m
The suite presents me with an accurate model of what I need for my work	0	0	1	4	1	4.00	0.632	4
I am able to complete the task quickly using the suite	0	0	2	3	1	3.83	0.753	4
The suite is useful for me in creating my services	0	0	1	4	1	4.00	0.632	4
The suite supports my understanding of basic concepts of logistics	0	1	3	2	0	3.17	0.753	3
Too much effort is required in developing services using the suite	0	3	1	0	2	3.17	1.472	2
I can focus on important logistics issues and not distracted by details	0	0	1	4	1	4.00	0.632	4
The suite provides many elements such that I cannot concentrate on any	1	3	1	1	0	2.33	1.033	2
The messages I get and the log files enable me to develop services better	0	0	0	4	2	4.33	0.516	4
The suite does not really do what I want it to do when carrying out the task	2	3	1	0	0	1.83	0.753	2
The suite provides me with a lot of useful functions for service development	0	0	1	3	2	4.17	0.753	4
The software services of the suite correctly represent the situation in my area	0	0	0	5	1	4.17	0.408	4
I have enough knowledge and experience to fill in any gaps left out in the suite	0	2	3	0	1	3.00	1.095	3
In general, I do not see any added value in using the suite to perform the task	1	2	2	1	0	2.50	1.049	3
In general, I would prefer to carry out the same task without the suite	0	2	1	3	0	3.17	0.983	4

Table 6.4: Responses from Infopreneurs™ on usefulness of the prototype

For results in which multiple values of the mode were encountered, we chose to take the highest value of *m* for the positive statements, and the lowest value of *m* for the negative statements. This was so especially if the data was skewed around high values for the positive statements or around the low values for negative statements. Several observations can be drawn from the responses presented in tables 6.3 and 6.4 regarding the perceived usefulness of the prototype. In the first place, we can infer that the overall perception among the two groups of subjects is that the prototype was considered to be useful in logistics brokering in the test areas. The use of a suite is likely to be well received as a means of supporting the Infopreneurs™ in their daily work activities in future. We can distil that the core features of the prototype are perceived to be of value in ICT-enabled logistics brokering services since they were rated highly by both groups of subjects.

The responses also indicate that the prototype provided the user with enough functionality to carry out the logistics brokering services. However, an interesting observation is that despite the responses by the logistics service practitioners scoring well on preference to use a suite in carrying out the same task ($m = 1$), majority of the responses from the Infopreneurs™ indicated that they would prefer to carry out some of the same tasks without a suite ($m = 4$). This can be explained by the fact that the idea of using a suite in developing ICT-enabled services was new to the Infopreneurs™. Some of the Infopreneurs™ reported that they did not have enough practice to use the prototype, as they were learning and getting used to it while carrying out their other non-logistics related daily tasks. This is also reflected in the attitude of some of the Infopreneurs™ towards the added value provided by the prototype in logistics brokering services.

The general spread of scores for the aspects related to continued use of the prototype and the value added to service development can be attributed to the fact that the Infopreneurs™ were located in communities that they were familiar with and would easily know where to source information from and deliver services without applying ICT-enabled interventions.

6.7.2 Usability

The frequencies of responses to the 27 items of the questionnaire that were used to measure usability of the prototype are listed in tables 6.5 and 6.6. For the positive statements, we arbitrarily took the mode value of 4 (Agree) as the cut-off for a good result, since this is higher than the neutral value of 3 on the Likert scale that was used. For the negative statements, we considered an arbitrary mode value of 2 (Disagree) as the cut-off for a good result. As was the case with the study on usefulness, the value of the mean is used to support the explanation for the mode if the mean is higher than the neutral value for the positive statements and if it is lower than the neutral value for the negative statements.

Usability	Logistics practitioners n=8							
	Answer							
	1	2	3	4	5	$\bar{x}$	σ	m
I was able to use services from different providers in a transparent manner	0	1	3	4	0	3.38	0.744	4
If the prototype is scaled into a full suite, I will use it in developing services	0	0	2	4	2	4.00	0.756	4
The suite improved my performance as compared to working without it	0	0	4	4	0	3.50	0.535	4
Using the suite in carrying out the task increased my productivity	0	2	4	0	2	3.25	1.165	3
Overall I find the suite to be usable in developing services	0	0	3	4	1	3.75	0.707	4
My interaction with the suite is clear and understandable	0	0	0	5	3	4.38	0.518	4
Using the suite, I had more control when developing services	0	0	3	5	0	3.63	0.518	4
Interacting with the suite does not require a lot of my mental effort	0	0	2	5	1	3.88	0.641	4
I found the suite to be easy to use	0	0	3	2	3	4.00	0.926	5
I was often confused while using the suite	3	3	1	1	0	2.00	1.069	1
I frequently made errors when using the suite	3	4	1	0	0	1.75	0.707	2
I found it easy to get the suite to do what I wanted it to do	1	3	2	1	1	2.75	1.282	2
I frequently had to consult the user instructions when using the suite	3	3	2	0	0	1.88	0.835	1
The user instructions provided helpful guidance when using the suite	0	0	1	3	4	4.38	0.744	5
I found the suite to be inflexible	3	2	3	0	0	2.00	0.926	1
Using the suite saved me time	0	2	3	3	0	3.13	0.835	4
It was easy for me to remember how to develop services using the suite	0	1	2	2	3	3.88	1.126	5
The suite often behaved in unexpected ways	5	3	0	0	0	1.38	0.518	1
The quality of support that I got from using the suite was high	1	3	4	0	0	2.38	0.744	3
I had no problem with the quality of the suite's interface	0	0	3	4	1	3.75	0.707	4
The suite worked consistently during the whole task	0	0	1	2	5	4.50	0.756	5
The suite worked in a predictable manner	0	1	2	3	2	3.75	1.035	4
The suite's interface clearly showed available functions and how to use them	0	0	0	3	5	4.63	0.518	5
I have no difficulty telling others about my experience in using the suite	0	0	0	2	6	4.75	0.463	5
I believe I can communicate to my peers the consequences of using the suite	0	0	2	4	2	4.00	0.756	4
The results of using the suite are apparent to me	0	0	0	2	6	4.75	0.463	5
I would have difficulty explaining why using the suite may be beneficial	5	3	0	0	0	1.38	0.518	1

Table 6.5: Responses from logistics practitioners on usability of the prototype

Usability	Infopreneurs™ n=6							
	Answer							
	1	2	3	4	5	$\bar{x}$	σ	m
I was able to use services from different providers in a transparent manner	0	2	4	0	0	2.67	0.516	3
If the prototype is scaled into a full suite, I will use it in developing services	0	0	3	3	0	3.50	0.548	4
The suite improved my performance as compared to working without it	0	1	0	5	0	3.67	0.816	4
Using the suite in carrying out the task increased my productivity	0	0	0	4	2	4.33	0.516	4
Overall I find the suite to be usable in developing services	0	0	0	6	0	4.00	0.000	4
My interaction with the suite is clear and understandable	0	0	1	5	0	3.83	0.408	4
Using the suite, I had more control when developing services	0	0	2	4	0	3.67	0.516	4
Interacting with the suite does not require a lot of my mental effort	1	1	2	0	2	3.17	1.602	5
I found the suite to be easy to use	0	0	0	3	3	4.50	0.548	5
I was often confused while using the suite	0	3	1	1	1	3.00	1.265	2
I frequently made errors when using the suite	0	3	1	2	0	2.83	0.983	2
I found it easy to get the suite to do what I wanted it to do	0	0	2	3	1	3.83	0.753	4
I frequently had to consult the user instructions when using the suite	0	2	2	1	1	3.17	1.169	2
The user instructions provided helpful guidance when using the suite	0	0	1	3	2	4.17	0.753	4
I found the suite to be inflexible	2	1	1	2	0	2.50	1.378	1
Using the suite saved me time	0	0	0	5	1	4.17	0.408	4
It was easy for me to remember how to develop services using the suite	0	0	0	5	1	4.17	0.408	4
The suite often behaved in unexpected ways	1	3	2	0	0	2.17	0.753	2
The quality of support that I got from using the suite was high	0	1	1	3	1	3.67	1.033	4
I had no problem with the quality of the suite's interface	0	1	1	3	1	3.67	1.033	4
The suite worked consistently during the whole task	0	0	4	2	0	3.33	0.516	3
The suite worked in a predictable manner	0	0	2	4	0	3.67	0.516	4
The suite's interface clearly showed available functions and how to use them	0	0	1	3	2	4.17	0.753	4
I have no difficulty telling others about my experience in using the suite	0	1	1	1	3	4.00	1.265	5
I believe I can communicate to my peers the consequences of using the suite	0	0	1	3	2	4.17	0.753	4
The results of using the suite are apparent to me	0	0	2	3	1	3.83	0.753	4
I would have difficulty explaining why using a suite may be beneficial	2	1	3	0	0	2.17	0.983	3

Table 6.6: Responses from Infopreneurs™ on usability of the prototype

With regard to the usability of the suite, we can observe from the data in tables 6.4 and 6.5 that overall, both groups of subjects were positive about the functionality of the prototype that enabled them to develop services better. An interesting observation from these results is that while the logistics service practitioners were neutral (m = 3) about the quality of support they got from using the prototype, the Infopreneurs™ seemed to be quite positive (m = 4) with the quality of support. This may be attributed to the fact that the logistics service practitioners tested the prototype using a scenario and task while the Infopreneurs™ applied the prototype in a real life situation and could therefore make more objective judgments. In their work environment, the Infopreneurs™ have to deal with walk-in customers, some of whose problems can be solved through local knowledge, and this may have been a reason for them to prefer to use other means than a suite to solve the problems in some instances.

The responses also revealed that some subjects from both groups rarely consulted user instructions when using the prototype, while others consulted more regularly. Many of the Infopreneurs™ reported that they were more confused when using the prototype, although overall the score for this aspect was good (m = 2). Some of the other responses can be attributed to the fact that the Infopreneurs™ were not so knowledgeable in the logistics domain compared to the rural logistics service practitioners, who had no difficulty explaining the benefits of using a suite in the development of logistics brokering services.

6.7.3 Usage

We present the frequency of responses on the 9 items that were used to measure usage of the prototype in tables 6.7 and 6.8. For the positive statements, we arbitrarily took the mode value of 4 (Agree) as the cut-off for a good response, since this is higher than the neutral value of 3 on the Likert scale that was used. For the negative statements, we considered an arbitrary mode value of 2 (Disagree) as the cut-off for a good response. As was the case with the study on usefulness, the value of the mean is used to support the explanation for the mode if the mean is higher than the neutral value for the positive statements and if it is lower than the neutral value for the negative statements.

Usage	Logistics practitioners n=8							
	Answer							
	1	2	3	4	5	$\bar{x}$	σ	m
The suite was easy to adapt and use	0	0	2	2	4	4.25	0.886	5
The suite fits very well within the context of my work	0	0	1	3	4	4.38	0.744	5
The guidelines accompanying the suite improve service development	0	1	4	3	0	3.25	0.707	3
The suite facilitated effective achievement of my goals & objectives	0	0	0	3	5	4.63	0.518	5
Overall I was satisfied with using the suite	0	0	0	4	4	4.50	0.535	5
Usage of the suite is relevant within my context	0	0	3	4	1	3.75	0.707	4
The suite address the key challenges of service development	0	2	4	2	0	3.00	0.756	3
I experienced many technical problems while using the suite	2	5	1	0	0	1.88	0.641	2
I was comfortable working with the suite	0	0	0	3	5	4.63	0.518	5

Table 6.7: Responses from logistics practitioners on usage of the prototype

Usage	Infopreneurs™ n=6							
	Answer							
	1	2	3	4	5	$\bar{x}$	σ	m
The suite was easy to adapt and use	0	0	1	4	1	4.00	0.632	4
The suite fits very well within the context of my work	0	0	0	6	0	4.00	0.000	4
The guidelines accompanying the suite improve service development	0	0	2	3	1	3.83	0.753	4
The suite facilitated effective achievement of my goals and objectives	0	0	2	2	2	4.00	0.894	5
Overall I am satisfied with using the suite	0	0	2	2	2	4.00	0.894	5
Usage of the suite is relevant within my context	0	0	2	3	1	3.83	0.753	4
The suite address the key challenges of service development	0	0	0	5	1	4.17	0.408	4
I experienced many technical problems while using the suite	1	1	4	0	0	2.50	0.837	3
I was comfortable working with the suite	0	0	1	1	4	4.50	0.837	5

Table 6.8: Responses from Infopreneurs™ on usage of the prototype

The responses presented in tables 6.7 and 6.8 indicate that on the whole, both groups of subjects valued usage of the prototype positively. We infer from the data in table 6.8 that the Infopreneurs™ were comfortable working with the prototype since it fitted quite well with their daily work activities. Both groups of subjects expressed their general satisfaction with using the prototype to develop logistics brokering services, and they all felt that the software services of the suite addressed the key challenges to logistics brokering services in rural environments. This is exemplified by the responses with mode values ranging between 4 (Agree) and 5 (Strongly agree) for the positive statements and values of 2 (Disagree) for the negative statements related to usage of the prototype to carry out their work.

For responses with multiple frequencies, we again decided to take the highest mode value for the positive statements and the lowest mode value the negative statements. This was so especially if the data was skewed around high values for the positive statements or around the low values for negative statements. Both groups of subjects felt that a prototype was relevant for usage in logistics brokering services within their context. Overall, both groups of subjects rated the usage of the prototype highly with responses having a high mode value (m= 5) for how comfortable and satisfying it was working with the prototype.

6.7.4 General Observations

In general, we believe that we can make valid inferences from the findings presented in tables 6.3 – 6.8 and from the answers to the open-ended section of the questionnaire in spite of having 14 subjects. Earlier research such as that presented in Nielsen (1994), Caulton (2001), Jamieson (2004) and Tastle et al. (2005) has shown that it is possible to draw conclusions based on a small sample size, since relatively imprecise conclusions about a population can enable the researcher to get an indication of the applicability of a tool. We believe further that we are able to draw valid conclusions from the findings since after the testing exercise we held broad discussion and debriefing sessions with the subjects, which enabled us to learn much more about the application of the prototype. After the discussions and debrief sessions, we felt that the findings were sufficient for this research since they brought out the relevant information on the applicability of a suite in logistics brokering. Furthermore, the exercise was aimed at testing the functionality of the prototype in logistics brokering rather than the variation of results between the different users.

We can infer that the overall perception among the subjects was that a suite was considered to be important for logistics brokering in rural areas, and that the functionalities provided in the prototype are likely to be used in future when they are implemented in a fully functional software suite. We can discern that the core features of the prototype were considered to be of value in logistics brokering in rural areas since they were rated quite highly by the subjects.

The set of items that were scored highly by the subjects can be considered to be of direct importance in facilitating the brokers' tasks of logistics brokering services. If we take a mode value of 4 (Agree) as the lowest for the frequency of responses obtained to the positive statements as a boundary between functions of the prototype perceived to be core or non-core since this is higher than the neutral score of 3, we find that almost all the subjects rate the core functionalities highly. If we take a mode value of 2 (Disagree) as the highest for the frequency of answers obtained in response to the negative statements as the highest boundary since this is lower than the neutral score of 3, we find that majority of the subjects score low on these statements. We can therefore infer that subjects' attitudes towards the facilitation provided by the prototype in service development were very positive. We can conclude that as observed through these case studies, a suite improves the support provided for developing logistics brokering services in rural areas.

Further, all the case study subjects were required to make an objective open-ended assessment of the suite by filling in section 3 of the questionnaire which required them to expound on their answers to questions related to their experience in application of the prototype. They were asked about the functionality of the prototype that was most attractive to them while carrying developing service. All the logistics service practitioners (100%) felt that the bulletinboard functionality was the most attractive since it provided a means for capturing and consolidating logistics service demand and supply. All the Infopreneurs™ (100%) were also happy with the bulletinboard functionality. The subjects were happy with the fact that the bulletinboard enabled them to have an overview of logistics service supply and demand, as well as enabling them to change the availability status for the service providers. In the current work environment, the Infopreneurs™ do not have the possibility to maintain status information for the logistics service providers.

Currently, in the rural areas there is a big problem with knowing who requires what kinds of transport services and when they require them, and the bulletinboard functionality provides a boost. On their part, 67% of the Infopreneurs™ were attracted most to the bulletinboard as a tool that enabled them to capture service demand in their local contexts, while the other 33% felt that the ability to register service providers was the most attractive to them since it enabled them to have an overview of who was doing what, when, where and to whom within their service area. We infer from the data that some of the disparity in results arises from the Infopreneurs™ responses, and can be explained by the fact that the two different sites in which the Infopreneurs™ operate and in which the tests were carried out, serve clientele with different contextual needs.

Further, the Infopreneurs™ felt that the functionality that allowed them to obtain services from remote or local service providers would add great value to their operations, and would definitely create more business volumes for the Infopreneurs™ business. This view was also agreed upon by all the logistics service practitioners, and both groups of subjects were of the opinion that the ability to develop services in a collaborative manner was a very good feature of the prototype, and one that should be explored further and expanded to provide increased functionality. The functionality used to match logistics service demand requests to service supply based on the type of goods and the destination was also rated highly by both the logistics service practitioners and the Infopreneurs™. Both groups were of the opinion that this functionality would provide a much-needed solution to the problem of transportation of defragmented freight and small freight and passenger movements in rural areas.

In response to the question about what functionality or software services were missing in the prototype and that would have improved the work of the suite's end-users in logistics brokering services, the logistics service practitioners felt that the suite would be of more value if it incorporated geo-spatial intelligence functionality. Such functionality would enable the Infopreneurs™ to identify transport service needs proactively in a given area using GIS data, and enable them to make service schedules and service points. In its current implementation, the suite can only be applied in a reactive manner, and is dependent on a client requesting a logistics service, or service providers sending information regarding their ability to deliver given services. With links to geo-spatial data, the Infopreneurs™ would have contextual information about a given area, and they will be able to identify where there is need to send a service provider, e.g. a transporter, based on the level of activity for the logistics-related needs gathered from the spatial maps.

Further, the logistics service practitioners expressed a desire for functionality that would enable the Infopreneurs™ to share ideas and information related to logistics services in their regions collaboratively through some form of discussion group that does not necessarily require them to be simultaneously logged into the system. The group discussion board would allow the Infopreneurs™ to work collaboratively and in a distributed manner with no regard to time and space, to solve common problems that occurred in their respective regions. The subjects also expressed the desire to have an extra functionality that allowed them to create their own logistics service schedules based on the schedule information gathered from the logistics service providers. This, they felt, would give the information brokers an edge over their competition and attract customers to request their brokering service. They felt that this functionality would enable the Infopreneur™ to combine information from different logistics service providers and give the customers the best available logistics service options.

On their part, the Infopreneurs™ expressed the desire to have a functionality that enabled them automatically and selectively to send short messages (via sms) or email from the suite to their customers once they had matched the given customer's service request. A feature for sending sms already exists in the inTouch Africa® software toolbox, and since one of the objectives of

developing the suite was to make use of already existing services, we observe that this need can be fulfilled at minimal cost by using the already available functionality.

Regarding whether the subjects had problems in using the prototype to develop services in their daily work activities, 100% of the respondents from both groups reported that they did not have any problems especially after they had some practise. Both groups of subjects thought that the prototype was easy to use once they got familiar with its functionalities and how to operate them. These observations have direct implications for the learning curve of using a suite in the actual development of services. The logistics service practitioners felt that they did not need much time to use the prototype to perform service development. This is further exemplified by the fact that the Infopreneurs™ used the prototype to carry out real life logistics brokering in parallel with their normal work activities. The Infopreneurs™ noted a distinct improvement in their service delivery using the prototype, particularly in the amount of time saved and more so in cases where they had to use services exposed by service providers in remote locations.

The Infopreneurs™ felt that the amount of time spent using the prototype to develop services was shorter than the amount of time it normally takes them to do similar kind of work. They were also of the opinion that in some cases, it would be easier and faster to provide services without application of a suite. An example the Infopreneurs™ gave in which doing the work manually would be better than using a suite was if they knew an appropriate service provider located nearby, they would be tempted to just contact the provider directly rather than using the suite to match user requests. This was also the feeling for logistics service requests in which the service was required immediately since in its current implementation the suite requires that, for a service match to be made, a request has to be made at least a few hours in advance of the need. All the Infopreneurs™ felt that with more practise in applying the prototype, they would definitely become more confident using its functionalities, and would probably be able to better incorporate its usage in their daily work activities.

Some of the other issues arising after using the prototype to perform the task that was set for the rural logistics service practitioners, and by the Infopreneurs™ in their daily work activities included: the lack of an easily understandable message log, since the current one is based on Java language's log functionality; lack of an interface with full portal functionality to allow the user to access the suite over the web; the fact that the prototype required access to service provider databases yet bandwidth for the Internet connection was limited during the testing period; and the lack of time for the subjects to practise more with the functionality of the prototype. For purposes of this research, we considered these issues to be non-core and decided to treat them as recommendations for improvements to the suite.

The general impression we got from the case studies was that the test subjects were very positive about the contribution of a suite in logistics brokering services as indicated in the findings presented in tables 6.3 - 6.8. The Infopreneurs™ were eager to have fully operational functionality, such as that implemented in the prototype, as soon as possible so that they could apply it in their daily work activities. We managed to establish that there was an actual need for application of a suite, and that the prototype proved that a suite provided the required support for improving logistics brokering services. By carrying out the tests, we were able to achieve the objective of assessing whether we could facilitate local service providers to develop logistics brokering services that fulfil local needs in rural areas. Application of the prototype in real life confirmed that a suite improves the support for development of services.

6.8 Analysis of the findings

In this section, we present a contextual analysis and interpretation of the case study findings based on the units of analysis in sub-section 6.3.1, complemented with the observations presented in the previous section. We applied non-parametric statistical tests for data analysis because the sample size for the case study was relatively small, yet we wanted to interpret the findings of the research directly without making unrealistic assumptions. According to (Weaver, 2002; Siegel, et al., 1988), using non-parametric statistical tests requires few, if any, assumptions about the underlying population distributions, and results in conclusions that require fewer qualifications. Given that our sample size was relatively small, there was no alternative to using non-parametric statistical tests. We also based our analysis on the in-depth discussions that were held with the subjects at the end of the testing exercise.

We based the analysis of the findings presented in tables 6.3 - 6.8 on the frequency of responses as recommended by Jamieson (2004), as indicators of the extent to which the case study subjects perceived each of the 3 U's of the prototype. Jamieson (2004) states that ordinal data may be described using frequencies and/or percentages in each category. Our data was collected using a 5-point Likert scale, which falls within the category of ordinal level of measurement. Previous research such as that carried presented by Jamieson (2004) and Blaikie (2003) recommends that for ordinal data, one should employ the median or mode as the measure of central tendency for ordinal data where numbers generally represent verbal statements. We adapted this recommendation and applied it to our findings.

The analysis was aimed at enabling us to come up with interpretations relating to the 3 U's as the basis for whether application of the prototype facilitated the development of logistics brokering services that fulfil local needs in rural areas. In addition, we reflect on the findings on the units of analysis presented in section 6.3. The units of analysis are summarised into 4 main categories, which were contained in the Likert-scale statements of the questionnaire. The statements were used to measure perceived user attitudes towards application of a suite and how the prototype facilitated the subjects in developing logistics brokering services. The units of analysis are:

- the end-users interaction with the suite
- application of the suite in daily work activities
- ability to develop and deliver logistics brokering services using the suite
- utility of the suite in developing logistics brokering services

Based on the data presented in tables 6.3 – 6.8 and on the discussion and debrief sessions that were held with the subjects at the end of the testing exercise, we can conclude that the prototype was considered by the subjects to be useful in facilitating the development of logistics brokering services. We present this discussion using the units of analysis that are presented above.

End-users interaction with the suite
A cursory examination of the data presented in tables 6.3 and 6.4 suggests that both groups of subjects found the prototype to be very useful in developing logistics brokering services. This may be explained by the fact that the rural logistics service practitioners evaluated the prototype from its functionality point of view and thought that it provided enough functionality to support the Infopreneurs™ in carrying out their daily service brokering tasks. The rural logistics service practitioners believed that the services of the prototype were representative of the rural logistics domain, and that using such a suite would greatly improve the service brokering effort. These sentiments were also obtained from the debrief session. From the data collected and presented in

tables 6.3 and 6.4 and the findings from the broad discussions with the subjects after the testing exercise, we can conclude that:

- it seems to pay to use a suite in developing ICT-enabled logistics brokering services. The results show frequency scores that reflect that the subjects rated the prototype highly on all items related to its usefulness in service development.
- the usability and usage of a suite in developing services may be greatly determined from what the users of the prototype considered as its usefulness.

From the data presented in tables 6.3 and 6.4, we can infer that both groups of subjects were of the opinion that the services implemented in the suite improved their performance in logistics brokering. The findings can therefore be used as an indicator of the usefulness of a suite in developing logistics brokering services in rural areas. This can be seen from the high frequency of responses for items related to functionality of the prototype. The findings were also supported by what we learnt from the debrief sessions, and based on the data and the discussion sessions, we can conclude that:

- the suite provides adequate functionality that represents local logistics situation. It incorporates main issues related to the development of services in a given area, and improves the facilitation of logistics brokering.
- the fact that the subjects performed logistics brokering without difficulty and were able to handle some actual customer enquiries using the prototype had a positive effect on their attitude to their perceived usefulness of a suite in facilitating the development of logistics services.

Application of the suite in daily work activities

We can infer from the data presented in tables 6.5 and 6.6 that the perceived added value of using a suite in developing services results from the satisfaction that was attained when using the prototype to carry out daily work activities. The interaction between the relevance of the services provided in the suite and the logistics brokering services task was significant in supporting this inference. This is also indicated by the findings which show high frequency of responses for positive items such as the amount of time it took to complete the task while using the prototype, and the fact that most subjects gave scores that indicated that they would use a suite to carry out similar tasks. The subjects gave explanations during the debrief sessions that further supported these findings. From these observations we can conclude that:

- the fact that the users achieved the desired results in a short time and the advantage of using a suite in service development was demonstrable, convinced the users that the quality of results was high and it made them consider a suite as a useful tool in logistics brokering services in their local environments.
- the output obtained also has an effect on usage of a suite since output considered to be good will encourage usage of a suite in developing logistics brokering services.

We also observed from the data in tables 6.5 and 6.6 that the immediate need to apply the suite in performing a relevant and frequently occurring task had an effect on its perceived usage. This observation was supported in one case study site at which there was a need to apply the prototype to solve real transport service problems experienced at the time of the study. The subjects used the prototype for extended periods of time dealing with real life logistics service requests that arose in the course of the case study and testing exercise. The high frequency of positive responses obtained in the results on usage of the prototype clearly indicates that a suite is likely to be applied if it can solve actual problems. The subjects concurred during the debrief session that the suite provided

them with facilitation to carry out their brokering tasks more efficiently. From the findings of these studies we can conclude that:

- how the prototype facilitates the solving of real life logistics service problems can be used as a determinant of how useful and usable the suite would be, and this will in turn ensure that it is used.
- the usage of the prototype to solve a problem and being able to produce results that demonstrated that using such a suite added value definitely had an effect on its usage. We were able to observe this directly during the case study.

Ability to develop and deliver logistics brokering services using the suite

The high frequency of responses recorded on the positive aspects of usability of the prototype as shown in tables 6.5 and 6.6 had a direct contribution to perceived usability of a suite in logistics brokering. Except for the situation where the logistics service practitioners felt that the quality of support was not high enough, most of them scored the prototype very positively on all other aspects of usability. The data for the Infopreneurs™ varied considerably, but still maintained a relatively high frequency of responses on the positive aspects of usability of the prototype. In the debrief sessions, we learnt that the Infopreneurs™ had given varied scores because some of them were not as confident in using the prototype, and preferred to be given more time to work with it. Based on the findings from the study, we can conclude that:

- the services implemented in the prototype need to incorporate more support for carrying out the service brokering task so that the users are able to feel satisfied with achieving the goals of the tasks they perform.
- the users of the suite will always rate it highly if it gives them the feeling that they can achieve more using the suite and they do not have to burden themselves with too much information to carry out the task of logistics brokering.

Utility of the suite in developing logistics brokering services

The frequency of positive responses in tables 6.5 and 6.6 related to flexibility of the suite and the fit with the situation encountered in the case study indicate that if the users could solve real life ad-hoc logistics services problems in their environment using the prototype, then they will be encouraged to use the suite in future. This is also the case when the suite fits well within the context of the task and the location in which it is being carried out. The discussion sessions that were held to debrief the subjects revealed that the suite would be better accepted if it provided some form of flexibility in the delivery of services especially if the end-users of the suite, the Infopreneurs™ in this case, wanted to attract more customers.

The frequency of responses for the positive aspects of usage of the prototype presented in tables 6.7 and 6.8 do not vary widely between what the logistics service practitioners and what the Infopreneurs™ consider to be effective in logistics brokering. The debrief session at the end of the testing also revealed that both groups of subjects were in agreement with the effectiveness of the application of a suite in logistics brokering. Based on the findings we can conclude that:

- the effectiveness of the prototype in developing services in situations that are of importance to the end user is a determinant of usage of a suite in logistics brokering.
- the ability of the prototype to incorporate different ways of working implies that the suite will be used when it becomes fully operational.

The aim of this research was to develop a studio-based approach to facilitate the development of ICT-enabled logistics brokering services in rural areas of transition countries. We developed a prototype of the suite for deployment within the studio, and tested its utility in a case study. We

observed the way the stakeholders functioned while using the prototype and made deductions based on the units of analysis that guided the human aspects of the study. We feel that the outcomes of the test exercise are considerably reliable, based on the fact that we tested, and obtained opinions on utility of the suite with its actual end-users in their work environments.

6.9 Conclusions from the tests

In this chapter, we presented details of the tests that were carried out on the prototype to study the utility of the suite in providing support for, and improving, the development of logistics brokering services in rural areas. The aim of carrying out the tests was to assess whether the use of a suite facilitates local service providers to come up with logistics brokering services that fulfil local logistics needs. We also aimed to test whether the use of a joint development approach to logistics brokering services as implemented in the prototype would improve the development of services in rural areas. The prototype was developed as part of a studio-based approach to the development of ICT-enabled logistics brokering services, and it was aimed at providing a technological response to problem solving in rural areas. We intended to make plausible the argument that using a studio-based approach improves the development of logistics brokering services as compared to developing the services without using the studio. We tried to do this by collecting data on perceptions of the usefulness, usability and usage of the suite from the stakeholders by deploying it in the rural environment.

The qualitative observations drawn from the quantitative analysis of the findings in the previous section and information obtained through the debrief sessions showed that in general the groups of subjects that were used to test the prototype had a positive evaluation of the functionalities presented to them. The subjects were also positive about the guidelines for developing logistics brokering services in rural contexts using the suite. The positive evaluation refers to both the degree with which the prototype was utilised in logistics brokering services and the appreciation by the case study subjects of the functionality of the services implemented in the prototype. We remark that the statistical tests that were performed were aimed at supporting the qualitative findings of the case study. The debrief sessions held at the end of the testing exercise were used to capture the extra information that may have been triggered among the subjects through the use of the prototype and was probably not covered by the questionnaire items.

Overall, from the results of the case study we can conclude that both the testing of the prototype and the case study objectives were achieved. We were able to collect adequate feedback regarding the usefulness, usability, and usage of the suite in facilitating local service brokers to develop logistics brokering services that fulfil local logistics needs. We collected this feedback through the questionnaire items and the debrief sessions that were held after the testing sessions. By using the prototype, the service brokers became aware of the role played by ICT-enabled interventions for collaborative and distributed logistics brokering in rural areas. They were also able to appreciate how ICT-mediated interventions can assist in solving local logistics problems that occur during their daily work activities. The concept of using a studio-based approach to improve the development of services, and using a suite to facilitate logistics brokering was considered to have been successfully tested and proven.

Through the case studies, we were able to learn that it is important to encourage collaboration between the service developers, service brokers and society in rural areas, because a good understanding of how society views the services delivered to them is essential for improving the development of services. The prototype was considered to be effective in supporting the collaboration between the service brokers and the logistics service providers since it enabled them to have a basis on which they could share their business information and gain from each other's

operations. The suite was considered as an effective tool that can be used to promote joint development of logistics brokering services in rural areas. The result of instantiating the prototype in the rural environment enabled the stakeholders to establish a common language for logistics service delivery. The prototype provided the stakeholders with tools for logistics brokering and enabled them to explore new methods of generating and fostering innovative service processes. The prototype was targeted at the logistics brokering services that are of importance at a rural societal level.

The rationale for using a single case study was based on the fact that we wanted to capture the conditions of a commonplace situation, which in this case was the use of the suite by the end users to support daily work activities. Yin (2003) states that it is possible to use a single case study to carry out research particularly if it represents a typical situation, and if the lessons learnt from the case can be assumed to be informative about the experiences of the average person. Through the tests we were able to learn the critical conditions for implementation of the suite. In the first place, the suite enables the end users to capture and consolidate service demand and supply. This means that rural areas experiencing problems of fragmented demand and supply in services would benefit from deployment of the suite. Considering that the suite is developed based on the concept of loose coupling of components such as that implemented in web services technology, it is possible to connect the suite with service providers who have exposed their services on the web. However, the suite needs to be hosted in a location with regular power supply, while the customers of the brokering service require devices such as mobile phones through which they can communicate remotely particularly in places where access to the Internet is limited.

With regards to the end users of the suite, the condition is that there is at least a person who offers services from a focal point through which customers can send their service demand requests. This can be implemented by using people already offering services in the rural area. Considering the fact that the suite was developed based on the existing ways of working in rural South Africa, some changes in its functionality may need to be made to reflect the local environment in which it is to be deployed with the aim of providing support for the business processes in those rural areas. We used the holistic design for the case study as described by Yin (2003) since the relevant theory regarding the utility of tools in improving the development of services is in itself holistic in nature. However we developed a set of units of analysis that enabled us to focus the study on the utility of the suite in more detail than at an abstract level. Some shortcomings of the prototype that were identified in the case study were presented and discussed in section 6.7, and will only be discussed further in the evaluation of the research presented in chapter 7. The shortcomings, mostly related to added required functionality from the perspective of the case study subjects, will not be corrected in this work.

7. Epilogue

We started the research by discussing the problems and challenges faced in developing ICT-enabled services in transition countries, with a focus on deep rural areas. The objective of the research was to develop a studio that effectively facilitates the development of logistics brokering services in rural areas of transition countries. The exploratory case study that was carried out in rural South Africa enriched our understanding of the problems and challenges in developing services, and enabled us to identify the main issues to consider when developing logistics brokering services in rural areas. Based on the issues identified through the case study and from a review of the literature, we formulated a set of requirements that the suite for deployment within the studio had to meet to be able to facilitate the service brokers in rural areas using ICT to deliver logistics services that meet local needs. We developed a prototype of the suite to facilitate and improve the development of logistics brokering services in rural areas. We carried out tests on the prototype in the rural environment to determine whether it facilitated and improved the development of logistics brokering services in reality. We based our tests on the three dimensions of usefulness, usability, and usage when we applied the suite to the development of logistics brokering services. In this chapter, we reflect upon the research. We begin by presenting the main findings, we then discuss how the research objective was achieved and then we provide answers to the research questions. We follow this with a reflection on the research approach, and provide guidelines for further research.

7.1 Research findings

In this section, we present the research findings, discuss the achievement of the research objective and provide answers to the research questions.

7.1.1 Achievement of research objective

The main objective of the research was:

> *To develop a studio to provide effective support for the development of ICT-enabled logistics brokering services in rural areas of transition countries*

We used the case study method to explore the area of research and to test a prototype of the suite for deployment within the studio, and we concluded that the empirical evidence gathered suggests that the research objective was realised. This is based on the fact that through the case study we wanted to study situations under which the suite is useful and can improve the development of logistics brokering services, and not to study the differences between case study subjects. The case study fulfilled the rationale on case studies provided by Yin (2003), which states that it is possible to use a single case study if the objective is to capture the circumstances and conditions of a commonplace situation. The prototype was used and evaluated by the end-users who found it to be useful and usable in their work environment, since it facilitated their daily logistics service delivery work activities. The existing logistics services situation in rural South Africa was used as a basis for the development of the prototype, but we believe that the suite can also be used in other rural areas of transition countries. The prototype was applied in a real life environment to study whether it provided utility to facilitate the local service brokers in the delivery of logistics services. The results obtained and presented in chapter 6 indicate that the work of the end users of the suite was greatly improved when using the prototype to deliver services to their local communities. We therefore conclude that the objective was achieved successfully.

7.1.2 Research questions

The research was aimed at providing an approach that can be used to facilitate and improve the development of ICT-enabled logistics brokering services in rural areas. There was need to study the main issues and challenges to be considered in developing such services. To enable us to achieve this, we formulated a central research question as follows:

> *How can we provide effective support for the development of ICT-enabled logistics brokering services in rural areas of transition countries?*

The research question was aimed at enabling us to come up with a studio that could be used to improve and facilitate the development of robust ICT-enabled logistics brokering services in rural areas. The research question was partly answered in chapter one, and further elaborated in chapter two. We carried out an exploratory case study to help us identify the issues to consider and the challenges to be met when developing logistics brokering services in rural areas. The exploratory case, carried out in rural South Africa, revealed that designing and developing logistics brokering services in rural areas is a complex and challenging activity. Some of the main reasons for this can be attributed to the following constraints:

- the rural areas are heavily underdeveloped and characterised by physical remoteness from basic amenities, low supply chain volumes, long distances to markets, and high unit transportation costs. The requirements for logistics services in these areas are very specific due to the characteristics mentioned in chapter two, which make it difficult to transfer existing urban service delivery solutions to rural areas.

- inaccessibility or poor accessibility to logistics infrastructure is one of the key impediments to service delivery in rural areas. Logistics service systems tend to be non-existent, and if they exist, they are usually haphazard, unsustainable, and driven by needs of the source rather than the needs of the recipient. The services tend to be inaccessible to poor folk, who are the majority in rural areas. The poverty and inaccessibility of rural locations makes it difficult to design or improve and optimise service delivery mechanisms that meet local user needs.

- the SMEs operating in rural areas do not trust each other and believe that sharing information gives undue advantage to their competitors. This means that it is not easy to create a catalogue of who is providing what services, when, where, to whom, and how. Improving the delivery of logistics services is very difficult if stakeholders are not willing to share information, especially if they have to share services delivery resources.

- creating and maintaining competitive and value-added logistics services in rural areas is not a simple task. The majority of the rural folk are cash constrained and unwilling or unable to pay for services that do not provide demonstrable value to them. In addition to this, it is difficult to determine the demand for logistics services in the rural areas. Facilitating the development of logistics brokering services that meet local needs is challenging, especially when considering the fact that demand for logistics services is seasonal.
- the small nature of SMEs in rural areas makes them have an ever changing base of customers and needs, depending on what is most profitable at the time. The logistics service providers have to be dynamic in their interactions when working with the different customers. This means that the services developed should be flexible and reusable to suit the many activities and roles of the rural folk and SMEs. The situation is complicated by the fact that most of the business relationships are loose and informal. It is difficult to scope the

exact service functionality that is essentially self-sufficient to be included in a given business process. It is also quite difficult to develop logistics services that reflect the multiple individual needs of work and everyday life in rural area contexts.

- it is difficult to provide consistent levels of ICT-enabled logistics brokering services due to the intermittent conditions that the service delivery infrastructure is vulnerable to e.g. power blackouts and loss of telecommunication signals. It is challenging to develop logistics brokering services that are robust enough to handle the unreliability of the service delivery infrastructure in rural areas.

These issues make it challenging and necessary to provide support to improve and facilitate the development of logistics brokering services to increase the operational efficiencies of the available logistics service providers. This would also ensure that the logistics services developed are representative of user needs, and that logistics service delivery is more predictable. Ineffective and inefficient logistics service provision leads to a high incidence of empty miles, lack of consolidation and synchronization of freight movements to and from the rural areas, an inability to plan and schedule service delivery, and the inefficient use of available logistics service provision capacities. For the deep rural areas, this has also resulted in an inability to identify latent movements, defined by Naudè (2005) as movements inhibited (possibly) by high transaction and logistics costs.

The manifestations of the issues identified were in line with the characteristics of logistics services in rural areas defined by Naudè & Brits (2003) and Ittmann (2004) as inaccessibility to services and markets; low and seasonal demand for logistics services; unreliability of logistics services; long distances from amenities; sparse population; under development of the logistics services industry; and the lack of community-based service models that address the key limiting factors associated with rural locations. The resulting manifestations were observed and confirmed through the exploratory case study from which we also learnt that logistics brokering services should be considered as a part of a wider means for improving the logistics service provision and coordination in rural areas.

Research question one:
To assist in analysing the issues that were presented earlier, we studied literature on ICT-enabled services and the impact of ICT on logistics services with the aim of learning how we could provide solutions to the rural logistics problems earlier identified. The research question supporting this line of enquiry was formulated as:

> *How can the current issues in the development of ICT-enabled services be contextualised to improve and facilitate ICT-enabled logistics brokering services in rural areas of transition countries?*

This research question dealt with relevant issues regarding solutions that are currently used or can be applied for the purpose of developing ICT-enabled logistics brokering services. We carried out a literature review to learn how the existing theoretical concepts could be applied to come up with the solution for rural areas. In chapter 3, we discussed the theoretical concepts related to ICT and its impact on logistics services in general, before tackling the issue of logistics brokering services. We then focused on service orientation and service oriented architectures (SOA) as a way of organising the development of services. We discussed dominant methodologies that were used in the past to facilitate ICT-enabled service delivery within and between organizations. We then briefly discussed enterprise application integration (EAI) and service component brokering (SCB), methods that were widely used in the past to develop ICT-enabled services.

We pointed out that logistics brokering services were faced with the challenge of combining information and services within a coherent single structure through which customers can navigate and receive services readily. We learnt that considerable interest was being shown by a number of organizations in deploying web services to enable the combination of services from different service providers. Two key concepts underlie the deployment of web services: service orientation and SOA, which adequately address the challenges to development of services. Service orientation is defined by Papazoglou (2003) as the computing methodology that utilizes services as fundamental elements for developing applications. At its most abstract, service orientation views everything, from the mainframe application to the printer to the shipping clerk to the overnight delivery company, as a service provider. Service providers expose capabilities through interfaces, while a service oriented architecture maps these capabilities and interfaces to deliver services. According to Papazoglou (2003) separation between interface and the implementation is fundamental to the service model.

The case study we carried out revealed that it is challenging to obtain information on the available logistics services in the rural areas, which makes it difficult to develop ICT-enabled logistics brokering services. However, we learnt that using concepts based on SOA would greatly enhance the development of logistics brokering services. Following on ideas taken from the work of van de Kar & Verbraeck (2007), Faber et al. (2003), and Edvardsson & Olsson (1996) we designed and engineered a logistics brokering service system. Using the service system framework, we developed a prototype that was deployed within the studio to facilitate and improve the logistics brokering business processes. To develop ICT-enabled logistics brokering services, the suite should capture and reuse service processes in such a way that developing services to meet current and future business needs is simplified. The prototype developed in the course of this research based on SOA concepts and the service systems framework, and its application in facilitating the development of services, forms a part of the studio-based approach to the development of services, which is the main contribution of this work.

Research question two:
After reviewing the challenges involved in developing logistics brokering services in rural areas and attempting to put the ideas we obtained from the literature into context, the next issue that was addressed in this research was the services that were required to be in the suite to facilitate the development of ICT-enabled logistics brokering services. Therefore the second and main research question was formulated as:

> *What services should a suite for facilitating ICT-enabled logistics brokering services in rural areas of transition countries contain?*

This research question directed us to develop services for a suite to facilitate service brokers in developing logistics brokering services that support and fulfil local needs and the service brokers' daily work activities. The design of the software libraries making up the suite, plus its implementation in a prototype, is described in chapters 4 and 5.

As discussed in chapter 1, we considered studio-based development of services to be an effective method for the development of logistics brokering services in a multi-stakeholder environment such as the rural areas of transition countries. The studio provides a guiding framework for applying principles for handling the process side of systems in terms of their reality in organizational life (Keen & Sol, 2007). The development of rural logistics brokering services requires the handling of many complex decisions that involve judgement, where information is not sufficient to point to the single best choice, and where many parties' interests and values must be addressed. This situation makes it necessary to provide integrated sets of technical and management tools that facilitate the

development of services. The technical tools offer us the ability to focus on relevant service design issues that enable the development of services to exploit the resources available and aid the decision making process in service development. The technical tools are known as suites (Keen & Sol, 2007). The suites are embedded in the studio, which in turn provides experiential process methods and recipes for leveraging the suites. A studio is the environment in which suites are deployed, giving an interactive environment with a clear purpose, i.e. to generate the best production within the constraints of cost, time, program and topic.

Eight requirements were formulated for the services of the suite based on the case study and findings from the literature. Satisfying these requirements resulted in a suite that facilitates and improves the development of logistics brokering services in rural areas. The requirements were focused on the three dimensions of usefulness, usability and usage of the suite in facilitating the development of services. The suite was conceptualised using ideas taken from Papazoglou & van den Heuvel (2006), who state that the development of services should focus on analyzing, designing, and producing a SOA that aligns with business process interactions between trading partners to accomplish a common business goal. The services of the suite were developed in such a way that they corresponded to the complex requirements of logistics services in rural areas, namely:

- capturing and maintaining details of logistics service demand
- identifying and maintaining details of available logistics service providers
- categorizing and prioritising the service demand and service providers available
- matching service demand to service supply
- creating service schedules and providing information on available logistics services

We developed a prototype of the suite representing these five components which were broken down and translated into services that closely matched, and provided the functionality required to fulfil, the rural logistics service needs. The services were considered to be logical in a completely technology-independent manner, and provided the functionality of the prototype. The overall concept is that by using the suite the broker is able to create service processes that fulfil local logistics needs of the rural areas. The services implemented in the prototype were required to interface with, and use some of, the functionality of the currently used inTouch Africa® software suite. This is in addition to using services exposed by remote service providers. Details on the inTouch Africa® software suite are presented in chapter 2, while details on the basis used to develop the prototype are presented in chapters 4 and 5.

Research question three:
The prototype had to be tested in the rural areas to determine whether it provided the required support and facilitated in logistics brokering services that met local user needs. We wanted to test the prototype in the rural areas to determine whether its application facilitated the delivery of logistics services as required by the service brokers. The guiding research question for this part of the study was formulated as follows:

> *How can we use the suite to provide support for ICT-enabled logistics brokering services in rural areas of transition countries given their characteristics?*

The prototype works by assembling information and services from existing web services and data sources to create logistics service business processes. The prototype was tested based on the three dimensions of usefulness, usability and usage in a case study setting. Logistics service demand and logistics service supply formed the starting points for running the functionality of the prototype. These were captured using a bulletinboard, containing a set of classes used to handle broker and service provider communication for modifying the contents of the bulletinboard. The prototype also

has a catalogue service that contains a set of classes that allow service providers to register with the broker and receive unique addresses; a matching service containing a set of classes for matching service demand to service supply; control services containing classes used to deploy and undeploy the ICT-enabled logistics services; the communication service containing classes for handling communication between service providers and the service broker; the data handler service, which is responsible for handling communication between the deployed services and the database layer; the GUI service that provides a browser-like interface to facilitate access to the software platform by users of the suite; a logging service that logs all the activities involved in running the service; and a parsing service that handles the translation of XML configuration files.

The case study incorporated stakeholders in the empirical testing procedures to gather direct feedback on their experience of using a studio-based approach to deploy the prototype in the actual development of services. The testing was carried out in two ways: in a test setting, to study application of the prototype from the rural logistics service practitioners' point of view; and in the daily work setting of the Infopreneurs™ to test whether the prototype facilitated the day to day logistics brokering service delivery. The aim of conducting the tests was to study the effectiveness of a suite in facilitating and improving the development of ICT-enabled logistics brokering services. We aimed to learn the situations under which application of the suite would provide valuable support to the Infopreneurs™ in their daily work activities by carrying out these studies. The main units of analysis for the testing case were: the end-users, application in the work process, ability of the user to develop services, and agility of the suite in developing logistics brokering services. Details of the tests were presented in sections 6.3 and 6.6.

The information presented in chapter 6 enabled us to conclude that the prototype provided the user with enough functionality to carry out the development of logistics brokering services in rural areas. The findings indicated that, on the whole, the subjects valued the usage and usefulness of the prototype positively. We inferred from the data that the Infopreneurs™ were comfortable working with the prototype since it fitted in well with their daily work activities. The subjects expressed their general satisfaction with using the prototype to develop services, and they all felt that the services implemented in the prototype addressed the key challenges to logistics service brokering in the rural environment. We inferred that the overall perception among the subjects was that the prototype was important for logistics brokering in rural areas, and that the functionalities provided in the prototype were likely to be used in future when they are implemented as a fully functional suite.

Based on the tests we carried out, we were strongly convinced that the use of a suite improves the development of logistics brokering services in rural areas. The prototype provided services that supported and facilitated brokering, and its contribution was significant for the rural areas in which there is need to consolidate and coordinate logistics services. We were strongly convinced that the usefulness and usability of such a suite could be generalized to fit any situation in which there is need to deliver services through a broker. In rural areas in which there is no broker model such as the Infopreneurs™ in South Africa, the service providers in the local community who provide services from a foal point can be taken as the end users of the suite. Examples of domains in which the use of a suite can be applied to improve and facilitate the development of other ICT-enabled services are in the domains of electronic ordering, electronic catalogues, electronic payments, and in the marketing of produce from rural areas. We tested the prototype in the domain of transportation of people and freight, but we believe that it can be used in other domains such as health logistics as observed from the rural areas of South Africa. The suite can be applied in rural areas of other countries that exhibit similar characteristics such as the ones where we carried out the tests.

7.2 Research approach

In this section, we reflect on the research methodology. This was three-dimensional, consisting of: a research strategy, a research philosophy, and research instruments.

7.2.1 Research philosophy

The research philosophy used was design science, since we considered the research problem to be ill-structured. The scientific contribution of this work comes through the development of a design artefact and testing its utility in improving the existing situation, thereby adding value to the practise of developing ICT-enabled services in rural areas. Following the work of March & Smith (1995), the choice of research perspective was based on the research objective rather than the research topic. In section 1.6 we presented the research objective to develop a studio that provides effective support for the development of ICT-enabled logistics brokering services in rural areas of transition countries. Epistemologically, design science strives to create innovative and valuable artefacts. A researcher using design science attempts to create things that serve a human purpose (March & Smith, 1995). Axiologically, design science is value-oriented. Design researchers believe that the proverbial 'truth' is not 'out there': instead they facilitate its enactment by creating artefacts (Orlikowski & Iacono, 2000; Purao, 2002). The outputs of design science are assessed against criteria of value or utility (March & Smith, 1995). The way we addressed the research objective (epistemology) was to develop a studio containing a suite of services, i.e. an artefact. We obtained knowledge about logistics brokering services in rural areas by studying applications of the prototype in solving real life logistics service problems through a case study. The goal of the work was to facilitate and improve the development of ICT-enabled logistics brokering services. We believe that the work was value-oriented, and served a human purpose (March & Smith, 1995), thereby supporting our choice of design science as an appropriate research philosophy for this work.

7.2.2 Research strategy

The problem we studied in this research exhibited characteristics of an ill-structured problem because the alternative courses of action for providing solutions were unlimited (Sol, 1982). This is because a great number of alternative solutions could be thought of to provide support for the development of logistics brokering services in rural areas. Considering the complexity and dynamics of service delivery in rural areas, there was probably no model available with sufficient correspondence from which solutions could be derived in an exact way.

We applied the design science paradigm discussed by Hevner et al. (2004) to carry out the research. The prototype we developed consisted of software libraries aimed at developing logistics brokering services. Considering that we had to understand the problem in detail before setting out to develop the prototype, we carried out exploratory research. The aim of carrying out exploratory research is primarily to formulate or elaborate a theory rather than to test the theory. In this research, we aimed to elaborate a theory on the utility of support tools in developing services. The exploratory case study enabled us to develop a descriptive model of the research challenges and to formulate the requirements for solving the problems we had observed. We followed the design science guidelines presented by Hevner et al. (2004) to design an artefact that fulfils the requirements of a rural area, evaluate the design, and determine our contribution to research. The guidelines enabled us to design and develop the prototype (artefact) by identifying the real business issue (problem relevance), and then evaluating the usefulness and usability of the artefact in a real life setting using a studio-based approach.

7.2.3 Research instruments

As stated by March & Smith (1995), the selection of a research instrument depends on the amount of existing theory available, on the nature of the research, and on the type of research question. We used several instruments to implement the research strategy. We used exploratory research to determine the actual issues to be handled in logistics brokering in rural areas, to determine the requirements for the services of the suite, and to understand the significance of providing support tools to improve and facilitate the development of ICT-enabled logistics brokering services.

After the prototype was developed, we used a case study to test its application, to determine whether it improved and facilitated the development of logistics services that met local rural needs. The choice of the case study method was based on the views of several renowned researchers who state that case study research is the most common qualitative method used in studying information systems (see Orlikowski & Baroudi, 1991; Alavi & Carlson, 1992). We used qualitative research methods because the aim was to obtain feedback on user attitudes and experience in using the prototype and the studio-based approach as a whole, in the development of logistics brokering services. We used questionnaires to gather feedback from the test subjects regarding whether the prototype facilitated them in the development of logistics brokering services. The case study enabled us to fulfil the aim of testing the artefact in its end-user environment.

We conclude that the choice of using design science research approach was appropriate for addressing the research objective tackled in this work. We agree with Hevner et al (2004) that rigorous evaluation methods are difficult to apply in design science.

7.3 Further research

While carrying out this research, several issues were addressed and a number of new issues arose. Given the time and resource constraints, we were unable to address all of these issues. In this section, we discuss issues that need to be investigated further.

In chapter six, we presented the case studies that were used to test the dimensions of usefulness, usability, and usage of the prototype. We chose the sites for the tests based on the fact that they were the ones that had service brokers in place at the time of the study, and also because the sites exhibited characteristics that fulfilled the requirements for logistics brokering services in a real life rural environment. Furthermore, the introduction of ICT-enabled logistics brokering services in rural areas was still a new concept at the time of the study, and therefore we were limited by the number of locations available in which to carry out the tests. We considered all three dimensions, usefulness, usability, and usage, since the aim was to study how effective the services implemented in the prototype were in facilitating service brokers in the development of logistics services in rural areas. To further investigate the feasibility of using a suite to support development of services and to study the resulting effect on how it facilitates the service brokers in their daily work activities, the prototype should be scaled up and tailored to a specific problem situation and tested in practise over a long period of time. The results of these tests can then be used to make generalizations about situations under which the utility of a suite is appropriate to facilitate and improve the development of logistics brokering services in rural areas of transition countries. These remarks lead to the following recommendation:

Recommendation 1: Test the usefulness, usability and usage of the suite in the end-user environment over a longer period of time and in other rural areas to determine how it supports and facilitates the development of logistics brokering services.

The prototype was modelled on the concept of outbound logistics and its services are invoked in reaction to a logistics service demand or a logistics service supply. The service demand and supply matching algorithm searches only for the logistics service providers that are registered with the service broker or those that have exposed their services via the Internet. It is not possible to connect to services delivered by logistics service providers whose activities are not yet known or registered with the catalogue at the Infopreneurs™ server. With links to geospatially referenced data services, it would possible to provide contextual information about logistics activities in a given area, which will enable the Infopreneurs™ to direct logistics service providers to the area based on the level of activity or level of need determined from geospatial maps. This would enable the users of the suite to operate in a proactive rather than reactive manner, which would enhance their service delivery capabilities. This leads to the following recommendation:

Recommendation 2: Investigate how the services of the suite can be integrated seamlessly with GIS, geospatial, and other existing location-based service systems to enable proactive and location-based logistics brokering services.

As presented in chapters 4 and 5, a basic argument of this thesis is that using a suite to facilitate logistics brokering services in rural areas should address the following 5 issues: determine the demand for logistics services in an area; determine the current logistics service supply; categorize service demand and supply; match service demand to supply; and communicate the results of a match to the concerned parties. To support these activities, the suite should work with existing systems and use technologies that have proven successful in delivering ICT-enabled services in rural areas, such as the inTouch Africa® software suite. The logistics brokering services functionality should be incorporated into existing ways of working in rural areas. In this way, the functionality of the suite offering support for load consolidation, synchronization, and scheduling of trips can be evaluated and more empirical data on the effects of how it addresses the local problems can be obtained and analysed. This would further facilitate addressing the challenges of logistics service delivery in rural areas and enable emerging economy participants, mostly SMEs, to do business with first economy participants. These remarks lead to the following recommendation:

Recommendation 3: Identify requirements from practise that provide effective decision support for incorporating the logistics brokering services functionality into existing rural service delivery mechanisms, especially those enabled by ICT.

The development of logistics brokering services in rural areas is a difficult task. The suite was aimed at facilitating stakeholders who are facing this challenge. However, developing logistics brokering services that meet the needs of all users in rural areas can take a lot of time. While carrying out the tests on the prototype, the subjects expressed the desire to have extra functionality in the suite, e.g. to enable them to collaboratively share ideas and information through a sort of discussion group. Such functionality would enable Infopreneurs™ to work in a collaborative and distributed manner to solve common problems that regularly occur during service delivery in rural areas. The subjects further expressed the desire to have a function that supports the sending of short messages (via sms) or email to customers and service providers once the service requests have been matched. This leads to the following recommendation:

Recommendation 4: Enrich the suite with a library of group discussion services that facilitate and support collaborative, distributed handling of problems and discussions among the Infopreneurs™.

We used a studio-based approach to service development, and developed a suite to handle the dynamics of developing logistics brokering services in rural areas. During the research, we realized that it was not easy to capture the needs and expectations of all rural logistics services stakeholders.

Simulation can be used to model the local situation and develop a portfolio of models representing stakeholder interests to evaluate the reliability, scalability, and agility of a suite in facilitating all stakeholders in service development. The models can be plugged into the service delivery infrastructure in rural areas to evaluate how the services are used. These remarks lead to the following recommendation:

Recommendation 5: Carry out research into the use of simulation models to support service development and to support the task of identifying and overcoming service implementation issues in rural environments.

Simulation is an effective method of inquiry for supporting organizational decision-making as shown by Jacobs (2005) and Tewoldeberhan (2005). Despite being a powerful methodology, it is not used widely for several reasons which will not be discussed in this thesis (see Jacobs, 2005; Tewoldeberhan, 2005 for an overview of simulation and its limitations). However, we recommend that research needs to be done to find out how simulation can be used to model the characteristics of logistics service delivery in rural areas with the aim of improving service implementation.

In this research, we chose to study problems related to logistics in deep rural areas, and carried out the research in the deep rural areas of South Africa. We recommend that further research should be carried out to investigate the feasibility of applying a suite to other types of brokering services, and in other types of rural areas. This would be especially important for those rural areas with less urban features such as a stable power supply. Although moving goods and people in rural areas of developing countries differs from moving people and goods in urban areas, clear similarities in the principles of the two types of transportation can be identified.

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Appendix 1: Joint requirements elicitation sessions

Location	Date	Topic	Tool	Participants	
				No	Type
Pretoria	20.09. 05	Identification of logistics brokering services	Group discussion; brainstorming.	10	Rural logistics practitioners (7); Rural ICT practitioners (2); Infopreneur™ (1).
Tombo; Port St. Johns	25.09. 05	Verification and refinement of logistics brokering service use cases	Questionnaire; Interview; Observation	10	Wholesale goods transporters (2); Fruit & vegetable transporters (2); Taxi owners (6).
Tombo	26.09. 05	Verification and refinement of logistics brokering service use cases	Interview; Observation	7	Vegetable farmers (5); Small shop owners (2).
Tombo	27.09. 05	Verification and refinement of logistics brokering service use cases	Interview; Questionnaire	3	Infopreneur™ (1); Small business developers (2).

Logistics services identified by the practitioners:

- *Spatially-referenced catalogue of supply and demand*: this service will be used to enable the transport service operators to access mapped displays of quantities to be transported at a given time. This would also contain information on who is doing what, where, and how; and should be delivered in a facilitated and self-service manner. The logistics service providers would either contact the MPCC in person or send/receive text (sms) messages from the Infopreneur™.

- *Scheduling service*: this service would be used to match the supply to demand and provide information on the available routes, in addition to ensuring that the service delivery is more predictable. The customers would indicate the demand for a service by sending sms or email to the MPCC giving details of the dates and times of travel, and the locations. Once a customer has indicated a demand (e.g. to move from A to B at time T or day D) the Infopreneur™ should be able to use the system to provide information about packaged service bundles i.e. services assembled for a group.

- *Tracking service*: this would provide information on what is where, when, and in what condition probably through the use of RFID technology. The service would be accessed through sending sms as the lowest common denominator in rural areas, and receiving a reply. The data would be updated automatically using location-based services as well as manually by the Infopreneur™.

- *Communication service*: this service should provide simplified, up-to-date information. The customers should also use the service to send queries about transport schedules, tracking information, pricing of transport, etc., through a single message. Through the service, the customers would be notified if there is any change in service delivery times and remedies to the situation.

- *Location service*: this service would be used by the Infopreneur™ to capture and store information about logistics service demand and supply in an area. The service would be used to provide schedules for service delivery based on what is stored in this database.

Appendix 1a: Interview questions for small business owners and farmers

Based on the introduction and use case presented, please provide answers to the following questions:

1. Where do you see yourself in the whole setup?

2. What do you normally do when you need transport from location A to B, either for yourself or for your goods?

3. When do you usually need to move between these (and/or other) locations?

4. What constraints (problems) do you face when you need to fulfil these transportation needs?

5. How do you overcome these constraints (problems)?

6. What would you think of the introduction of a logistics brokering service like the one presented to you? Would you use such a service?

7. Apart from what was presented to you, what other functionality would you expect or require from the brokering service?

8. How would you like this (new) functionality delivered to you?

9. What other services that are not directly related to transportation, would you like to be provided via the brokering service (e.g. e-payment, e-ordering, etc.)?

10. Would you be willing to pay to use the brokering service? If yes, how much? How would you like to pay for it (monthly, pay per use, etc)?

11. Do you have any suggestions regarding how the brokering service should be operated?

Appendix 1b: Interview questions for the Infopreneur™

Based on the introduction and use case presented, please provide answers to the following questions:

1. Where do you see yourself in the whole setup?

2. What do the people you serve normally do when they need transport from location A to B, either for themselves or for goods?

3. When do they usually need to move between these (and/or other) locations?

4. What constraints (problems) do they face when they need to fulfil these transportation needs?

5. How do they overcome these constraints (problems)?

6. Would you consider introduction of a logistics brokering service like the one presented as part of your service delivery portfolio?

7. How do you expect the service to be used?

8. Which other logistics services come immediately to your mind as candidates for brokering that can assist the small enterprises you serve to move up the value network?

9. How do you expect to deliver these (new) services?

10. What other services that are not directly related to transportation, do you think can be provided via the brokering service (e.g. e-payment, e-ordering, etc.)?

11. Do you know of any transport subsidization needs among the people you serve?

12. How do you suggest that you can create demand for the brokering services?

13. What payment model would you think can work best when you provide the brokering services?

Appendix 1c: Interview questions for the logistics service providers

Based on the introduction and use case presented, please provide answers to the following questions:

1. Where do you see yourself in the whole setup?

2. What is your logistics offering/nature of business (e.g. passenger transport, freight transport, short distance transport, etc.)?

3. Who is your target market? Where is your target market located?

4. What is the number of enterprises you serve, and how do they pay you for the services you provide?

5. How do you communicate with your target market (e.g. sms, (mobile) phone, Internet, MPCC)?

6. Would you consider introduction of a logistics brokering service like the one presented as part of your service delivery portfolio?

7. What does your fleet look like (e.g. bakkies, minibuses, specialised transport, etc)?

8. What do you transport mostly (e.g. passengers, raw material, finished products, etc.)?

9. What are your main transport routes? Do you combine requests for transport along this route? Is there an empty leg?

10. How do you charge for your services (e.g. per kilometre, per unit size, per trip, etc)?

11. How do you get paid for your services (e.g. cash only, cash and credit, in kind, etc.)?

12. Do you experience seasonal demand for your services? If yes, when are your busy times?

13. What do you think about the introduction of the brokering service? Would you use the services provided by the broker?

14. What problems do you face in the provision of transport services that can be solved through the brokering service?

Appendix 2: Questionnaire

Dear Sir/Madam,

This questionnaire is designed to assess the application of a prototype in the development of ICT-enabled logistics brokering services. The questionnaire consists of three parts. In part one, we ask background questions to gather demographic and general ICT skill-related information. In the second part, closed ended questions related to the usefulness, usability and usage of the prototype are asked to collect information on the main functions of the prototype. The third part contains open ended questions that are directed to the identification of missing features and problems faced during usage of the prototype. The results of the questionnaire are for academic purposes. It is expected that you will fill in the questionnaire sincerely. Thank you for your help and cooperation.

PART ONE. BACKGROUND QUESTIONS

I am a:

- ❑ Man
- ❑ Woman

I have experience with using the following ICT-enabled services:

- ❑ Email
- ❑ Web browsing
- ❑ Voice (over mobile or fixed line phone)
- ❑ SMS
- ❑ I work professionally with ICT-enabled services. My activities in this field are ……
- ❑ Other, namely ……
- ❑ None of the above

The general level of my ICT usage skills is:

- ❑ Low (e.g. cannot work alone)
- ❑ Moderate (e.g. have some knowledge but need assistance frequently)
- ❑ Good (e.g. highly knowledgeable, need very little assistance in using ICT)
- ❑ Proficient (e.g. need no guidance at all in using ICT)

The highest level of my education is:

- ❑ Matriculation
- ❑ College diploma
- ❑ Degree
- ❑ Other, namely……

My experience with functionalities of the inTouch Africa® software toolbox is:

- ❑ Little (e.g. just newly introduced to it)
- ❑ Moderate (e.g. have some knowledge, but need regular guidance)
- ❑ Good (e.g. can use it without much guidance)
- ❑ Proficient (e.g. can use all functionalities without assistance)

My understanding of the local transport and logistics service needs in my area is:

- ❑ Poor
- ❑ Moderate
- ❑ Good

The domain for which there is most need for transport and logistics brokering services in my area is:

- ❑ Health services
- ❑ Education
- ❑ Agriculture
- ❑ Small businesses
- ❑ Other, namely……

I work in (Province/District) …….

I work as ……

PART TWO. USEFULNESS, USABILITY, and USAGE OF THE PROTOTYPE

The aim of the questions in this part is to gather feedback on application of the prototype in fulfilling the given service development task. Please indicate how much you agree or disagree with each of the statements about the prototype by placing a mark in the corresponding box on the right hand side.

Usefulness	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. The suite presents me with an accurate model of what I need to carry out the task					
2. I am able to complete the task quickly using the suite					
3. The suite is useful for me in creating my services					
4. The suite supports my understanding of basic concepts of web-enabled services					
5. Too much effort is required in performing the task given to me					
6. I can focus on the important service development issues and not distracted by details					
7. The suite provides too many elements such that I cannot concentrate on any one					
8. The messages I get and the log files enable me to develop services better					
9. The suite does not really do what I want it to do when carrying out the task					
10. The suite provides me with a lot of useful functions for service development					
11. The components presented in the suite correctly represent the situation in my area					
12. I have enough knowledge and experience to fill in any gaps left out in the suite					
13. In general, I do not see any added value in using the suite to perform the task					
14. In general, I would prefer to carry out the same task without the suite					

Usability	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I was able to combine services from different providers in a transparent manner					
2. If the prototype is scaled into a full suite, I will use it in my service development tasks					
3. The suite improved my performance as compared to doing the task without it					
4. Using the suite in carrying out the task increased my productivity					
5. Overall I find the suite to be usable in performing the task					
6. My interaction with the suite is clear and understandable					
7. Using the suite, I had more control over the service development task					
8. Interacting with the suite does not require a lot of my mental effort					
9. I found the suite to be easy to use when carrying out the task					
10. I was often confused while using the suite					
11. I frequently made errors when using the suite					
12. I found it easy to get the suite to do what I wanted it to do					
13. I frequently had to consult the user instructions when using the suite					
14. The user instructions provided helpful guidance when using the suite					
15. I found the suite to be inflexible					
16. Using the suite saved me time in performing the task that was given					
17. It was easy for me to remember how to perform tasks using the suite					

18.	The suite often behaved in unexpected ways					
19.	The quality of support that I got from using the suite was high					
20.	I had no problem with the quality of the suite's interface					
21.	The suite worked consistently during the whole task					
22.	The suite worked in a predictable manner					
23.	The suite's interface clearly showed available functions and how to use them					
24.	I have no difficulty telling others about my experience in using the suite					
25.	I believe I can communicate to my peers the consequences of using the suite					
26.	The results of using the suite are apparent to me					
27.	I would have difficulty explaining why using the suite may or may not be beneficial					

Usage		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.	The suite was easy to adapt and use when carrying out the task					
2.	The suite fits very well within the context of my work					
3.	The guidelines accompanying the suite improve the service development effort					
4.	The suite facilitated me to effectively achieve the goals and objectives of the task					
5.	Overall I am satisfied with using the suite in the given task					
6.	Usage of the suite is relevant in service development within my context					
7.	The suite address the key challenges of service development in my environment					
8.	I experienced many technical problems while using the suite to perform the task					
9.	I was comfortable working with the suite					

PART THREE. OPEN ENDED ASSESSEMENT OF THE PROTOTYPE

1. Was there any functionality in the suite that attracted you most while carrying out the task? If yes, please explain.

2. Was there anything missing in the suite that would have helped you to carry out the task better? If yes, please explain.

3. Did you have any problem with using the suite to perform the task? If yes, please explain.

4. What did you think of the amount of time it took you to complete the task using the suite? Do you foresee any distinction between using the suite and not using it in your daily tasks?

5. Do you have any further remarks and/or suggestions about the suite? If yes, please explain.

Thank you for your time.

Appendix 3: Example scenarios for logistics brokering services

Scenario 1: A need for transport of finished goods and raw materials

The problem
I need transport to go and fetch goods from town x. I do not know if anybody else also needs to go to the same place, or who is willing to provide transport. I would typically phone somebody or ask around at the local taxi rank or ask somebody that I know has a bakkie.

The solution
I send a SMS to the logistics service number. The SMS says where I want to go and when. At the ICT-enabled logistics support centre a database is maintained of transport service providers, their routes and their prices. When the SMS is received the database is checked and the request for a service is SMSed out to the appropriate set of service providers. They can then respond either directly back to the ICT-enabled logistics support centre or to the requestor of the service with a "quote". The ICT-enabled logistics support centre can add value by screening the responses and only passing those on that are relevant. The ICT-enabled logistics support centre can also keep a track record of the quality of service of the service providers. The service requestor receives the SMSes and makes a choice of service provider, and sends an SMS or calls the ICT-enabled logistics support centre to accept the offers. After the service has been provided the customer will send an SMS to the ICT-enabled logistics support centre to let them know if the service was bad.

Scenario 2: Getting supplies at the best prices

The problem
I need to find out where I can buy my supplies at the best prices. I am in Tombo and the suppliers are in Umtata, East London and Durban. It is expensive to phone each of them separately, and I have no other means of access to information (e.g. Internet, catalogues, etc). I also need to place pre-orders for some supplies (e.g. day-old chicks).

Solution
If I have an e-mail address I can request quotes and place orders. I want to be able to inform someone at a central point via SMS of my specific need for information, who could then request information from the suppliers on my behalf. The ICT-enabled logistics support centre can send me (a part of) the content of my e-mail via SMS, or inform me via SMS when I have e-mail so that I can come in and pick up my e-mail from the centre.

Appendix 4: UML diagrams for the suite implementation

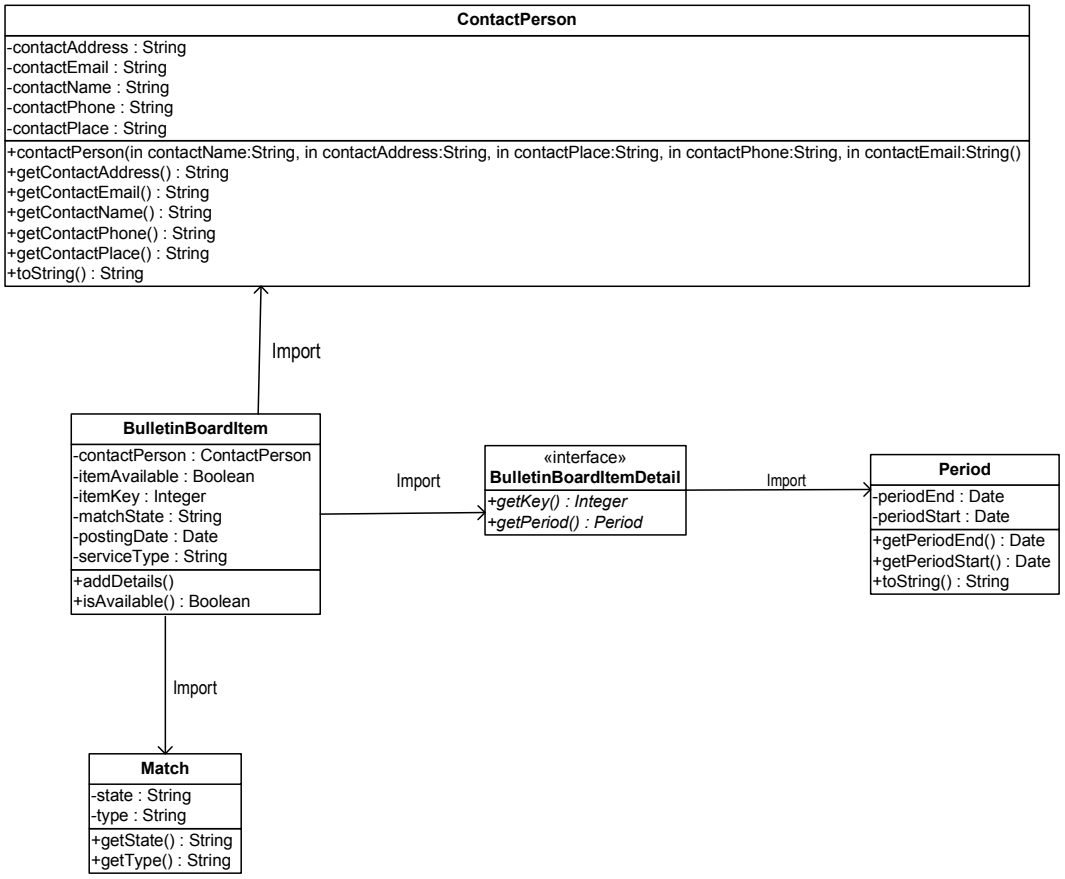


Figure 1: UML class diagram showing how bulletinboard items are matched

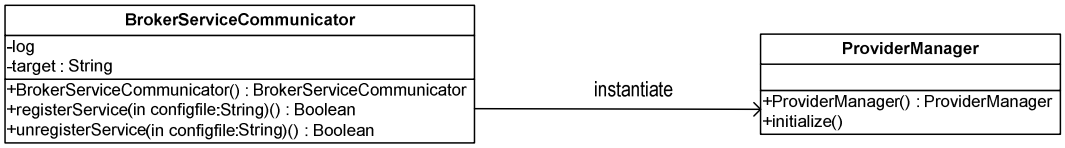


Figure 2: UML class diagram showing how the provider manager is instantiated by the broker services communicator

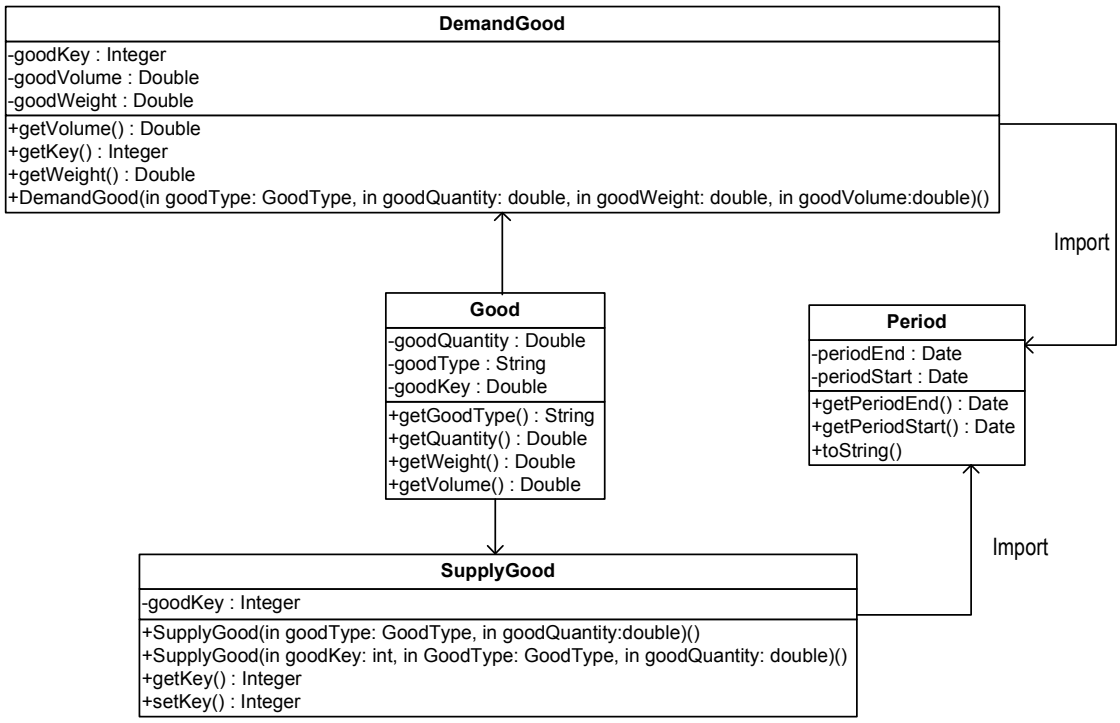


Figure 3: UML class diagram showing how the supply and demand of goods is captured

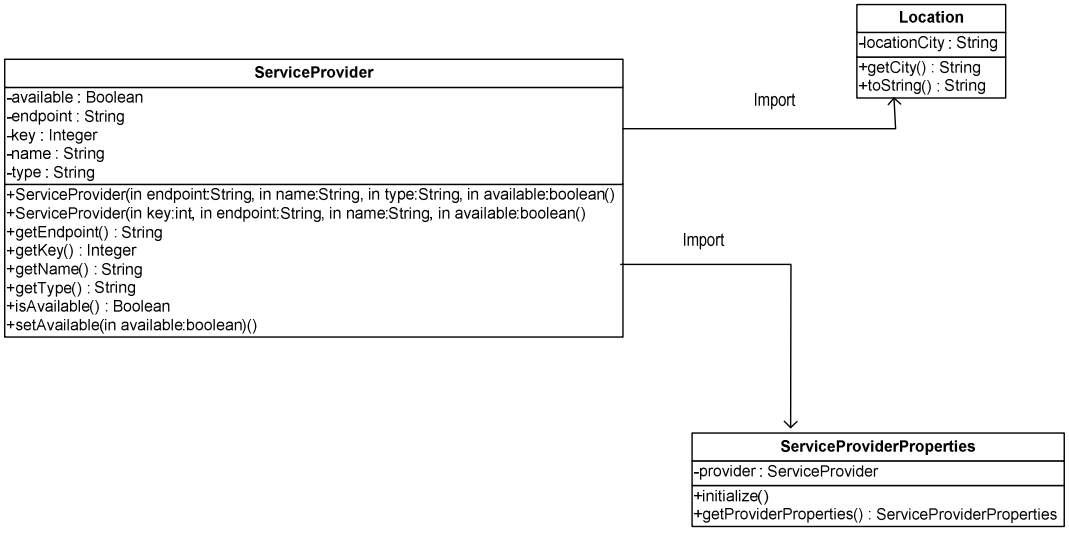


Figure 4: UML class diagram for the logistics service providers

Summary

Introduction
Logistics services are essential components of economic development in all countries, particularly so in rural areas of those countries still in the process of development. The logistics problems in rural areas of developing countries stem from several causes, the most obvious simply being that the countries are developing. As the demand for logistics services increases, rural areas experience many problems that have ready-made solutions developed in the Western world and in urban areas, but that need considerable adaptation to tailor them to the particular needs and conditions of the rural context. Evidence from the literature suggests that ICT is capable of providing solutions to some of the problems faced in rural areas, and that delivery of services using ICT could accelerate development in the rural areas. There is a valid case for presenting this argument given that the context of rural areas is characterised mainly by numerous small, spatially isolated actors for whom service delivery results in high transaction costs occasioned by the long distances to service delivery points. Investing in ICT-enabled service delivery systems improves the general accessibility to services by rural households and enterprises. To overcome the challenges of service delivery occasioned by lack of transport, it is important to apply joint approaches to ICT-enabled service development that enable us to come up with logistics services that link national and local levels.

Many of the service delivery models that have been adapted in the past to address the challenges to the lack of services occasioned by the sparse population and limited access to services in rural areas, do not take into account the social and technological characteristics of the areas. In this research, we state that these challenges can be best addressed through the use of support tools that allow for complex services to be defined, composed and developed. We also state that effective service development can be done using software tools that are deployed in an environment that involves rural end users, with the aim of meeting the highly specific rural user needs. The environment in which the support tools are deployed should enable decision-makers to focus on the relevant service design issues and treat context specific issues from various perspectives. A studio is used as the environment to support the development of services because it places emphasis on leveraging the agility and effectiveness of decision support systems to a level that has already been achieved in more operational management based decision making. We developed a suite for deployment within the studio to address the challenges identified in the research with the aim of facilitating and improving the development of logistics brokering services.

The focus of this work was to study how we could facilitate and improve the development of ICT-enabled services using the technology available and conditions in rural areas. The research challenge lay in developing tools that could be used to facilitate and improve the development of logistics brokering services in rural areas of developing countries. Therefore, we formulated the research objective as: '*To develop a studio to provide effective support for the development of ICT-enabled logistics brokering services in rural areas of transition countries'*. The four research questions that were addressed in the research were as follows:

- How can we provide effective support for the development of ICT-enabled logistics brokering services in rural areas of transition countries?
- How can the current issues in the development of ICT-enabled services be contextualised to improve and facilitate ICT-enabled logistics brokering services in rural areas of transition countries?
- What services should a suite for facilitating ICT-enabled logistics brokering services in rural areas contain?
- How can we use the suite to provide support for ICT-enabled logistics brokering services in rural areas of transition countries given their characteristics?

In this research, we focused on the utility of the suite to facilitate and improve the development of ICT-enabled logistics brokering services in rural areas as the criterion.

Research methodology

To address the research questions we followed the design science paradigm. We used the design science paradigm to create and evaluate a prototype of the suite (artefact) to facilitate and improve ICT-enabled logistics brokering services in rural areas. We obtained knowledge about the logistics brokering services in rural areas by studying the general characteristics of the rural environment and the service delivery mechanisms applied in the rural areas, using exploratory case studies. We also used the design science paradigm to evaluate the application of a prototype of the suite in facilitating real life logistics brokering services among the end users of the suite in a rural area. The goal of the work was to improve and facilitate ICT-enabled logistics brokering services to meet the needs of the rural areas. Various research instruments were used in the design science strategy. We used a literature search to obtain the starting points for the research and to sharpen the early ideas arising from the exploratory case study. The exploratory case study enabled us to get a better understanding of the main issues to be considered in logistics brokering services in rural areas. We used a separate case study to gather information on the perceived utility and usefulness of the prototype in facilitating logistics brokering services, and the studio-based approach as a whole in solving the problems faced by the service brokers in rural areas.

Logistics services in rural areas

An exploratory case study was carried out to help us understand the issues to be considered in the development of logistics brokering services in rural areas. We chose to study the logistics service delivery practise in the rural areas of the Eastern Cape Province of South Africa, a province in which most logistical, marketing and related services are unreliable, ineffective and/or very expensive, thereby marginalizing and excluding most SMEs from ‘mainstream’ supply chains. The study enabled us to understand the main issues in logistics service delivery in rural areas and to determine how ICT-enabled tools could be used to improve the delivery of logistics services in these areas.

The case study revealed that the development of ICT-enabled logistics services in these areas could be complex because of the seasonality of agricultural production, which leads to seasonality of transport service demand and subsequent under-utilization of the available infrastructure; uncoordinated demand for transport capacity, which results in inefficiently small vehicle or shipment sizes, high transport costs, limited bulk purchasing possibilities and discounts; the inherent need for transportation of high volumes of low value produce, e.g. maize, and low volumes of high value produce, e.g. grapes and honey, which leads to uneconomic transport utilisation; poor information on, and access to, major markets and specialized services, which leads to lack of knowledge about who is doing what, how, where, to whom, and when, resulting in the need to travel long distances to markets and incurring high transportation costs; and a general lack of accessible or scale efficient support services and infrastructure, resulting in poor communication and high transaction costs, lack of accessible storage facilities, underdeveloped brokerage services, which all lead to high transportation costs. The main challenge of this research was to look for ways in which ICT could be used to facilitate the rural communities to overcome these problems and improve the coordination of logistics service processes.

Theoretical framework

A literature review was conducted to identify a number of initial theories that could be used to study the problem under investigation, i.e. development of ICT-enabled logistics brokering services. The concepts of service orientation and service oriented architectures were identified as appropriate approaches that could be used to develop services in an effective manner. We learnt that using ICT

in logistics makes it possible to process more information, more accurately, more frequently, from more sources. We also learnt that the effective use of ICT in logistics depends on the capabilities of customers to obtain the data they need to make informed decisions quickly and easily, something that is best done through intermediaries or parties that facilitate market transactions by providing brokering services. We identified and studied frameworks that could be used to define and implement ICT-enabled logistics brokering service systems effectively in rural areas, and also studied literature on new service development. Using the service system framework, we developed a prototype of the suite to facilitate and improve the development of rural logistics brokering business processes.

A suite for logistics brokering services

Based on the case study and findings from the literature, eight requirements to be satisfied were formulated for the services of a suite to facilitate the development of logistics brokering services in rural areas. The suite was to be deployed within the studio. The requirements were focused on the three dimensions of usefulness, usability and usage of the suite in facilitating logistics brokering services. The suite was focused on designing and producing a service oriented logistics brokering tool that aligns with local logistics business process interactions between trading partners to accomplish a common business goal. The services of the suite were developed in such a way that they corresponded to the complex requirements of logistics services in rural areas, namely:

- capturing and maintaining details of logistics service demand
- identifying and maintaining details of available logistics service providers
- categorizing and prioritising the service demand and service providers available
- matching service demand to service supply
- creating service schedules and providing information on available logistics services

We developed a prototype of the suite representing these five components which were broken down and translated into services that provided the functionality required to fulfil logistics brokering service needs in rural areas. The overall concept is that by using the suite in the rural area, the service broker will be able to create service processes that fulfil local logistics needs. The services implemented in the prototype were required to interface with, and use some of, the functionality of the currently used inTouch Africa® software suite, which was a requirement for the case studies that were carried out. This is in addition to using services from remote service providers.

The design of the prototype was based on a concept of assembling information and services from existing web services and data sources to create logistics service business processes. Logistics service demand and logistics service supply formed the starting points for running the functionality of the suite. These were captured using a bulletinboard, containing a set of classes used to handle broker and service provider communication for modifying contents of the bulletinboard. The suite also has a catalogue service that contains a set of classes that allow service providers to register with the broker and receive unique addresses; a matching service containing a set of classes for matching service demand to service supply; a control service containing classes used to deploy and undeploy the ICT-enabled logistics services; the communicator service containing classes for handling communication between service providers and the service broker; the data handler service, which is responsible for handling communication between the deployed services and the database layer; the GUI service that provides an interface to facilitate access to the software platform by users of the suite; a logging service that logs all the activities involved in running the service; and a parsing service that handles the translation of XML configuration files.

Implementing the suite

A prototype of the suite to facilitate ICT-enabled logistics brokering services in rural areas was developed using Java programming language. The Axis HTTP server was used as the web server for handling customer requests and keeping track of the services that were running at any given time. Apache Tomcat, an implementation of the Java Servlet technology, was deployed as the Java Servlet server for purposes of running the prototype. For persistent storage of data and results regarding the service providers and service customers, Oracle 9i with Java Database Connectivity (JDBC) was used as the database management system. The services implemented in the prototype were developed in a loosely coupled manner using service-oriented design and modelling.

The prototype allows the logistics service providers to expose and register their services with the service broker. The Tomcat server was used to deploy the web services at the broker side, and it is where the logistics service providers could register their services through the service registry we created. The registry contains information about the service providers as well as details of whether their services were running or not. Each time the prototype invokes a function to search for service providers information is obtained from this registry. For demonstration purposes, the broker and service providers systems were both run on the same machine. The choice for using this approach to demonstrate the system was governed by the fact that the areas in which we tested the prototype did not necessarily have a stable or regular access to the Internet with which we could access remote service provider databases. There was need to demonstrate the utility of the prototype with the function of remote service invocation. We emphasize that this choice was made only within the context of testing the prototype.

The prototype captured the essential characteristics of the logistics system in rural areas. Each of the services was developed as a separate, loosely coupled, component with the purpose of providing services only when required. The choice for doing this was motivated by the fact that the for the case studies that were carried out, the prototype was required to interface with and use some of the functionality of the existing inTouch Africa® software suite, as well as to use the services exposed by other service providers. The inTouch Africa® suite was the one that was currently used to deliver ICT-enabled services in rural areas, and once the functionality of the prototype was accepted by the users, the logistics brokering functionality would be incorporated into this system. It was therefore very important to ensure that the prototype supported loose coupling of services.

The functionality for matching service demand to supply was implemented in a way that enhances the use of local service providers, and only invokes remote services when a match is not possible from the local bulletinboard at the service broker. The algorithm first goes through the bulletinboard to see if any of the logistics service providers who have offered to supply the service are able to meet the conditions set, and if not it connects to remote service provider endpoints. This is done to determine whether local matches to service requests can be made, to make use of the available service supply within a region. This choice was also made for the purposes of reducing complexity in developing a matching algorithm.

The prototype actually consists of two separate applications: the service broker application for the service demand and supply functions; and the logistics service provider application that takes care of the logistics service providers registering their services and responding to service offerings. These applications were executed simultaneously and independently using service orientation and web services technology. The applications were developed in Java, using libraries for web services, and provided access to an Oracle database management system.

Testing the suite

The case study methodology was used to test the utility of a prototype of the suite and the studio-based approach as a whole, and it incorporated stakeholders in the empirical testing procedures to gather direct feedback on their experience in using the prototype in actual logistics brokering service delivery. The tests were carried out in two ways: in a test setting, to evaluate the application of the suite from the rural logistics service practitioners' point of view; and in the daily work setting of the local service brokers, known as Infopreneurs™, to evaluate whether the suite facilitated the day to day logistics brokering service activities. The aim of conducting the tests was to evaluate the effectiveness of the studio-based approach in facilitating and improving ICT-enabled logistics brokering services. In carrying out these studies we aimed to learn about the situations under which application of the studio-based approach would provide valuable support to the Infopreneurs™ in their daily work activities. The main units of analysis for the testing case were: the end-users of the suite, application of the suite in the work process, ability of the user to develop services using the suite, and agility of the suite in developing logistics brokering services.

Conclusions and recommendations

Based on the research we carried out, we were strongly convinced that a suite is useful and usable in facilitating and improving the development of ICT-enabled logistics brokering services in rural areas. The prototype contained services that supported and facilitated the development of logistics brokering services, and its use was a significant contribution for the utility of tools for service development in the rural areas. During the research, several issues were addressed and a number of new issues arose that required further research. One possible direction for future research is to test the usefulness, usability and usage of a suite in the end-user environment over a longer period of time to determine how it supports and facilitates the development of logistics brokering services. The second possible direction is to investigate how the services of the suite can be integrated seamlessly with GIS, geospatial, and other existing location-based service systems to enable proactive and location-based logistics brokering services. The third possible direction is to further identify requirements from practise that provide effective decision support for incorporating the logistics brokering services functionality into existing rural service delivery mechanisms. The fourth possible direction is to enrich the suite with a library of group discussion services that facilitate and support collaborative, distributed handling of problems and discussions among the users of the suite. The last possible direction we recommend is to carry out research into the use of simulation models to support service development and to support the task of identifying and overcoming service implementation issues in rural areas.

Samenvatting

Inleiding
Logistieke diensten zijn in alle landen essentieel voor de economische ontwikkeling, in het bijzonder in rurale gebieden van ontwikkelingslanden. Logistieke problemen in die gebieden kunnen verschillende oorzaken hebben, waarvan de meest voor de hand liggende is dat die landen zich aan het ontwikkelen zijn. Terwijl de behoefte aan logistieke diensten toeneemt, kennen rurale gebieden veel problemen waarvoor al kant-en-klare oplossingen zijn ontwikkeld in de westelijke wereld en in stedelijke gebieden. Die oplossingen moeten echter nog behoorlijk worden aangepast aan de rurale behoeften en omstandigheden. De literatuur bevat aanwijzingen dat ICT oplossingen kan bieden voor sommige van de in rurale gebieden bestaande problemen. Wij stellen dat het aanbieden van diensten die gebruik maken van ICT de ontwikkeling in rurale gebieden kan versnellen. Deze redenering wordt ondersteund door het feit dat de context van rurale gebieden wordt gekenmerkt door talrijke kleine, ruimtelijk gescheiden, actoren voor wie dienstverlening vanwege de grote afstanden tot de plaats van dienstverlening leidt tot hoge transactiekosten. Investeren in ICT-gedreven dienstverlenende systemen verbetert de algemene toegankelijkheid van diensten voor rurale huishoudens en ondernemingen. Om de complicaties bij de dienstverlening wegens gebrek aan transport-faciliteiten het hoofd te bieden, is het belangrijk de ontwikkeling van ICT-gedreven diensten gezamenlijk te benaderen om zo te komen tot logistieke diensten die nationale en locale niveaus aan elkaar koppelen.

Veel dienstverleningsmodellen die in het verleden zijn toegesneden op het gebrek aan diensten en de beperkte toegang daartoe in dunbevolkte rurale gebieden houden geen rekening met de sociale en technologische karakteristieken van die gebieden. In dit proefschrift bepleiten we dat dit het best kan worden ondervangen met behulp van gereedschap waarmee de definitie en ontwikkeling van complexe diensten kan worden ondersteund. We stellen tevens dat om aan de zeer specifieke wensen van rurale eindgebruikers te voldoen diensten alleen effectief kunnen worden ontwikkeld met behulp van ondersteunende programmatuur. De omgeving waarin deze programmatuur wordt gebruikt dient de ontwerpers van diensten in staat te stellen om zich te concentreren op de relevante ontwerpvragen en daarbij context-specifieke aspecten vanuit verschillende gezichtspunten te benaderen. Het gebruik van een ontwerpstudio als ondersteuning van de ontwikkeling van diensten legt de nadruk op het vergroten van de scherpte en doeltreffendheid van beslissingsondersteunende systemen, waarbij het niveau kan worden bereikt dat we kennen van beslisingsondersteunende systemen voor operationeel management. We hebben een assortiment (suite) van gereedschappen ontwikkeld voor toepassing in de studio voor het faciliteren en verbeteren van de ontwikkeling van *logistic brokering*-diensten.

Het hoofddoel van dit onderzoek was uit te vinden hoe de ontwikkeling van ICT-gedreven diensten zou kunnen worden gefaciliteerd en verbeterd, met behulp van de beschikbare technologie en rekening houdend met de omstandigheden in rurale gebieden. De onderzoeksuitdaging was een gereedschap te ontwikkelen dat de ontwikkeling van *logistic brokering*-diensten in rurale gebieden van ontwikkelingslanden zou kunnen faciliteren en verbeteren. Het onderzoeksdoel hebben we daarom geformuleerd als: '*Ontwikkel een studio om effectieve ondersteuning te bieden bij de ontwikkeling van ICT-gedreven logistic brokering-diensten in rurale gebieden van landen in transitie*.' De vier deelvragen die in het onderzoek aan de orde kwamen waren:

- Hoe kunnen we de ontwikkeling van deze *logistic brokering*-diensten effectief ondersteunen?
- Hoe kunnen recente inzichten over de ontwikkeling van ICT-gedreven diensten worden gebruikt binnen de context van het verbeteren en faciliteren van *logistic brokering*-diensten?
- Uit welke gereedschappen zou zo'n *suite* moeten bestaan?

- Hoe beïnvloeden de specifieke eigenschappen van de gewenste diensten het gebruik van de suite?

Hierbij hebben we als belangrijkste prestatie-indicatoren gekozen voor de effectiviteit en efficiëntie van het faciliteren en verbeteren van de ontwikkeling van ICT-gedreven *logistic brokering*-diensten in rurale gebieden.

Onderzoeksmethodiek
Bij de beantwoording van de onderzoeksvragen hebben we het *design science* paradigma aangehouden. Zodoende konden we eerst een prototype van de *suite* (het artefact) creëren en dit vervolgens evalueren. De kennis over de *logistic brokering*-diensten in rurale gebieden werd opgedaan door de algemene kenmerken van rurale omgevingen te onderzoeken, en daarnaast, in verkennende *case studies*, de mechanismen van dienstverlening in rurale gebieden. Het *design science* paradigma hebben we ook gevolgd door het gebruik van het prototype van de suite door de eindgebruikers in de praktijk te onderzoeken. Een literatuur-studie en de eerste ideeën uit de verkennende *case study* vormden samen de startpunten voor het onderzoek. De verkennende *case study* gaf inzicht in wat de hoofdvragen zijn bij het ontwikkelen van *logistic brokering*-diensten in rurale gebieden. De doeltreffendheid van het prototype en van de studio-benadering op zich is in een aparte *case study* onderzocht.

Logistieke diensten in rurale gebieden
Voor de verkennende *case study* hebben we gekozen voor de logistieke dienstverlenings-praktijk in de rurale gebieden van de Eastern Cape Province in Zuid-Afrika. In deze provincie zijn de meeste diensten op het gebied van logistiek, marketing en aanverwante zaken onbe-trouwbaar, ondoeltreffend en/of erg duur, zodat het grootste deel van het MKB gemargina-liseerd wordt en uitgesloten van de voornaamste bevoorradingsketens. Dit onderzoek heeft ons de hoofdvragen in de logistieke dienstverlening in rurale gebieden duidelijk gemaakt en verschafte inzicht hoe ICT gebruikt zou kunnen worden om de logistieke dienstverlening in deze gebieden te verbeteren.

De *case study* onthulde dat ontwikkeling van ICT-gedreven logistieke diensten in deze gebieden complex zou worden omdat de landbouwproductie en daarmee de vraag naar transportdiensten seizoensafhankelijk is, waardoor de infrastructuur die de piekvraag aankan gemiddeld wordt onderbenut. Tevens bleek de vraag naar transportcapaciteit slecht gecoördi-neerd wat leidt tot inefficiënt kleine zendingen en vervoermiddelen, hoge transportkosten, en beperkte mogelijkheden tot schaalvoordelen. Verder bleek er een duurzamee behoefte te zijn aan transport van grote volumes van goedkope producten, zoals mais, en kleine volumes van dure producten, zoals druiven en honing. Dit leidt niet vanzelf tot economisch gebruik van transportmiddelen. Voorts was er sprake van gebrekkige informatie over, en toegang tot, grote markten en gespecialiseerde diensten (wie doet wat, hoe, waar, voor wie en wanneer). Dit gebrek aan kennis maakt het nodig om grote afstanden af te leggen naar markten en leidt tot onnodig hoge transportkosten. Tenslotte bleek er een chronisch gebrek aan toegankelijke en op de juiste schaal beschikbare ondersteunende diensten en infrastructuur, bijvoorbeeld slechte communicatie en hoge transactiekosten, gebrek aan toegankelijke opslagfaciliteiten, onderontwikkelde *brokering*-diensten, wat allemaal leidt tot hoge transportkosten. De grootste uitdaging van dit onderzoek was manieren te vinden om met behulp van ICT deze problemen te overwinnen en om de coördinatie van logistieke processen te verbeteren.

Theoretisch raamwerk
Op basis van een literatuuroverzicht hebben we een aantal uitgangspunten gevonden voor de beantwoording van onze onderzoeksvraag. Zo hebben we bijvoorbeeld geconstateerd dat de concepten van ‘service orientation’ en ‘service oriented architectures’ (SOA’s) geschikte

benaderingen zijn om doeltreffend diensten te ontwikkelen. Ook kan door ICT meer informatie worden bewerkt die bovendien accurater is, frequenter beschikbaar en afkomstig van meer bronnen. Het effectieve gebruik van ICT in de logistiek blijkt bovendien afhankelijk van de vaardigheid van klanten in het verkrijgen van de gegevens die zij nodig hebben. Dit kan daarom het best gedaan worden via tussenpersonen of partijen die markttransacties faciliteren door *brokering*-diensten te bieden. We hebben raamwerken gevonden voor het definiëren en implementeren van ICT-gedreven *logistic brokering*-diensten in rurale gebieden en hebben ook literatuur bestudeerd over het ontwikkelen van nieuwe diensten. Aan de hand van het SOA raamwerk hebben we een prototype van onze *suite* ontwikkeld.

Een *suite* voor *logistic brokering*-diensten

Op grond van de *case study* en bevindingen uit de literatuur zijn acht eisen geformuleerd waaraan de diensten van een *suite* moeten. De *suite* moest in de context van een studio kunnen worden ingezet. De eisen waren gericht op de drie dimensies van bruikbaarheid, gebruiks-vriendelijkheid en feitelijk gebruik van de *suite.* De suite was gericht op het ontwerpen en produceren van service-gericht *logistic brokering*-gereedschap dat het bedrijfsproces onder-steunt van handelspartners die een gemeenschappelijk zakelijk doel willen bereiken. De diensten van de *suite* werden zo ontwikkeld dat die voldoen aan de complexe eisen van logistieke diensten in rurale gebieden, namelijk:

- vastleggen en bijhouden van details over de behoefte aan logistieke diensten,
- identificeren en bijhouden van details over beschikbare logistieke dienstverleners,
- categoriseren en prioriteren van de vraag naar diensten en het aanbod van dienstverleners,
- aan elkaar koppelen van vraag en aanbod van diensten,
- opstellen van dienstroosters en verstrekken van informatie over beschikbare logistieke diensten.

Ons prototype van de *suite* omvat deze vijf componenten die zijn uitgesplitst en vertaald naar diensten met de vereiste functionaliteit. Het algemene idee is dat de *service broker* door het gebruik van de *suite* in staat zou zijn om dienstverlenende processen te creëren die voorzien in de locale logistieke behoeften. De diensten die in het prototype zijn geïmplementeerd moesten samenwerken met (een gedeelte van) de functionaliteit van het momenteel in gebruik zijnde inTouch Africa® programmatuurpakket. Daarnaast werden diensten van *remote service providers* gebruikt. Het prototype is gebaseerd op het SOA-concept van het samenstellen van logistieke diensten uit bestaande web-services en gegevensbronnen. De vraag naar, en de levering van, logistieke diensten vormde het uitgangspunt bij het selecteren van de gewenstefuncties van de *suite*.

De suite bestaat uit:

- een bulletinboard om de communicatie tussen broker en dienstverlener te faciliteren;
- een *catalogue service* die het dienstverleners mogelijk maakt zich te registreren bij een broker die hen voorziet van een uniek adres;
- een *matching service* voor het afstemmen van vraag en aanbod;
- een *control service* die dient voor het uitrollen en verwijderen van *ICT-enabled logistics services*;
- een *communicator service* voor het faciliteren van de communicatie tussen dienstverleners en de *service broker*;
- een *data handler service* die zorgt voor het faciliteren van de communicatie tussen de uitgerolde diensten en de database;
- een *GUI service* die gebruikers van de suite toegang geeft tot de software;
- een *logging service* voor het registreren van de activiteiten tijdens het uitvoeren van de dienst;

- en tenslotte een *parsing service* voor het vertalen van XML-configuratiebestanden.

De implementatie van de suite
Het prototype van de suite voor het faciliteren van *ICT-enabled logistics brokering* is ontwikkeld in Java. Voor het afhandelen van aanvragen van klanten en het bijhouden van de actieve diensten werd de Axis HTTP webserver gebruikt. Apache Tomcat, een implementatie van de Java Servlet technologie, werd gebruikt als de Java Servlet server tijdens prototype runs. Voor het opslaan van gegevens en resultaten met betrekking tot *service providers* en klanten werd gebruik gemaakt van Oracle 9i met Java Database Connectivity (JDBC). De diensten in het prototype waren zoveel zo min mogelijk gekoppeld (loosely coupled) in overeenstemming met *service-oriented design and modeling.*

Het prototype stelt logistieke dienstverleners in staat om hun diensten bij een service broker kenbaar te maken en te registreren. De Tomcat server werd gebruikt om web-services uit te rollen bij de broker. Daarnaast werd de Tomcat server gebruikt door dienstverleners om hun diensten te registreren in een door onszelf ontwikkeld register. Dit register bevat informatie over de dienstverleners en details over de operationele status van hun diensten. Met behulp van een zoekfunctie haalt het prototype regelmatig gegevens over dienstverleners uit het register op. Voor demonstratiedoeleinden waren de service broker- en de dienstverlener-systemen beide geïnstalleerd op dezelfde machine. Deze keuze was ingegeven door het feit dat in de evaluatie-omgeving de toegang tot het Internet, danwel de databases van de dienstverleners, niet stabiel genoeg en gegarandeerd beschikbaar waren. Het prototype hoefde alleen te demonstreren dat “remote service invocation” zou werken. We onderstrepen nogmaals dat deze keuze werd ingegeven door de situatie waarin het prototype geëvalueerd werd.

Het prototype representeerde de essentiële kenmerken van een logistiek systeem in een landelijke omgeving. Elke dienst werd ontwikkeld als een zoveel mogelijk ontkoppelde (loosely coupled) component die alleen een dienst verricht als daarom gevraagd wordt. Deze keuze werd ingegeven door het feit dat het prototype moest samenwerken met de bestaande inTouch Africa® suite, en met de functionaliteit van andere dienstverleners. De inTouch Africa® suite werd gebruikt voor het aanbieden van de huidige *ICT-enabled services* in rurale omgevingen. De *logistics brokering service* zou in gebruik genomen kunnen worden zodra de functionaliteit van het prototype door de gebruikers wordt geaccepteerd. Daarom was het erg belangrijk dat het prototype een losse koppeling van beschikbare diensten zou ondersteunen.

De functionaliteit voor het afstemmen van vraag en aanbod is geïmplementeerd op een manier die het gebruik van locale dienstverleners stimuleert en die alleen *remote services* aanroept wanneer een match niet mogelijk blijkt via het bulletinboard van de locale *service broker*. Het algoritme stelt eerst op het bulletinboard vast of er logistieke dienstverleners zijn die al hebben aangeboden om de dienst te verlenen, en of deze ook in staat zijn om aan de gestelde condities te voldoen. Pas als dit niet het geval is wordt er gezocht naar *remote service provider endpoints.* Dit wordt zo gedaan om ervoor te zorgen dat locale dienstverleners zelf aan de behoeften kunnen voldoen, en gebruik te maken van het aanwezige aanbod in de regio. Deze keuze viel mede zo uit om het matching-algoritme relatief eenvoudig te houden.

Het prototype bestaat eigenlijk uit twee afzonderlijke applicaties: de *service broker* applicatie voor het bijhouden van vraag- en aanbod-taken, en de *logistics service provider* applicatie voor het registreren van logistieke dienstverleners en hun diensten en voor het beantwoorden van offertes voor diensten. Deze applicaties werden gelijktijdig maar onafhankelijk van elkaar uitgevoerd, gebruik makend van *service orientation* en *web services* technologie. De applicaties zijn ontwikkeld

in Java, gebruik makend van bibliotheken voor *web services* en toegang tot een database management system van Oracle.

Het testen van het prototype

De *case study* methode is gebruikt om zowel het prototype als de studiogebaseerde aanpak op zichzelf te testen. Er zijn empirische evaluaties uitgevoerd met de belanghebbenden om zo directe feedback te krijgen over hun ervaringen met het prototype bij het gebruik van *logistics brokering*. De evaluaties werden op twee manieren uitgevoerd. Ten eerste in een test-omgeving; hierbij werd het gebruik van de *suite* bestudeerd vanuit het perspectief van ervaringsdeskundigen in rurale logistieke dienstverlening. Ten tweede in een dagelijkse werkomgeving van locale *service brokers*, beter bekend als Infopreneurs™; hierbij werd getest of de suite hun dagelijkse logistieke brokeringactiviteiten kan ondersteunen. De tests hadden tot doel de doeltreffendheid van de op een studio-gebaseerde benadering voor *ICT-enabled logistics brokering services* te bestuderen. Door middel van deze studies hoopten we uit te vinden in welke situaties de toepassing van een studio-gebaseerde benadering een waardevolle bijdrage levert aan de dagelijkse werkzaamheden van Infopreneurs™. De belangrijkste aspecten van de analyse betroffen: de eindgebruikers van de suite, de toepassing van de *suite* in het werkproces, de capaciteit van de gebruiker om de diensten te ontwikkelen voor de *suite*, en de toepasbaarheid van de *suite* voor het ontwikkelen van *logistics brokering services*.

Conclusies en aanbevelingen

Op basis van dit onderzoek hebben we de stellige overtuiging dat de *suite* nuttig en bruikbaar is voor het faciliteren en verbeteren van de ontwikkeling van *ICT-enabled logistics brokering services* in rurale omgevingen. Het prototype omvatte de diensten die de ontwikkeling van *logistics brokering services* vereenvoudigden, en het gebruik ervan leverde een significante bijdrage aan de ontwikkeling van diensten in rurale gebieden waar behoefte is aan het verenigen en coördineren van logistieke diensten. Tijdens het onderzoek zijn verscheidene onderwerpen behandeld. Een aantal nieuwe discussiepunten kunnen aanleiding geven tot vervolgonderzoek. Een mogelijke richting voor toekomstig onderzoek moet het nut, de bruikbaarheid, en het gebruik van een suite bij de eindgebruikers over een langere tijdspanne evalueren om zo te bepalen hoe die de ontwikkeling van *logistics brokering services* vereenvoudigt. Een tweede mogelijke onderzoeksrichting heeft betrekking op de vraag hoe de diensten van de *suite* foutloos met GIS en andere bestaande plaats-gebaseerde systemen kunnen worden geïntegreerd om zo pro-actieve en plaats-gebaseerde *logistics brokering services* mogelijk te maken. Een derde mogelijke onderzoeksrichting is het verder identifi-ceren van eisen uit de praktijk met betrekking tot de efficiënte ondersteuning van de besluit-vorming voor het opnemen van de *logistics brokering* functionaliteiten in bestaande landelijke mechanismen van dienstverlening. Een vierde mogelijke onderzoeksrichting heeft betrekking op een bibliotheek van diensten die een groepsbespreking ondersteunen en vergemakkelijken, en een plaats-onafhankelijke behandeling van problemen en besprekingen door middel van de *suite* ondersteunen. De laatste mogelijke onderzoeksrichting die wij aanbevelen is een onderzoek naar het gebruik van simulatiemodellen ter ondersteuning van de ontwikkeling van diensten, het identificeren van taken en het wegnemen van problemen bij de implementatie van diensten in rurale omgevingen.

Curriculum Vitae

Simaati Mwenya Muniafu was born on May 14th 1967 in Nairobi, Kenya. After graduating with his 'A' levels from Friends' School Kamusinga in 1987, he studied for a BSc degree in Information Sciences at Moi University in Eldoret, Kenya. During his BSc degree, he did his internship at The Kenya National Library Services and Business Machines Limited, both in Nairobi. After graduating with an Upper 2nd Class honours degree in 1992, he was employed as a graduate assistant, and later as a lecturer in the department of Information Technology at Moi University. During that period he taught bachelor level courses and supervised several end-year projects, in addition to working as a network administrator in the Faculty of Information Sciences. He was involved in several university-wide ICT projects financed both by the university and international development partners. In 1999 he began a Masters degree in Technical Informatics at the Faculty of Electrical Engineering, Mathematics and Computer Science at Delft University of Technology. His Masters Thesis project, which was conducted at ABN AMRO Bank's IT Service and Support Centre in Amsterdam, was about models for estimating the human resources required to provide IT service management. After he graduated in 2001, he went back to Kenya and continued teaching in the department of Information Technology at Moi University. In 2003 he began working on his PhD in the Systems Engineering section of the Faculty of Technology, Policy and Management at Delft University of Technology. During his time in the Systems Engineering section, he participated in a number of projects, taught several courses, published several papers, and supervised a number of Master Thesis projects. He has participated and contributed to the European Union Sixth Framework Programme Collaboration @ Rural (C@R) project on behalf of the CSIR and SAP (Germany), in defining user-centric requirements elicitation and validation methods for information technologies in rural areas.