Modelling change management of evolving heterogeneous networks
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Proefschrift

Ter verkrijging van de graad van doctor aan de Technische Universiteit Delft op gezag van de Rector Magnificus Prof. dr. ir. J. Blaauwendraad in het openbaar te verdedigen ten overstaande van een commissie aangewezen door het College van Dekanen op maandag 2 juni 1997 te 16.00 uur

door

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geboren te Vleuten-De Meern
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Hemmen, L.J.G.T. van
Modelling change management of evolving heterogeneous networks
Doctoral dissertation Delft University of Technology
ISBN: 90-9010446-1
Key words: network management / information system management

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Preface

Organizations rely heavily on their communication networks to realize their primary objectives. Models and theories for the support of the management, control and maintenance of these networks are only formulated from a technical point of view and there has been little fundamental scientific research on organizational aspects of this subject.

The research described is intended to support the management of organizations when they have to manage, control and maintain evolving heterogeneous networks, which is defined as Network Management in this thesis. Two major trends, that influence Network Management, were observed and are described in this thesis. One the formulation of requirements of users in contracts called Service Level Agreements, and two the continuous and rapid changes in technology and the escalating requirements of users.

Two models to support management when performing Network Management are provided in this thesis. Managers can use these models when making an analysis of whether a change will be sensible and beneficial for the quality, cost, and functionality of the network services that are the objects of Network Management. The models are also intended to be used during the audit and design phases of Network Management. The models are based upon a literature study and case study research. The two models are described in chapter 3 and expanded in chapters 6 and 7 with regard to the trends observed.

The results of this research are intended to be used in practice. I therefore look forward to receiving comments and suggestions from practitioners working in Network Management and using the two models provided in this thesis.

Louis van Hemmen
Klarenbeek, March 1997
1 Network Management: the mainstay of contemporary organizations

1.1 The network decade

Each day everyone of us is confronted, whether we are aware or not, with computers, both in business and at home. Commonly computers do not stand alone but are connected to other computers. At work the workstation or PC is usually connected to remote printers, file servers, database servers and worldwide electronic mail facilities. We are also faced with connected computers in private business situations such as visiting a bank or booking a vacation. An automated bank teller can access customer records at their home bank anywhere in the world for e.g. credit validation. A travel agent can access the on-line reservation systems of dozens of airlines, hotels or car rental companies. Even a simple home computer may be connected to other computers by modem to access electronic mail, bulletin boards or remote computing facilities.

Many organizations, for example banks, insurance companies, telephone companies and airline companies, cannot function without computers. Organizations no longer depend solely upon a centralized mainframe; today they also depend on an ability to exchange information rapidly and reliably between computers within and between organizations. Many present day organizations therefore rely heavily on communication networks to realize the primary objectives of the organization, meaning that networks are crucial to the continuation of organizations. Unavailability of a network can have negative or even disastrous, consequences for an organization, leading to huge losses and eventually to possible bankruptcy ([Bates92]). It is therefore essential that these networks are managed properly according to well defined requirements and preconditions.

1.1.1 History

Each of the last three centuries has been dominated by a single technology. The eighteenth century was the time of the great mechanical systems that accompanied the
Industrial Revolution. The nineteenth century was the age of the steam engine, which impacted heavily on society. During the twentieth century, the key technology has been gathering, processing and distributing information ([Tanenbaum89]). Networks are used to support these processes.

Networks, however, are not only a phenomenon of the twentieth century, which is illustrated by figure 1.1 which shows the evolution of network services from 1845 till now.

Figure 1.1 Evolution of network services
Source: Consortium British Teleconsulted Detecon et all. European Commission
The first primitive network was introduced in 1845, in the form of the telegraph system. The telegraph system was used to transmit messages in Morse code over transmission links. In 1876 transmission links were designed that could transmit voice, called the telephone service. The telegraph system was used and telephone is used for communication between people at different locations. These kinds of services are known collectively as telecommunication services ([Dijk91]).

Another kind of service was introduced in 1920 when radio was invented. Sound was supplied with moving pictures and when it was broadcasted in 1930 it became television. Radio as well as television signals are broadcasted through the atmosphere. These types of communication services are known collectively as mass-communication services ([Dijk91]).

During the sixties organizations began using information technology (IT) for administrative applications. One or several computers were installed centrally at a computer centre. Networks were used to transport data between computers. This was the beginning of datacommunication services ([Dijk91]).

Various services have been expanded or derived from the basic services such as video on demand, which is a mix of mass-communication and datacommunication. As we move towards the final years of this century, all three areas are converging rapidly ([Tanenbaum89]).

1.1.2 Trends

Four trends that are leading to an increased heterogeneity and evolution of networks are recognized in the literature: integration of network services, increasing functionality and quality, capabilities to Manage, Control and Maintain, and sharp drop in overall costs.

Integration of network services

Telecommunication and datacommunication have been integrated for the greater part. The introduction of the Integrated Service Digital Network (ISDN) will complete this integration. Mass-communication is being integrated by e.g. the introduction of two-way cable-television which introduces videotext alongside television and telephone. This integration will not be available before 2020 ([Dijk91]). The process of integration is shown in Figure 1.2.
Increasing functionality and quality
Due to the integration of telecommunication, mass-communication and datacommunication new kind of services have been and need to be introduced. These new kinds of services demand a higher quality, like for example video conferencing which demands delay times of less than 100 milliseconds ([Eveleens95]).

Capabilities to Manage, Control and Maintain networks
In the sixties people with a technical background were able to develop new software and hardware and eventually this resulted in the introduction of new network services. Only these experts were able to carry out the management, control and maintenance of the software and hardware. When mini and microcomputers were introduced, less experienced people became capable of performing tasks concerning management, control and maintenance of software and hardware ([Looijjen89]).

This development and falling costs due to mass production, led to more demanding users. They bought their own hardware and software and expected it to be tuned to meet their specific requirements, however, there was a lack of consistency among the various user groups, which gave rise to islands of automation where the diversity of hardware and software was large. Due to this diversity and the huge number of small independent information systems, the need for management, control, and maintenance increased and became more and more complex. At this stage only experts could manage, control, and maintain these information systems. Networks were used to connect the islands of automation, which also increased the complexity of the management, control and maintenance.

Networks and network services are changing rapidly and evolving constantly, both technically and functionally. These complex, changing networks and network services require adequate management, control and maintenance, and only experts are able to perform these complex tasks.
Sharp drop in overall costs
Over the last twenty years the costs of hardware have decreased, leading to an explosive increase in the application of computers and especially in the use of personal computers (PC's). This in turn has lead to a profusion of Local Area Networks and Wide Area Networks to connect the computers.

Looking at the spread of PC's over the last ten years, shows us that the number of PC's installed by organizations has doubled every two years, which seems to be a general trend. The number of people employed by organizations has not increased to the same extent ([Kauffiels92]).

1.1.3 Outline of the remainder of chapter one
The subject of this thesis is the management of networks and network services. In section 1.2 the definitions of networks and networks services are given within the context of this thesis. In section 1.3 the definitions of networks management within the context of this thesis are given. The demarcation of this research is given within the definitions of the subject of this thesis and within the research programme on the management of information systems in section 1.4. The research framework is formulated in section 1.5.

1.2 Networks
In the previous section networks were mentioned without defining what is considered to be a network. The term networks is explained technically (1.2.1) and functionally (1.2.2) in this section. Heterogeneity (1.2.3) and evolution (1.2.4) of networks are also explained in this section.

1.2.1 Technical definition of networks
Many networks can be considered for example social networks among a group of people and computer networks found in the place of work. This research focuses on computer networks that are part of network systems. A network system is considered to be an information system, which is defined in [Looijen95] as:

A structured composition of hardware, software, data, procedures and people used to control, to improve and to obtain better knowledge of real systems or business processes.

A network system is both a subsystem (components) and an aspect system (relationships within) of an information system. Only components that support the communication function are considered and the research is focused on the communication relationships. A (computer) network is part of such a network system.

Several different definitions of a network are available in the literature ([Digital85], [Verdonck92], [Stallings88], [Terplan92]). A network is defined in this research as:

A composition of communication devices and links that connect at least two nodes that consist of hardware and software. These connected communication devices and links perform interactions between nodes using exact prescriptions, including protocols.
According to this definition and from an analytical point of view a network consists of the following components:

* **Communication devices.**
  Communication devices such as front end processors, modems, multiplexers, pabx's, bridges, routers, repeaters, transceivers, hubs, gateways, and faxes, can be characterized by level of standardization, interfacing to other devices and amplification and weakening of signals ([Looijen95]).

* **Links.**
  Several kinds of links are considered: coax-cables, Unshielded Twisted Pair (UTP), Shielded Twisted Pair (STP), optical fibre, terrestrial microwave, satellite microwave and radiotransmission ([Thienen90]). The links can be characterized by reliability, capacity and speed ([Looijen95]).

* **Nodes.**
  Only those parts of the nodes consisting of hardware (excluding communication devices) and software that support the communication function are part of the network. Two of the possible characteristics of this hardware and software are speed, and the level of standardization ([Looijen95]).

* **Prescriptions.**
  As well as prescriptions for the utilization of the network, prescriptions are also needed that specify the format of the datatransmission. Organizational prescriptions are called procedures; technical prescriptions are called protocols, for example the Asynchronous Transfer Mode (ATM) and Frame Relay (FR) protocols. Protocols, that are the translation of these prescriptions in software products, are characterized by speed, and level of standardization ([Looijen95]).

When network components are connected, characteristics like topology, and reach are created and these characteristics can be used to describe the network.

**Network topologies**

The topology of a network is the geometric pattern in which its communication devices, nodes and physical lines are arranged or configured ([Digital85]). Several types of network topologies can be distinguished: star, ring, mixed, bus, hierarchical (tree), and hybrid (figure 1.3). Each topology has its own characteristics and areas for application.

A. **Star:** all nodes are connected to a central point.
B. **Ring:** the nodes are connected head-to-tail.
C. **Mixed:** all nodes are connected to at least one other node.
D. **Bus:** all nodes are connected to a bus where all nodes receive the messages that are transmitted.
E. **Hierarchical (tree):** Several nodes are connected to a node.

In large networks several topologies can be used within the one network this is called a hybrid topology.

![Figure 1.3 Possible topologies](image-url)
Reach
A distinction is made between Local Area Networks (LAN), and Wide Area Networks (WAN) ([Digital85]). A LAN is a short distance network, typically within a building or campus. The properties of a LAN are ([Anzenhof93a]): the reach is within a radius of a few kilometres, and the utilization is to link together computers and peripheral devices, such as printers. In contrast a WAN is a network that connects locations that are located over a wide geographical range. The properties of a WAN are: the radius is wider than a radius of a few kilometres, and it is used to link LAN's in distant buildings and possibly in distant cities.

The difference between Network Management of WAN's and LAN's is disappearing due to the convergence of characteristics of network components that are applicable to both LAN's and WAN's. This is illustrated by the application of the ATM protocol for both LAN's and WAN's.

1.2.2 Functional definition of networks

Networks take care of communication between the connected nodes. Communication means transmitting a message between sender and receiver with the goal of mutual understanding and notification [Starreveld90]. The sender transmits data to satisfy the need of a receiver for information, this is the interpretation of the data that has been sent (figure 1.4).

![Figure 1.4 Principle of communication (DAelen89)](image)

The communication function of networks is achieved by the transport of data consisting of voice, text, images and video to enable users at different locations to communicate and to share (computer) resources that are stationed elsewhere. The data transport can be used to offer value added network services (VAN's) such as file transfer, electronic mail, bulletin boards, electronic data interchange (EDI), teleworking, teleshopping, telebanking, multimedia, video conferencing, music on demand, and video on demand.
1.2.3 Heterogeneity of networks and network services

Nowadays it is impossible to build a network with only one type of component produced by one vendor. Networks consist of several components from several vendors. These kinds of networks are called heterogeneous.

**Description of heterogeneity**

*Heterogeneity means that there is a diversity of types of components.*

With regard to networks, there are four kinds of heterogeneity: multi vendor, multi fabric, multi protocol and multi functionality. The first three kinds of heterogeneity indicate that the diversity arises with the four kinds of network components: communication devices, links, nodes, and prescriptions:

* Hardware and software in the network, including the communication devices and nodes, are produced by different suppliers. Nowadays it is not even possible to develop a network consisting of hardware and software from a single vendor. Interfaces between different networks are therefore important. Heterogeneity based on hardware and software from several suppliers is called 'multi vendor' ([Digital87]).

* Different kinds of links can be used. The choice of a link imposes restrictions on the topology ([Anzenhof93b] pp. 4-05). The heterogeneity based on links is called 'multi fabric'.

* The transport of data over a link is based on prescriptions. The data is divided into predefined formats, which depend on the protocols used. Sometimes it is possible to transform a format belonging to specific protocols into another format. This makes it possible to use several protocols in a network. The heterogeneity based on protocols is called 'multi protocol'.

The last kind of heterogeneity indicates that the diversity arises from the network services based on the network. The services can differ in functionality. This heterogeneity is called 'multi functionality'. A classification of network services is given in chapter 2, which is based on the differences in functionality of the services.

1.2.4 Evolution of networks and network services

Telecommunication services, mass communication services and datacommunication services are combined in integrated networks. This integration leads to a modification of the characteristics of the network and of the services based upon an integrated network:

* The characteristics of communication devices.
  The integration of links, software, and hardware of telephone and datatransmission is required to transmit data consisting of voice, text, images, and video. This integration is only possible if there is a certain level of standardization.
  The interface to other devices is very important when dealing with the multi-vendor problem. It is necessary to create 'open systems', which are able to connect the hardware and software of different vendors without problems.
The characteristics of links.
The capacity and speed of the links have to increase to transmit integrated data consisting of text, voice, sound, images, and video. The need for increasing capacity and speed means that higher bandwidth services (Nx64 kbit/s, 2 Mbit/s, 34 Mbit/s, etc.) are required. These higher bandwidth services demand the use of new technology e.g. ATM based switches and the utilization of optic fibre in the network.

The type of transmission is also changing, the possibilities of mobile services have led to a switch between transmission via links and by air; radio and television used to be broadcast via air but, increasingly this type of transmission is now realized via cables; telephone used to be transmitted via links but this type of transmission is increasingly realized atmospherically ([Sven93]).

The characteristics of nodes.
The characteristics of the nodes that are connected by the network are also changed by changing technology that offers more functionality at equal or lower costs.

The characteristics of protocols.
New advanced protocols need to be introduced to realize higher transmission speeds, e.g. Frame Relay and ATM. These protocols must reach a certain level of standardization before they can be used in practice.

The characteristics of networks.
Networks will become less hierarchical in their topology due to an abundance of bandwidths and the introduction of more functionality in network components. Another consequence is that the network will evolve to a general purpose infrastructure in which many logical networks are mapped. This means that the reach of the network will increase. The huge networks that emerge will form Wide Area Networks that will be used and owned by various organizations.

The technical changes in networks have consequences for the diversification of network services. The number of services based upon remote access systems is increasing due to the economies of large switching systems and low cost of transmission. These modifications are part of the evolution of the network and network services.

Description of evolution
Evolution is the transition via changes to increasingly differentiated and complex structures.

In the context of this research gradual transition is the change in the characteristics of network components, with minimal disturbance of the present network services. The increasingly differentiated and complex structures should lead to a better tuning of quality, costs, and functionality which are all related to the requirements and the preconditions imposed by utilization, and the characteristics of the network components.

The evolution of a network is initiated by:
- Changing demand concerning requirements and preconditions (demand pull).
  The parties concerned have different interests in the network and in the network's
services. Network users require a specific functionality, low prices, high quality of the network and network services. Owners want good prospects for the network without loss of investment, together with a better position in the market and better tuning to the demands of users. Network managers desire a better manageable network and a reduction of the complexity of the network and Network Management. In general all parties concerned have requirements and preconditions with regard to costs, quality, and functionality.

* Changing characteristics of the network components (technology push).

There is an urge to apply new technology to avoid a loss of competitiveness. New technology is introduced on a basis of improved or new functionality.

1.3 Necessity of Network Management

1.3.1 What is Network Management?

A network system is part of an information system, as stated in the previous section. The management of information systems is defined in [Lootjen95] as:

*The management of Information Systems entails the management, control, and maintenance of implemented Information Systems in accordance with the requirements and preconditions imposed by utilization and the characteristics of the components of the Information System.*

Network Management is defined analogously to the management of information systems in this research as:

*Network management entails the management, control and maintenance of implemented network systems in accordance with the requirements and preconditions imposed by utilization and the characteristics of the network system components.*

The management of network systems, as defined above, is called Network Management (NM) for the purpose of this thesis.

Network Management includes several tasks on three different levels ([Verdonck92], [Terplan92]) namely, the strategic, tactical, and operational level. Management at the strategic level is responsible for information planning and for the formulation of the goals of Network Management in the information policy. Management at the tactical level is responsible for the preparation and implementation of policy concerning Network Management. The hardware, software, financial resources, personnel and the administrative resources that form the basis of the operational Network Management are controlled at this level. Management at the operational level is correlated to tasks concerning the actual performance of day to day Network Management. These levels involve three fundamental types of management decisions: the strategic level involves long term decisions, the tactical level involves medium term decisions, and the operational level involves immediate and short term decisions.
1.3.2 Driving forces for Network Management

Considerable research has been carried out into techniques for building networks (see chapter 2). This research is of a mainly technical nature. The focus is on creating new technology to make new kinds of services possible. Technical problems have been solved for the greater part by these activities, but Network Management is still a problem.

Network Management has been neglected traditionally both by manufacturers and users. The neglect of Network Management has led to ([Terplan92], [Verdonck93]):

- A need for more and higher qualified staff to keep the increasingly complex networks operational.
- Poor reliability of networks.
- An overall underutilization of communication resources.
- Long lead times for the provision of new services.
- A lack of integration due to heterogeneity.
- The fact that existing standards are not used or not applicable.
- A lack of insight into the utilization of networks and the equipment, causing management to hesitate to upgrade a network until it is evidently needed.
- Increasingly unskilled users due to the increasing complexity of networks.
- The fact that completely new network services are available to users, but without proper control, which means that their full power and usefulness are barely tapped.

The need for Network Management is fortified by the increasing strategic importance of networks, their increasing complexity, expanding costs, a lack of knowledge, the need to improve services and the need to balance the various needs.

Increasing strategic importance

Networks are increasingly essential to support the primary processes of organizations. Many organizations therefore have recognized the strategic importance of their network and its Network Management. Better control ensures, in most cases, a higher level of security, a higher level of performance and this performance corresponds with higher productivity.

Increasing complexity

The rapidly declining costs of personal computers and departmental computing power means that there is an increasing number of network components to be connected and controlled. As well as the constantly growing number of network components, the number of users, interfaces, protocols, vendors, and network services are also increasing. This leads to many network managers having little or no control over a network.

Expanding costs

Network Management should control all costs associated with data and voice communications. The network manager is expected to spend a reasonable amount of money, though this may still be considerable. If cost management is under control, the quality of service may be improved without increasing costs.
Knowledge
Senior management has become aware of the strategic importance of networks that support the primary business processes, however, many senior managers have insufficient knowledge of or even no knowledge of networks. Therefore, senior management depends on employees that are specialized in Network Management. This means that senior management does not have direct control over the network and will be uncertain about investments in the network and in the resources required to manage, control and maintain the network.

Improving the network services
Users require a constant or improving level of service, despite growth and changing technology. Ensuring constant availability of networking resources and services is the ultimate goal of Network Management.

Balancing the various needs
Those who manage networks are expected to satisfy certain business needs such as supporting new applications and customers, providing improved connectivity and ensuring stability and flexibility. At the same time, users' requirements, such as availability, reliability, performance, and stability have to be met when performing Network Management, however there is lack of procedures and suitable tools, skills are limited, and there is a serious shortage of qualified personnel.

1.3.3 Trends in Network Management
The trends in Network Management include integrated management, central control, status dependent monitoring, and outsourcing ([Terplan88], [Terplan92], [Wijs95]). These trends are discussed in this section.

Integrated management
Nowadays the network usually consists of components from several suppliers. Most of these suppliers have developed their own tool to perform Network Management, and the tools of the suppliers are often not compatible when Network Management has to be performed. So various organizations are now confronted with the choice of an integrated system of network management tools which can be used in "multi-vendor environments" ([Terplan92]). Several international standardization bodies and consortiums of suppliers are active in this field. These standardization bodies and consortiums are described briefly in the next section.

Ultimately these efforts are aimed at creating open systems based on freely accessible and supplier independent international or de facto standards. This stage has not yet been reached by present day tools like HP OpenView, NetView/6000, and SunNet Manager. These tools offer a solution to the growing demand for constant access to critical information about components of the network. The information originating from all parts of the network is collected using the tools at a central management workstation.

Central control
Network Management is centralized when networks increase in size, interconnectivity and responsibility, to take advantage of economies of scale, and also to have a single
view of the complete network. Capacity planning, network configuration, problem management, and other Network Management functions reside at a central site (Terplan88). The control of parts of the network can be distributed to intelligent devices. The data that is gathered at these control points is then made available to the local administrator, and also to the central Network Management organization.

The gathering of data concerning the network into a central site also increases the authority and influence of that central organization (Terplan88). The collected data concerns aspects like traffic history, problem history and configuration data. This data is necessary to make decisions that affect the network.

Status dependent monitoring
Analyzing network components and performing periodic preventive maintenance after a certain number of service hours is less essential, due to an increase in the reliability of individual components. Instead status dependent monitoring is emerging, with provisional analysis based on the concentration of measurements and centralization of responsibilities. This necessitates an insight into company requirements such as reliability, continuity, flexibility, security and costs/efforts to satisfy these requirements (Looijen89).

Outsourcing
This trend comes from a drive to focus on primary business processes, core competencies, and to create flexibility in organizational structures by outsourcing and purchasing maintenance in the form of e.g. co-makership relationships (Looff96). A large amount of attention is devoted to the modifications in the network and Network Management, caused by outsourcing mentioned in chapters 4 and 6 of this thesis. An important role is played by service level agreements when a network and its Network Management are outsourced. Service level agreements consist of the levels of performance, the costs and the functionality of the network services that are agreed upon in consultation with the customer.

1.3.4 Attention for Network Management

Several organizations have developed standards for services, protocols and architectures for Network Management. The following organizations are (expected to become) the most influential (Terplan92, Verdonck93, Pras95):

* The International Organization for Standardization (ISO) with OSI Network Management.
* The Comité Consultative Internationale de Telegraphique et Telephonique (CCITT) with the Telecommunications Management Network (TMN). This organization is nowadays called the Telecommunication Standardization Sector (T) of the International Telecommunication Union (ITU).
* The Internet Engineering Task Force (IETF) with the development of the Simple Network Management Protocol (SNMP) for TCP/IP.
* The Open System Foundation (OSF) with Distributed Management Environment (DME).
* The Network Management Forum (NM/Forum) with OMNIPoint.

The NM/Forum is dedicated solely to Network Management, which is not the case for the other organizations listed here.
The organizations mentioned focus mainly on technical aspects of Network Management. The organizational aspects are scarcely mentioned. The exception is OMNIPoint which also focuses on organizational aspects. Some theories that focus primarily on the organizational aspects as described in [Looijen95] and [CCTA90] are considered in this research.

1.4 Demarcation

In previous sections some hints about the demarcation of the research area were given, a definitive demarcation of the research area is given below. This research is aimed at the relationships and interactions between networks and their management and a demarcation is given for both the network and network management. The demarcation on aspects of the network is given in section 1.4.1. The demarcation of the research programme on information systems is given in section 1.4.2.

1.4.1 Demarcation of the object of research

The demarcation was made on basis of the kind of systems that are distinguished in [Leeuw90]: a subsystem, an aspect system, and a phase system. A subsystem restricts the set of objects of the system but all relationships are considered. An aspect system restricts the relationships and the whole set of objects is considered. A phase system is used to look at the system at particular points in time.

Subsystem: requirements and preconditions (heterogeneity)
The focus of this research is on organizational aspects of Network Management rather than technical aspects. So problems that occur due to the connection of two different kind of links or two different protocols are not considered. These problems can be solved by developing a link or a protocol converter. Considerable research has been done to solve these technical problems. Organizational problems receive little attention in the literature (see chapter 2). The focus is therefore on the requirements and preconditions that have to be fulfilled using network components with specific characteristics.

Aspect system: the communication relationships between network system components (heterogeneity)
The communication aspect of the network system is considered because of the function of a network. The function of a network is to transport data in the form of voice, text, images and video to enable users at different locations to communicate and to share computer resources that are stationed elsewhere.

Phase system: the dynamics (evolution)
Networks are continually changing due to changing requirements or preconditions imposed by utilization, or by the changing characteristics of the network components. The network and its Network Management have to be considered at certain specific points of time to focus on the aspects that have been changed. This means that attention is paid in this research to trends like outsourcing, which initiates change.
1.4.2 Demarcation on the research programme

The research programme on the management, control and maintenance (MCM) of information systems ([Looijen93], [Looijen95]) consists of a management paradigm, the frame of reference for MCM tasks and the state model.

Management paradigm
The management paradigm is based on the information paradigm. The information paradigm distinguishes a real system (RS) and an information system (IS), in which the IS describes what happens in the RS and (at least partially) determines it (figure 1.5). The network system is part of an information system which supports the primary processes of companies.

![Diagram showing the information paradigm](image)

Figure 1.5 The information paradigm

The management paradigm is based on an information paradigm ([Brussaard80]), with the management aspect added to it. Here the management serves to maintain the IS in accordance to the requirements and preconditions set by the RS. So three systems are distinguished in the management paradigm: the Real System, the Information System and the Management System. In the case of Network Management a Network System (NWS) is considered instead of an information system. The NWS is a specific information system, namely an information system that focuses on only the realization of communication via a network. The NWS consists of the network, network services, users of the network services, procedures to use the network, requirements made on the network services, characteristics of the network components, and preconditions that are formulated by management.

The mutual relationships among Network Management (NM), the Network System (NWS) and the Real System (RS) are also considered in the management paradigm (figure 1.6). For example the requirements that are formulated by the users of the network services, the preconditions that are derived from the strategy of the company, and the characteristics that are implied by the components of the network.

Further, there are external influences that differ in nature, e.g. managerial, organizational, economical, technological and contractual influences.
Tasks - Frame of reference

[Looijen95] describes a frame of reference which consists of tasks. The tasks are grouped into task fields, which are grouped into task areas. The task areas are positioned on a strategic, tactical or operational level of the NM organization.

The research is focused mainly at the tactical and strategic levels, which means that the operational level is subordinate. The emphasis is on the organization of management, control and maintenance of networks.

Tasks belonging to the task field 'change management technical infrastructure' of the task area 'maintenance of technical infrastructure and operations support' are positioned centrally due to the focus placed in this research on evolution. This task field is limited to the aspects involving communications and it's relationships to other task fields.
State model
The evolving aspect of networks is the central issue in this research, especially the effects of the evolving aspect of the management, control and maintenance of the networks. This can be related to the expanded state model described in [Looijen95] (figure 1.7). This state model is part of the hard core of the Delft research programme into the management, control and maintenance of information systems ([Looijen95]). The present research project is focused on the state Maintenance (M) and the related transitions: the transition from the state Exploitation (E) to another state Exploitation (E1) and the transition from the state Utilization (U) to another state Utilization (U1).

A network has to change to fulfil the changing requirements of users. [Looijen95] makes a distinction between two kinds of changes: M1 and M2 changes. This distinction is based on the consequences for the states utilization (U) and exploitation (E). In the case of an M1 change the states U and E will hardly be changed, while in case of a M2 change new states U1 and E1 are introduced.

![Figure 1.7 The expanded state model](image)


1.5 Framework of the research
All research should be based on a framework according to [Verschuren91]. This framework should consist of a problem, and a research design. The problem can be divided into the research objective: why the research is performed, and the research question: what is considered in the research. The research design can be divided into the research approach: how is the research performed, and the research environment: where is the research performed.
1.5.1 Research objective (why)

The exploration of the object of research given in the previous sections, was used to formulate the objective of this research. Networks appear to be increasingly important for companies, and this increasing strategic importance emphasises the need for research into developing instruments (directives, methods, techniques and models) to support Network Management.

Instruments that support technical aspects of Network Management have been researched and developed, however, most problems that occur are not technical problems but problems with the organization of Network Management. The organization of Network Management is underexposed in the literature and therefore, this research is aimed at solving this lacuna by modelling Network Management.

Network Management is also confronted with heterogeneity and evolution that characterize most networks. The impact of heterogeneity and evolution on Network Management must be reduced by introducing models to support (senior) managers and to assist them to obtain better control over the heterogeneity and evolution of a network.

The objectives of this research were therefore twofold:

* To analyze and describe evolving heterogeneous networks and their Network Management.
* To develop models that support Network Management in coping with the evolution of a network. The goal for the use of these models is to realize adequate and appropriate Network Management.

1.5.2 Research question (what)

The following general research question was formulated based on the objectives of this research:

General research question:

* How can management be supported with regard to the organization of Network Management of evolving heterogeneous networks and network services based upon these networks?

This research question is very broad, therefore the research question was specified into three parts, each of which focus on a specific phenomenon of Network Management.

Evolution and heterogeneity originating from outsourcing of a network and its Network Management forms the focus of the first part of the research. Outsourcing leads to several changes of different kinds. The heterogeneity of the network can be increased by these changes. The objective of this part of the research was to develop a model to support the outsourcing of a network and its Network Management. The emphasis is placed on the rearrangement of Network Management organization.
Research question first part: focus on changes caused by outsourcing:
How can management be supported with regard to changes in the network and network services caused by outsourcing?

Evolution brought about by particular changes forms the focus of the second part of the research. The objective of this part was to design a model to support the handling of these changes. Here the focus is, in particular, on supporting the decision making concerning these changes. To implement or not to implement? That is the question! Data must be obtained to assist managers to make well considered decisions. The consequences of a change can be assessed on basis of the data obtained.

Research question second part: focus on the handling of changes:
How can management be supported when handling changes in the network and network services caused by external influences in general?

The models developed were validated in practice against situations in the third part of the research. This validation allowed the usefulness, correctness, and completeness of the models to be checked. The validation may lead to an apposition (adjustment or refinement) of the models according to experience in other situations in practice.

Research question third part: focus on the testing of the models developed:
Are the instruments developed applicable in general to Network Management in other situations outside the research environment?

1.5.3 Research approach (how)

The research was based on a case study design, a detailed analysis of three case studies provides the basis for the development of appropriate models, which were then validated empirically using two other case studies.

A case study involves examining a phenomenon in its natural setting, and employing multiple methods of data collection to gather information from one or a few relevant entities (people, groups, organizations). According to [Yin84] a case study strategy is extremely useful for appraising a situation if the boundaries of the phenomenon are not clearly evident at the outset of the research and no experimental control or manipulation is used. Typical situations in which the case research strategy is appropriate have been characterized by [Yin84]:

* The need to study the phenomenon of interest in its natural setting, to study practical problems where the experience of actors is important and the context of the actions involved are crucial.
* Problems in a rapidly changing environment, or one where a steady state is not maintained long enough to permit proper research of the phenomenon under investigation.
* An emphasis on the why and how questions, i.e. understanding the nature and complexity of the process taking place.
* A lack of previous studies, and elaborated theoretical understanding, with respect to the phenomenon.

A literature study was performed before and during the execution of the case studies
to explore and define the object of research. The literature study resulted in a theoretical model ([Zwaan90]), which consisted of well defined terms and suppositions about the connections to be found between these terms. An explorative case was performed to discover the lacunae which arise with Network Management. The object of research was demarcated and the research question was sharpened based on the literature study and the explorative case study. The literature study and the explorative case are described in chapter 2.

A general model for Network Management is described in chapter 3. This general model deals with the evolution and heterogeneity of a network system in a general manner, and forms the basis of the models that are developed in the following chapters.

Chapters 4 and 5 both contain an empirical descriptive case study. These case studies position the problem of the research in real life situations. Based on experiences gained during the case studies the general model was expanded with prescriptive models to facilitate Network Management. In chapter 4 the focus is on the research question that deals with changes caused by outsourcing of a network in practice. In chapter 5 the focus is on the research question that deals with the handling of particular changes in a specific situation in practice.

The application of the models in three real life situations are described in chapters 6 and 7. The application of the models was performed in three case studies; one focusing on the model for outsourcing and two case studies focusing on model for handling of changes. The purpose of these case studies was to look at the feasibility and effectiveness of the models for arranging parts of Network Management.

The final chapter, 8 covers the main research findings and directions for further research. The phasing of the research project is illustrated in figure 1.8.
1.5.4 Research environment (where)

This research was performed within the RCC organization. The research environment and the suitability of this research environment for this particular research are described in this section.

RCC Informatieservices BV

RCC was founded over 40 years ago, and it was called the Rijks Mechanische Administratie (RMA). The name was changed to the Rijks Computer Centrum (RCC) in 1969, to reflect the application of continually altering technology. RCC was moved from the Hague to its present location in Apeldoorn in 1973. RCC used to be a government organization and was therefore strongly committed to the Dutch government, with a primary mission to automate Dutch government processes.
November 1990 RCC was privatized with the Dutch government retaining 100% ownership.

Automation of the Dutch government was based on huge personnel and financial systems with demanding requirements for confidentiality of data, continuity and security. In the eighties the need for these huge systems decreased with the increasing decentralization and retrenchments of the Dutch government.

RCC changed from a partial supplier serving only the Dutch government to a non partial supplier to anticipate on this tendency. This modification took place using the strategy of purchases, and led to the foundation of the Roccadie group. The Roccadie group consists of ten organizations (November 1995) which offer a complex package of services for diverse markets on a basis of different platforms. These organizations are RCC information services, Bowhouse Data, Consis (50%), Data Process, Infracare, JBA/Ratioplan Benefux, L+T Informatica, Pink Elephant, TWINFO, and Trendsoft. Local authorities, financial institutions (banks, pension funds) and information intensive organizations within commerce and industry form the primary market of the Roccadie group.

RCC provided, and still provides, system integration and facilities management, under the device of 'automation without own risks'. RCC handles all aspects of operational management and supervision of data processing organizations by providing facilities management. RCC also develops, maintains, and operates information systems and local and wide area networks on a basis of service contracts and using proven technology.

Network services and telematics services have been expanded since 1 November 1990. These services were offered mainly to government agencies, and can be offered independently from other services involving the mainframe.

Criteria for selection of the research environment
RCC was approached by Delft University of Technology Department of Information Systems in 1993, and asked to participate in the research project discussed in this dissertation. RCC was selected as a suitable organization in which to perform the case studies as this organization meets a number of important selection criteria with regard to a suitable research environment for this research. The selection criteria were derived logically from the research question and the research approach, and were formulated as follows ([Hemmen93], [Wijs95]):

- The research environment should be involved with Network Management of networks that are characterized by an extensive dispersal, a diversity of network components, and a dynamic nature.
- Network Management should be involved with problems that concern the evolving and heterogeneous aspects of networks.
- The research environment should provide outstanding opportunities to investigate real life Network Management situations and enable interaction with critical reflection from professionals in the field.

Network Management and RCC: a dynamic couple
The challenges for Network Management are twofold: the network and network services have expanded enormously due to new projects, and the organization of Network Management has changed due to an increased workload and the increasing automation of NM tasks.
Expanding network and network services
Several projects have been started and accomplished in the past two years. These projects concerned the expansion and upgrading of the RCC network and the development of new network services. Examples of some RCC projects concerning networks are:

* **WAN and LAN management for the department VROM.**
  Several LAN's are managed, controlled and maintained for the VROM department of the Dutch government. These LAN's are connected using links of the RCC WAN, called the R-net (see also chapter 5).

* **GemNet.**
  RCC, in combination with Getronics, is developing a network for the Vereniging van Nederlandse Gemeenten (VNG) and the NV Bank Nederlandse Gemeenten (BNG). This network, called GemNet, connects local authorities in the Netherlands using a WAN (see also chapter 6).

* **Pilot Belasting Automatiserings Centrum (BAC).**
  Four locations of offices of BAC were connected by a network in the pilot project. BAC decided to develop a new network that was cheaper, faster and more reliable. This pilot was accomplished to provide information concerning realizable requirements and preconditions for a future network. Based on this pilot Trionet, a combination of RCC, Getronics and the PTT, was selected to develop an infrastructure called ON2000 for the Dutch government.

Rearrangement of Network Management at RCC
Network Management at RCC had to be reorganized at both the organizational and technical levels, due to the expanding network and new network services.

The number of employees in the RCC Network Services (RNS) department doubled in one year. One consequence of this enormous growth has been the division of the RNS department into teams that are responsible for specific areas. The IT Infrastructure Library, commonly referred to as 'ITIL', was used to facilitate the rearrangement of the Network Management organization. The aim of ITIL is to facilitate improvements in efficiency and effectiveness in the provision of quality IT services and the management of the IT infrastructure within any organization ([CCTA90]). ITIL will be discussed further in chapter 2.

It is not possible technically to manage, control and maintain the RCC network without adequate Network Management systems due to network expansion. The Network Management systems in use, were not able to exchange data, and therefore, RCC has implemented an integrated Network Management system.

Judgement of RCC as research environment
RCC is a research environment that meets the selection criteria for this research. RCC is confronted with a network that is characterized by extensive dispersal, a diversity of network components, and a dynamic nature, due to the projects and Network Management reorganization. The Network Management of the network is involved with problems that concern the evolving and heterogeneous aspects of networks.

Real life Network Management situations need to be investigated. Research should be carried out in a situation where interaction with, and critical reflection from professionals in the field is possible; in this RCC provided an ideal environment for the case studies.
2 Network Management: state of the art

2.1 Introduction

The need for research into Network Management was discussed in the previous chapter. The aim of this chapter is to describe useful models that support the management, control and maintenance (MCM) of networks, referred to as Network Management (NM) in chapter 1, and to provide a literature review of models that are relevant to the research question:

General research question:
How can management be supported with regard to the organization of Network Management (NM) of evolving heterogeneous networks and network services based upon these networks?

The research is focused primarily on two factors of the complexity of Network Management: on the heterogeneity of the network and its dynamics, called evolution. The complexity of Network Management is increased due to these two factors. [Looijen95] states that the concept of complexity can be defined by six factors: heterogeneity, dynamics, massiveness (large numbers), geographical distribution, ownership (responsibilities), and utilization.

The heterogeneity of networks is discussed in section 2.2, the focus of section 2.3 is on the evolution of networks, and the focus of section 2.4 is six models that can be used to organize management, control and maintenance (MCM) of networks.

2.2 Heterogeneity

The heterogeneity of the network points to a diversity of network components:
- Hardware and software in the network, including communication devices produced by different suppliers. This heterogeneity is called 'multi vendor'.
- Different kinds of links. This heterogeneity is called 'multi fabric'.
- Transport of data over a link is based on prescriptions. The data is divided into predefined formats, that depend on the used protocols. This heterogeneity is called 'multi protocol'.

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These three kinds of heterogeneity are described in sections 2.2.1, 2.2.2 and 2.2.3. The network services provided by a network may also be heterogeneous, with the services differing in functionality. This type of heterogeneity is called 'multi functionality'. The heterogeneity of network services is described in section 2.2.4.

### 2.2.1 The Open Systems Interconnection reference model: focus on multi vendor

Networks can be modelled using the Open Systems Interconnection (OSI) reference model, which is independent of vendors ([Black93], [Stallings88], [Tanenbaum89]). Vendors, however, apply their own architectures due to their hardware and software having specific characteristics, including a vendor specific philosophy on Network Management.

The Open Systems Interconnection (OSI) reference model is the only internationally accepted framework of standards for communication between two systems made by different vendors ([Newton93]). The OSI reference model was developed by the International Organization for Standardization (ISO). ISO's major goal is to create an open systems networking environment where any vendor's hardware, connected to any network, can share data freely with any other hardware on that network or a linked network. Communication between two systems is therefore described independently from the implementation. The description is a layered network architecture which consists of seven layers (figure 2.1). This approach creates the possibility for vendors to develop their own products with a capacity to communicate with products of other vendors when the OSI specification is used.

![The 7 layer OSI reference model](image)

Figure 2.1 The 7 layer OSI reference model

**Layer 1:** Physical link layer, concerned with the transmission of unstructured bit stream over a physical medium. It also deals with the mechanical, electrical, functional, and procedural characteristics to access the physical medium.

**Layer 2:** Data link layer, provides for the reliable transfer of information across the physical link. It sends blocks of data (frames) with the necessary synchronization, error control and flow control.

**Layer 3:** Network layer, provides upper layers with independence from the data transmission and switching
technologies used to connect systems. It is also responsible for establishing, maintaining and terminating connections.

Layer 4: Transport layer, provides reliable, transparent transfer of data between end points. It also provides end-to-end error recovery and flow control.

Layer 5: Session layer, provides the control structure for communication between applications. It also establishes, manages and terminates connections (sessions) between cooperating applications.

Layer 6: Presentation layer, provides independence to the application processes from differences in data representation (syntax).

Layer 7: Application layer, provides access to the environment for users and also provides distributed information services.

2.2.2 Vendor specific architectures: focus on multi protocol

The network architecture, referring to the way the network is built, has to deal with the heterogeneity of the network. The network architecture is modelled independently of any vendor in the Open Systems Interconnection (OSI) reference model described in the previous section. In this section other network architectures are also mentioned, these network architectures are vendor specific and use their own specific protocols.

Proprietary architectures, such as TCP/IP (Department of Defense USA), SNA (IBM) and DNA (Digital), are in use and compete with OSI (figure 2.2, [Meijer82], [Terplan92]). To persuade customers of the long range applicability of their products, manufacturers offer gateways into networks bases on the OSI reference model. New versions and releases come closer to OSI and it may be assumed that they will coexist for many more years. TCP/IP is the interim "de facto standard" that can be adopted until the OSI layers 4 and 5 standards are defined completely.

Problems that occur due to the connection of two different protocols are not considered in this research (see demarcation chapter 1). This kind of problems can be solved by technical solutions, e.g. using protocol converters.
### 2.2.3 Types of link: focus on multi fabric

Several types of links are considered: coax-cables, Unshielded Twisted Pair (UTP), Shielded Twisted Pair (STP), optical fibre, terrestrial microwave, satellite microwave and radiotransmission ([Thienen90]). The links are characterized by capacity and speed ([Looijen95]).

- **Application of coax cables.** The coaxial facilities of CATV companies pose a long-term alternative for bypassing in rural as well as urban areas. CATV is widely distributed. Federal legislative efforts seem favorably inclined toward allowing CATV companies to provide most telecommunication services without regulation. CATV companies could conceivably sell their entertainment services to cover their principal costs and use incremental costs as a technique for gaining entry into communications. CATV coax cables first have some major hurdles to overcome. There is no equipment today that puts two-way voice and data on CATV coax cable economically, however, a great deal of effort is going into equipment development and some experiments have been executed in Dutch cities (e.g. Nijmegen, Wageningen and Delft).

- **Application of Unshielded Twisted Pair (UTP) and Shielded Twisted Pair (STP).** UTP is usually used to provide an infrastructure for an telephone service. STP is used to provide a LAN infrastructure.

- **Application of optical fibre.** Two types of fibre are distinguished: monomodus and multimodus fibre. Monomodus fibre is only used when an high transport capacity is
needed, so its application is found in the public infrastructure. Multimodus fibre has its application in high speed LAN's and backbones.

- **Application of terrestrial microwave (TM).** Terrestrial microwave are point to multipoint microwaves. Standard configurations entail three or four back-to-back antennas, each serving one sector, transmitting and receiving messages. Each message has an address, with customers picking up only the messages addressed to them.

- **Application of satellite microwave (SM).** There are two types of satellite broadcast: one way and two way. Two way systems are very expensive; a lot of traffic is needed to justify their use. As a result, two way systems have not developed into a serious bypass alternative for any but the largest customers in large urban areas. A one way system is aimed initially at the rural home television market, competing with cable TV.

- **Application of radiotransmission (RT).** Cellular radio has received a lot of publicity. Cellular radio might be expected to be used for the realization of telephone services. Everyone will carry a personal portable telephone, eliminating the need for a standard office or home telephone; however studies do not show that the costs of mobile telephone will drop very drastically for at least 10 years. Realistically, cellular radio is not expected even to begin to replace standard telephones before the end of this century.

Problems that occur due to the connection of two different kind of links are not considered in this research (see demarcation chapter 1). These problems can be solved by technical solutions, e.g. using link converters.

### 2.2.4 Classes of network services: focus on multi functionality

Two main categories of network services are identified in the ITU recommendation I.211 ([ITU92]): interactive services and distribution services. Interactive services are subdivided into three classes of services, viz., conversational services, messaging services, and retrieval services. Distribution services are represented by the class of distribution services without user individual presentation control and the class of distribution services with user individual presentation control.

Definition of the five service classes ([ITU92]):

- **Conversational services:** conversational services provide the means for bidirectional communication with real time (no store and forward) end to end information transfer from user to user or between user and host (e.g. for data processing). The flow of the user information may be bidirectional and in some cases (e.g. video surveillance) the flow of information may be unidirectional. The information is generated by the sending user(s), and is dedicated to one or more of the communication partners at the receiving site. Examples of conversational services include video telephony, video conference facilities and high speed data transmission.

- **Messaging services:** messaging services offer user to users communication between individual users via storage units with store and forward, mailbox and/or messages handling (e.g. information editing, processing and conversion) functions. Examples of messaging services include message handling services and mail
services for moving pictures (films), high resolution images and audio information.

* Retrieval services: the user of retrieval services can retrieve information stored in information centres provides for public use. This information will be sent to the user only on demand. The information can be retrieved on an individual basis. Moreover, the time at which an information sequence is to start is controlled by the user. Examples include broadband retrieval services for film, high resolution image, audio information, and archival information.

* Distribution services without user individual presentation control: these services include broadcasting services. These provide a continuous flow of information which is distributed from a central source to an unlimited number of determined authorized receivers connected to the network. The user can access this flow of information without the ability to determine at which instant the distribution of a string of information will be started. The user cannot control the start and order of the presentation of the broadcast information. The information may not be presented from the beginning, depending on the point of time of user access. Examples include broadcasting services for television and audio programmes.

* Distribution services with user individual presentation control: information is distributed from a central source to a large number of users, however, the information is provided as a sequence of information entities (e.g. frames) with cyclic repetition. This means that the user can access the cyclical distributed information individually and can control the start and order of presentation, and because of the cyclic repetition, the information entities selected by the user will always be presented from the beginning.

One example of such a service is full channel broadcast video on demand.

Each class of services has its own characteristics and imposes different kinds of requirements on the network. Within the classes of services a diversity of services can be offered that have more or less the same functionality, e.g. mail services like WP Office mail, and IBM mail.

2.3 Evolution

The driving forces for changing the network are described in section 2.3.1, the contingency factors in section 2.3.2, the evolution of network services in section 2.3.3, and the evolution of networks in section 2.3.4.

2.3.1 Driving forces for changing the network

Evolution was defined in chapter one as the gradual transition, via countless small changes, to increasingly differentiated and complex structures. In the context of this research these increasingly differentiated and complex structures should lead to an adjustment of the network for the services provided by the network to improve:

* Fulfilment of the requirements and preconditions demanded by users.
* Price in proportion to performance.
* Management, control and maintenance.
* Competitiveness.
[Daas95] makes a distinction between two kinds of driving forces: pull elements and push elements. Increasing competition among companies, the increasing uncertainty and unpredictability with regard to developments in the field of politics, economics and technology, and increasing complexity in the management of organizations are all examples of pull elements. Push elements are mostly of a technological nature when new network components are introduced that have different characteristics and provide more functionality.

Several external influences are distinguished in [Looijen95]. Four of these external influences are:

* **Managerial influences.** The organizational structure of the real system may be changed as a result of merges, alliances, joint ventures or disposal of certain business units.

* **Technological influences.** New technological innovations and improvements in price/performance may lead to the replacement of existing network components. These influences are discussed in section 2.3.3.

* **Economic influences.** Demand by customers and supply by service providers have their consequences for a network service and the management of that service. These consequences are described in the table 2.1.

<table>
<thead>
<tr>
<th>SERVICE X</th>
<th>demand</th>
<th>high</th>
<th>low</th>
</tr>
</thead>
<tbody>
<tr>
<td>supply</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>continuation and perfection present service</td>
<td>focuses on other services or increase the portion of the market</td>
</tr>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>adjusting of the service to requirements of the customer</td>
<td>quit present service (when possible)</td>
</tr>
</tbody>
</table>

Table 2.1 Consequences of supply and demand

* **Informational influences.** New laws and, or regulations enacted by the government may lead to changes in a network e.g. laws concerning privacy, encryption, or regulation. [Brock96] focuses on regulation aspects that influence the Network Management of international networks.

A combination of these external influences can also occur, e.g. the outsourcing of a network is mainly a managerial influence, however, the outsourcing can be the result of an economic influence. Outsourcing is usually accompanied by a contractual influence to document the quality, functionality and cost of the outsourced services.

These external influences, or a combination of them, may lead to a change in the network or services based upon the network.

### 2.3.2 Contingency factors

Contingency factors that concern the company where the Network Management is performed influence the organization of Network Management. These contingency factors are ([Looijen89]):

* **Type.** The type of organization distinguishes organizations into categories like
industry, banks, insurance companies, departments, education, and research. Each type of organization has its own area of application and specific automation needs.

* **Size.** The size of a company can be indicated by turnover and profit, number and kind of products, number of employees and geographical departments. Size influences the way a network is developed.

* **Culture.** Usually several cultures can be distinguished in large companies; culture influences user requirements.

* **Power.** Power is important when decisions have to be made concerning changes in the network. Fast technological change leads to power being held in the hands of people who perform the actual Network Management.

* **Organization structure (formal and informal).** The organization structure also determines the utilization of the network to support the business processes.

* **Company age.** In general more formal procedures will be found in an older company than in a relative young company.

* **IT utilization stage.** The IT utilization stage can be indicated using the Nolan model which contains six stages ([Boonstra92]), see table 2.2.

<table>
<thead>
<tr>
<th>Stage of Growth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation</td>
<td>Early use of computers by small numbers of users to meet basic organization needs. Decentral control and minimal planning.</td>
</tr>
<tr>
<td>Contagion</td>
<td>Experimentation with and adopting of computers by many users. Profiliation of applications. Crisis due to rapid rise in costs.</td>
</tr>
<tr>
<td>Control</td>
<td>Organizational controls established to contain growth in use and apply cost-effectiveness criteria. Centralization. Controls often prevent attainment of potential benefits.</td>
</tr>
<tr>
<td>Integration</td>
<td>Integration of applications. Controls adjusted. Planning well established. Alignment of information system to organization.</td>
</tr>
<tr>
<td>Data administration</td>
<td>Focus on data administration. Some slack to encourage development of systems which contribute to strategic advantage of the organization.</td>
</tr>
<tr>
<td>Maturity</td>
<td>Application portfolio is complete and matches the organizational objectives</td>
</tr>
</tbody>
</table>

Table 2.2 Nolan IT utilization stages

### 2.3.3 Evolution of network services

Evolution of network services implies changing functionality offered to users via the network. Figure 1.1 shows the evolution of network services from 1845 to the present day. The differences between telecommunication, mass communication and datacommunciation are disappearing, and these three areas are converging rapidly (figure 1.2).

### 2.3.4 Evolution of networks

The integrated network services demand higher quality of the network, therefore, the network also has to change. The network has to increase in quality: increasing speed.
increasing reliability, increasing capacity, and increasing availability of the network.

The objective of fast transmission is to transmit integrated data, voice, images and video. Such information requires isochronous transmission with a delay time between sending and receiving that has little or no variation. A delay time of more than 5 msec is already disturbing for the transmission of voice and video ([Steenis95]). The evolution of networks involves increased speed and capacity using new techniques that support isochronous transmission with small delay times.

Full scale transition to a high speed solution requires that a network is replaced, at considerable cost and effort. While new installations can be wired from the outset for high speed technologies with a minimum of additional overhead, upgrades to existing facilities must maximize cost effectiveness while minimizing network and employee downtime ([Gottlieb94]).

A move to high speed technologies may not reduce the potential for bottlenecks if a network is poorly designed. Improving performance by increasing speed simply removes a symptom. The first step in addressing bandwidth limitations is to design the network to optimize performance. Managers can use time tested products and technology to improve traffic flow and add more intelligence to the network, while allowing for future technologies. Upgrading the network in this way minimizes downtime, and with the right equipment, provides a smooth migration path to higher speed technologies as they mature ([Gottlieb94]).

2.4 Models supporting the Network Management organization

The focus of this research project is on the Network Management organization. Several models exist which are related to the Network Management organization. The following five models are considered:

- OSI Network Management, section 2.4.1.
- Telecommunications Management Networks, section 2.4.2.
- OMNIPoint theory, section 2.4.3.
- IT Infrastructure Library, section 2.4.4.
- Tasks - Frame of reference, section 2.4.5.
- DUnet Management Model, section 2.4.6.

These six models were selected because they have been applied within the field of management, control and maintenance (MCM) of IT, more specifically for the management of networks. The first three models are accepted and applied internationally. The last three models are used mainly in the Netherlands. ITIL is also used in the United Kingdom, where it was developed.

As the research was performed as part of the research programme of the Technical University of Delft, two models were selected that were developed at this university. The research was also performed in practice within commercial organizations. The organizations selected all used ITIL to arrange the Network Management.

The models are described briefly, whereafter they are reflected critically for there suitability to support the network management of evolving heterogeneous networks in section 2.4.7.
2.4.1 OSI Network Management

**Aims**
OSI Network Management is designed for the MCM of OSI stacks in Open Systems, which are systems that can communicate with other systems according to the principals of Open Systems Interconnection (defined by ISO). Arrangements have to be made that define the way the information for the MCM can be exchanged to manage, to control and to maintain Open Systems.

**Concepts**
The International Organization for standardization (ISO) describes, in the OSI Network Management reference model five functional areas for Network Management, which are described in the Specific Management Information Services (SMIS). The functional areas, including a short explanation in conformance with [Obsitnik94], are:

- Configuration management: management of the setup of the network and its devices.
- Fault management: management of abnormal network conditions.
- Performance management: maintenance of and planning for network capacity.
- Accounting management: allocation of network costs.
- Security management: management of network access and control.

These functional areas are described below ([Terplan92], [Verdonck93], [Hemmen94]).

**Configuration management**
Configuration management covers the configuring of the network and monitoring and control of the network. The (planned) maintenance of network components is usually also part of the configuration management activities. So, configuration management provides a complete survey of the network e.g. knowing what network components are where and what the status of the network is. Configuration management is an ongoing process. It does not stop after acceptance and implementation.

**Fault management**
Fault management is a collection of activities required dynamically to maintain the network service level. These activities ensure high availability problems and performance degradation are quickly recognized, and controlling functions are initiated when necessary, these may include diagnosis, repair, test, recovery and backup. Log control and information distribution techniques are also supported. Fault management focuses on fault detection, fault diagnosis and fault repair.

Faults can be detected by the Network Management organization in two ways through the receipt from an alarm on a management system or a user complaint received by the Help Desk.

**Performance management**
Performance management is the process of defining the ongoing evaluation of the network to verify that service levels are maintained, identify actual and potential bottlenecks, and to establish and report on trends for management decision making and planning. Building and maintaining the performance data base and automation
procedures for operational control are also included. Performance analysis is aimed at getting the Quality Of Service (QOS) parameters of the complete network and the separate telecommunication services of the network. QOS parameters include:

- Availability.
- Reliability (e.g. Bit Error Rate, Block Error Rate).
- Response time (seconds).
- Throughput (kbytes/sec).
- User appreciation.

Accounting management
Accounting management is the process of collecting, interpreting, processing and reporting costing and charging oriented information on resource utilization. This information is used to determine the tariffs for utilization of the network services.

Security management
Security management is a set of functions used to ensure the ongoing protection of a network. These functions are used to analyze and minimize risks, to implement a network security plan, and to monitor the success of the strategy. Special functions include surveillance of security indicators, partitioning, password administration, and warning or alarm messages on violations.

Management of network security involves managing security facilities for access to, and the use of, the network at the physical, electrical, logical and procedural/organizational levels.

2.4.2 Telecommunications Management Networks

Aim
To coordinate activities on standardization in the area of telecommunications management, a new form of management was necessary, to meet growing management needs, these include:

- Interoperability of management systems.
- Increasing demand for management functions i.e. automatic reconfiguration, bandwidth management.
- Increasing number of services providers via the telecom network.
- Multi vendor Network Management.
- Easy extension of management functions.
- Facilities for the user to perform configuration of access management of the network as a whole: integrated view of the quality and reliability of the network.

A model to fulfill these needs is being developed by the Comité Consultative Internationale de Télégraphique et Téléphonique (CCITT). This organization is now called the International Telecommunication Union, section Telecommunication Standardization Sector (ITU-T). CCITT has developed a management network comprising management systems: a Telecommunications Management Network (TMN). CCITT started to work on TMN in 1985, to address the administration and management of complex telecommunication networks. The finalising of all TMN standards is expected to take another couple of years; however, the TMN architecture
is stable and based on requirements and objectives, which are also stable. The latest version of TMN is defined in Recommendation M.3010, 'Principles for a TMN'.

The basic concept behind TMN is to provide an organized network structure to achieve interconnections between the various types of management systems and the network to be managed. An architecture with standardized interfaces is essential in the TMN approach. The standard interfaces comprise the protocols used and messages exchanged. The TMN architecture is aimed at meeting the following requirements, to:

- Minimize management reaction times to events.
- Minimize network load on telecom network caused by management traffic.
- Allow geographic distribution of control of network operation.
- Provide isolation mechanisms to locate network faults.
- Improve service assistance and interaction with customers.

Concepts
The TMN architecture has three perspectives: the functional architecture, the physical architecture and the information architecture, and is divided into four layers.

**TMN Functional architecture**
This architecture is the first step necessary to achieve standardized exchange of management information. This is modelled by function blocks and reference points. A function block is a cluster of functions with common characteristics. For example, the functions used to measure network traffic.

Function blocks exchange information at reference points. The type of a pair of function blocks exchanging information determines the name of the in-between reference point.

**TMN Physical architecture**
This architecture is derived from the functional architecture, and defines connected systems where the system boundaries are determined by reference points. Each system comprises one or more function blocks. If two function blocks are implemented on different systems, then the in-between reference point is implemented physically as an interface. Five types of systems are distinguished in TMN: network element (NE); operation system (OS); workstation (WS); q-adapter (QA); and medication device (MD).

**TMN Information architecture**
This architecture defines the principles for exchanging management information between function blocks, defining the structure (syntax) and meaning (semantics) of the messages that are exchanged. This architecture uses the same model, techniques and methods as the OSI management structure of management information. This is reflected by the following characteristics:

- Representation of equipment to manage using managed objects.
- Managed objects react to operations and generate events.
- Same naming and addressing method.

**TMN architecture layer**
The TMN architecture consists of four layers: 'network element management', 'network management', 'service management', and 'business management'. These
layers form a hierarchy with the layer 'business management' on top and at the bottom, the layer 'network element management'.

**Network element management**
This layer offers functions for the MCM of a set network elements of a specific class (e.g. the class represented by elements of one supplier/vendor). This layer also screens the upper layers from specific vendor MCM functions. These specific vendor MCM functions are made into a uniform standard format (e.g. the SNMP protocol is available to transform the data into a standard format).

**Network management**
A total overview of the network is present in this layer, which means that the topology is visible as well as the individual network components, without the vendor specific characteristics. The functions in the network management layers are responsible for an integrated MCM of the network elements.

Network management is defined by the functional areas for Network Management, as described and standardized in ISO (section 2.4.1).

**Service management**
The service management layer offers functions for the MCM of services based upon the network. The physical details concerning the way the services are implemented are not visible in this layer. Several business processes are responsible for the MCM of the services. The functions for the MCM support the business processes.

The functions of the MCM can be divided into two groups:
- Functions to support operational customer processes, which include the appointment of service contracts, service level reporting, determining and collecting the costs of the services, handling complaints about the quality and cost of the services; trouble ticketing and help desk, and distributing information on the utilization of the network services.
- Functions to support service managers, which include returns and sales per service, billing and chargeback, quality of the services, and trends in the utilization of services, traffic analysis & capacity planning.

**Business management**
Business management supports the business managers with the accent on market economy, turnover, positive and negative trends, cost effectiveness. Business management concerns primarily, the MCM of the network at a strategic level. This concerns the following aspects:
- Long term plans, in accordance with the company plans.
- Projects, taking into account time, personnel and budget.
- Quality, in accordance to the SLA.
- Security, in accordance to the security procedures of the company.

### 2.4.3 OMNIPoint theory

**Aim**
The Network Management Forum (NM/Forum), which develops and adjusts
OMNIPoint (Open Management Interoperability Point), is a consortium of over 100 vendors, users and service providers; all the important network vendors are members. The aim of the NM/Forum is to accelerate the development, implementation and availability of multi-vendor Network Management. NM/Forum bases it activities on, but does not restrict them to, OSI Network Management ([NM/Forum90]). Where needed, standards are supplemented.

Once in two years the NM/Forum makes a best fit between user requirements and available standards. These events are called OMNIPoints. Each OMNIPoint results in a new release of NM/Forum specification.

The aim of OMNIPoint is to ([NM/Forum90]):

* Provide a common approach to the integration of diverse technologies.

* Coordinate market standards, such as the Simple Network Management Protocol (SNMP) with formal standards, such as the ISO Common Management Information Protocol (CMIP), which ensures that service operators and their customers share a common approach to management that will offer new service opportunities.

* Provide a consistent and practical approach to the implementation of the Telecommunications Management Network (TMN) model.

* Make good procurement and development decisions with the help and guidance of experts from many parts of the networked information industry.

* Minimize investment outlay and investment risk by choosing the combination of technologies that is right for the task and by following a path that has the support of all of the major suppliers of information and telecommunications equipment and services as well as major user organizations.

* Enable the automation of management functions through application integration, enhancing operational efficiency and reducing costs.

**Concepts**

OMNIPoint 1 is a set of standards, implementation specifications, testing methods and tools, and object libraries that make possible the development of interoperable management systems and applications. OMNIPoint 1 defines a complete infrastructure that, when implemented, enables management systems to interoperate and exchange information in a common way.

OMNIPoint provides specifications for the basic infrastructure to implement open management of networks; it does not define the actual management applications themselves, like an user interface or a management information base; nor does it mandate the Application Programming Interfaces (APIs) employed with them. The detailed functions to be performed by particular management applications are not defined by OMNIPoint 1. OMNIPoint 1 defines the elements that must be implemented to achieve effective exchange of management information.

Definitions are provided for:

* Common Management Information Services required by management applications.

* External Communication Services that a management system must use to communicate with another management system, together with an application interface.

* Managed Objects that may be stored in the Management Information Base.
Common Information Management Services
The Common Management Information Services (CMIS) define the protocols required to transfer management information providing the vehicle for the transfer of management commands and responses. It also achieves interoperability between management systems, and is made up of the following:

- Information Services that define a naming architecture for Managed Objects as well as standard ways for two communication management systems to negotiate a common understanding of their management capabilities.
- General Management Services that specify a set of capabilities that are required for configuration management and event reporting.
- Security of Management Services that provide mechanisms to protect management applications and information from unauthorized access.
- Trouble and Testing management Services that provide formal procedures to initiate trouble reports as a result of a problem detected by a management system. Remote testing of a management system is also provided.

External Communication Services
OMNIPoint I provides specifications for an OSI transport network, and it also provides for the information to be transported over other networks, including those supporting the TCP/IP protocols. Within a management system, common interfaces enable applications to be developed without concern for the particular protocols being employed.

Managed Objects
OMNIPoint I specifies the method by which the details of the resources being managed are recorded so that the information can be communicated between different systems. These are known as the Guidelines for the Definition of Managed Objects (GDMO).

Business model for networked information systems management
Due to the complexity and broad scope of areas and functions that are involved with Network Management, OMNIPoint defines a model for the business. The model describes the organization of the business, identifies the purpose of each business area and identifies the relationships between all the areas. It does not make any assumptions about departmental or geographic boundaries within the business. It attempts to define business areas such that the model fits different departmental organizations.

The business model can provide a formal basis for specifying requirements of a Network Management System in a systematic manner ([NM/Forum92]). A diagram of a logical model for the business is shown in figure 2.3.
2.4.4 IT Infrastructure Library

Aim
The aim of the IT Infrastructure Library, commonly referred to as 'ITIL', is to facilitate improvements in efficiency and effectiveness in the provision of quality IT services and the management of the IT infrastructure within any organization ([CCTA90]). Therefore, the processes that are necessary to support the exploitation and the MCM of the IT infrastructure are described.

Concepts
ITIL recognizes over forty processes and objects that are of importance for the MCM of the IT infrastructure. ITIL defines IT infrastructure as the total of technological components, the system and application software, the documentation and all the procedures that are necessary to realize one or more IT services. Each of the forty processes and objects is described in a module. In each module a reference is made to other modules that are related to the process or object described by that module.

A distinction is also made between modules involving short term operational goals, modules concerning medium term tactical goals, and modules involving long term strategic goals. Modules that mostly involve Network Management are: configuration management, help desk, network services management, problem management, change management, availability management, capacity management, contingency planning management, cost management, and service level management.

The module Network Services Management (NSM) is not a description of a process to achieve Network Management. NSM is primarily a module that gives an overview of Network Management by defining a NSM 7-layer model, which is the central topic.
The NSM 7-layer model
Traditionally a bottom-up approach has been adopted with regard to Network Management, i.e. the network itself is the focus rather than the services that are provided, when in reality what is required is a top-down approach ([CCTA94]). The total requirement of NSM is represented as seven separate layers of functionality.

This NSM model is similar to the OSI reference model (section 2.2) with regard to the way of working: each layer relies upon a service provided by the layer underneath and is a service provider to the layer above. It is essential that the emphasis is placed on satisfying the business needs of the organization, and that NSM is planned as an integral part of the network and not added on as an afterthought. This will ensure that the NSM staff, tools and procedures will all work in harmony with the network and its technology rather than fighting against it.

Layer 7 - Business Management
This is the top layer of the model and represents the functions needed by the business managers for example, accounting, billing, design, development, operations and planning and control.

Layer 6 - Network Services Management (NSM)
This layer is responsible for coordinating the activities of the four supporting disciplines in layer 5. It also satisfies the needs of the business managers by supporting the operation of facilities and information required to optimize the performance of the business management function. NSM is responsible for:

* The control and integration of all of the network services and users.
* The provision of a central point of contact for all aspects of the NSM activities.
* The provision of an interface to all business, IT and service managers on all network matters.
* Ensuring that all network modifications and enhancements have minimal impact on continuity of service.
* Planning, monitoring and controlling the four NSM disciplines (layer 5) and their environment.

Layer 5 - NSM Disciplines
Four supporting disciplines supply the reports and information that the NSM requires to function in a cost effective manner and to provide the required level of service. These disciplines support the organization of the Network Management.

There are four distinct, yet interrelated, disciplines:

* Network Services Planning (NSP) encompasses the strategic and tactical planning processes undertaken prior to implementing or enhancing a network service. NSP develops and maintains the strategic Network Plan that will underpin the business strategy.
* Network Services Administration (NSA) is responsible for the tactical planning and implementation of network equipment and information analysis and reports, rather than the strategic planning of network services. It also supports the Network Services Control function.
* Network Services Control (NSC) is responsible for the provision of the day to day operation and support of the network and network services and provides the interface between the help desk and NSA.
Network Services Project Control (NSPC) provides the project management of major new networks or network enhancement projects. This function is not normally staffed on a permanent basis, but will utilize secondees form other networking functions.

Layer 4 - NSM Mechanisms
The mechanisms and procedures that the NSM supporting disciplines are dependent upon constitute layer 4. Procedures are required for operation and control, configuration management, diagnostic monitoring and testing, project planning, report production, and statistical analysis. Wherever possible manual intervention should be minimized and procedures should be automated and reviewed regularly.

Layer 3 - NSM Tools
Layer 3 represents the actual tools that are required within the NSM. These tools are the basis of the procedures and mechanisms of layer 4 which provide NSM. The mayor tool requirements are: capacity management tools, costing tools, environmental monitoring systems, project management packages, planning and design tools, service monitoring tools, statistical analysis packages, and testing tools.
All tools utilized within the NSM function should conform to the overall strategies as dictated by the Network Plan and to the Network Management standard and interfaces supported within layer 2. This will than ensure that the procedures developed in layer 4 can be fully automated and integrated.

Layer 2 - Network Management Standards
Layer 2 represents the Network Management standard which should be documented in the technical policies of the organizations IS/IT strategies. These standards should be incorporated into all of the products and tools contained in layer 3 to provide an integrated approach to NSM, so that, in the long term, all the disciplines both inside and outside NSM, can exchange consistent information automatically in a concise and structured manner. [CCTA94] suggests that only Network Management standards that are open and internationally agreed should be considered, such as OMNIPoint, OSI, TCP/IP, and ITU/T standards.

Layer 1 - Network Technology
Layer 1 provides the physical network connections that allow all of the layers above to communicate. This layer supplies all of the network technologies: ISDN, LAN's, WAN's, and voice networks. Not all of these technologies will be in use within every organization, but each organization will probably use more than one.

NSM needs to develop the technology strategies within a Network Plan so that physical networks are developed on convergent rather than divergent paths. This will enable an integrated approach to be implemented with regard to the associated Network Management protocols and NSM tools.

The Network Plan
It is essential that the Network Plan contains details of the strategies to be adopted by the organization, in each of the seven layers of the NSM model. These details should cover what is actually achieved in each of the layers currently, what is to be attempted in the short term, and what the long term strategy is for each of the layers.
2.4.5 Tasks - Frame Of Reference (T-FORce)

The MCM of information systems is depicted in [Looijen89], [Looijen95], and [Delen92]. The MCM of information systems is described using the management paradigm, the state model and a frame of reference of the tasks that have to be performed when managing an Information System. The frame of reference is described in this section. The management paradigm and the state model are described in chapter 1.

Aim
The aim of the T-FORce is to offer methods, models and techniques for managing information systems; this entails managing, controlling and maintaining implemented information systems in accordance with the requirements and preconditions imposed by utilization and the characteristics of the components of information systems. An information system is defined as a structured composition of hardware, software, data, procedures, and people to control, improve and obtain better knowledge of real systems or business processes.

Concepts
The following concepts are considered in the T-FORce:

- MCM tasks, task areas, task fields.
- Levels of management.
- Forms of management.
- Logo of Mintzberg.

MCM tasks, task areas, task fields
The MCM of information systems consists of several tasks that are described in [Delen92]. These tasks are grouped into task fields which on their turn are grouped into task areas. The MCM of information systems is divided into the following task areas: strategic management (SM), tactical management (TM), technical support (TS), personnel management (PM), general business support (GB), operational management (OM), operations (O), maintenance of technical infrastructure and operations support (MO), technical service (TS), management of systems use (MU), functional maintenance (FM), and finally application management (AM).

Levels of management
A distinction is made between the level of management: strategic, tactical and operational. The staff at the strategic level is responsible for information planning and formulating the goals of the MCM of information systems in the information policy. The staff at the tactical level is responsible for the preparation and implementation of the policy concerning the MCM of information systems. The staff at this level controls the hardware and software, financial resources, the personnel and administrative resources that form the basis of the operational MCM of information systems. The staff at the operational level correlates tasks concerning the actual performance of day to day MCM of information systems. The task areas are positioned within the three levels of management.
Forms of management
Clusters of task areas are found within the MCM tasks. These clusters are totally different with regard to contents, responsibility, knowledge and resources. MCM is therefore divided into three forms of management, which represent a specific area of the MCM. These areas are technical management, application management, and functional management.

Technical management involves managing the hardware, the technical infrastructure and the system software i.e. all tasks that are necessary to install, accept, and operate technical infrastructures. Optimization of the technical infrastructure as a consequence of faults, expansion or replacement is also part of technical management.

Application management involves managing the application software. There are lots of situations that will initiate a change in the application software, e.g. the detection of faults in the software, the expansion of the functionality, this is called application software maintenance.

Functional management involves managing the functional specifications and the functionality of the information system, i.e. all management tasks that are necessary within the framework of the utilization of the network, since utilization concentrates on the functionality. Many problems, e.g. unfamiliarity with applications, disturbances and faults can occur, new functions may also be required.

Mintzberg logo
Each form of MCM with its specific task areas are positioned in Mintzberg logo’s. A Mintzberg logo models an organization that consists of a strategic appix, a middle line, operating core, technostructure and a support staff ([Mintzberg89]). Each form of management forms an autonomous part of the organization, and can be divided into the three levels of management.

Figure 2.4 Tasks - frame of reference

2.4.6 The DUneT Management Model

Aim
The aim of the DUneT Management Model is to order the different network services
and to define service interfaces. Network services is a broad concept, provision of a
cable is a network service; at the other end, provision of a cable with applied
communication protocols is also a network service ([Daalen93]). The protocols
provide for a reliable and correct transmission of information.
Due to the fact that the concept is very broad and many different parties, service
providers and customers, are involved with network services, it is necessary to define
the responsibilities of the service provider and the responsibilities of the customer.
The DUenet Management Model was developed to do this; the model can be used to
determine which party is concerned with the MCM of which network component.
This distinguishes this model from the OSI model, which is a functional model. The
DUenet Management Model describes the functions that are necessary for data
communications.

**Concepts**
The DUenet Management Model is a layered model. Each lower layer offers a service
to assist the realization of a service that is necessary to perform the service in the layer
above, as in the OSI model. Figure 2.5 shows the six layers of the DUenet
Management Model. In all layers a service provider can offer its own network
services.

![DUenet Management Model Diagram](image)

**Figure 2.5 The DUenet Management Model**

**The six layers**
- The layer "Services" are the network services presented to end users, for example
an electronic mail service.
- The layer "Applications" consists of the software that is specific to the network
service in the layer above e.g. the application WP-Office in case of an electronic
mail service.
- The layer "Application architecture" contains system software, such as the
operating system, e.g. Solaris, the operating system of SUN.
- The layer "Network architecture" provides transport services over a network by
addressing, formatting and wrapping data through out the network. TCP/IP,
Netware and SNA are examples of network architectures. These architectures
originated historically, in some cases related to a specific vendor.

- The layer "Connection" provides for a faultless transmission of information over cables that are not fully free of disturbances, access to a cable is also handled when several systems use one cable.
- The layer "Cables" consists of cables which are able to transmit signals.

Service interfaces

Service interfaces can be distinguished with the DUnet Management Model. Customers and service providers make agreements that concern the way the service is offered to the customer. The layers are chosen such that service interfaces correspond to practice. This makes it possible to establish agreements between different parties in Service Level Agreements (SLA's).

2.4.7 Similarities and differences

The models described contain a number of differences and similarities, these are discussed and the models are compared using key success factors [Terplan88] and some aspects, like the scope and focus of the models.

Comparison using key success factors

A way of thinking described by Terplan is used to compare the models that support the organization of Network Management. [Terplan88] gives five key success factors that are necessary for an efficient Network Management, these factors are:

- **Network Management architecture**: the framework of subsystems such as configuration, performance, problem, application and capacity management, and their mutual relationships.
- **Network Management functions/tasks**: the specific functions/tasks supporting the framework of subsystems that must be performed by either the Network Management systems or the network management organization.
- **Network Management instrumentation**: the set of tools for collecting, compressing and processing information and instruments for predicting future service levels and resource utilization.
- **Organizational components**: the organizational structure put in place to carry out the network management functions.
- **Organizational approach**: factors such as personnel skills and education that are critical to the successful, long term, operation of human resources in management.

Each model is compared by the way the key success factor is present and how it suffices in the remainder of this chapter.

**Network management architecture**

OSI Network Management focuses primarily on the Network Management architecture, which is described on a global level in five functional areas. TMN describes the Network Management architecture in more detail than OSI. The Network Management architecture as defined in OSI Network Management is expanded in the TMN model, where the OSI functional areas are used to define one of the four layers, namely the 'network management' layer.

OMNIPoint describes a business model where an architecture is built by defining
procedures and their mutual relationships, which are necessary for Network Management.

The ITIL module 'Network Services Management' ([CCTA94]) defines processes and their mutual relationships. These processes and their mutual relationships are applicable to the infrastructure (IT) in general. This arrangement of processes can be used to define an architecture for Network Management.

The T-Force does not recognize processes but tasks, however these tasks can be grouped to form a process.

The DUnet Management Model does not describe a network management architecture.

Network management functions/tasks
Network management functions are not considered in OSI Network Management, TMN, OMNIPoint, and the DUnet Management model.

The ITIL module 'Network Services Management' ([CCTA94]) focuses on four Network Management disciplines that must be performed.

T-FOREc focuses mainly on almost forty tasks that apply to the MCM of Information systems. T-FOREc considers information systems instead of networks. Networks are defined as a part of an information system in chapter one, therefore this model is only partly applicable to Network Management. Not all tasks that are considered in T-FOREc apply to Network Management.

Network management instrumentation
A technical view of Network Management instrumentation in the form of defining management protocols is formulated by OSI Network Management. These management protocols are as yet not fully crystallized.

TMN also defines technical standards for the development of management instrumentation to cope with heterogeneity.

OMNIPoint does not consider Network management instrumentation.

The ITIL module 'Network Services Management' discusses Network Management instrumentation in the form of specifications of the functions that can be performed by Network Management instrumentation; some examples of Network Management instrumentation are also discussed.

Network Management instrumentation is not considered in T-Force, however [Looijen93] discusses some examples of instrumentation that can be used to realize Network Management.

The DUnet Management Model does not discuss network Management instrumentation.

Organizational components
Organizational components are not considered in OSI Network Management, OMNIPoint, and the DUnet Management Model.

TMN distinguishes four layers viz. network element management, network management, service management, and business management. ITIL and T-FOREc consider an operational, a tactical, and a strategic level. It is not possible to make an exact translation between the three levels and the four layers, although it can be stated that the strategic level is similar to the business management layer and the operational level is analogous to the network management layer.
The ITIL module 'Network Services Management' concerns organizational components, divided into processes that involve strategic, tactical and operational levels.

In T-FORce the organizational component is worked out in logo's, defined by [Mintzberg89]. The logo's represent a division of an organization or company in a strategic appex, a middle line, an operating core, a technostructure and a support staff. The task areas are placed in those parts of a logo. Several logo's are used to specify the forms of MCM, functional, technical and application management.

Organizational approach
Organizational approach is not considered in OSI Network Management, TMN, OMNIPoint, T-FORce, and the DUneT Management model.

The ITIL module 'Network Services Management' presents an organizational approach by giving specifications for vocations that are necessary to perform Network Management.

As stated above the T-FORce does not consider this key success factor, however [Looijen95] refers to the NGI report ([NGI93]) that describes vocations in the area of automation.

The models are compared based on the five key success factors in table 2.3. The indications ++, +, ±, - reflect an impression or indication of the sufficiency of the models. These indications are formulated based on a literature study ([CCTA90], [CCTA94], [Daalen93], [Delen92], [Hemmen94], [Looijen89], [Looijen95], [NM/Forum90], [NM/Forum92], [Mintzberg89], [Terplan92], [Verdonck93], [Obstnigk94]).

<table>
<thead>
<tr>
<th>Key success factor</th>
<th>Model</th>
<th>OSI</th>
<th>TMN</th>
<th>OMNI-Point</th>
<th>ITIL</th>
<th>T-Force</th>
<th>DUneT MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM architecture</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>±</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>NM functions/tasks</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>±</td>
<td>++</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>NM instrumentation</td>
<td>±</td>
<td>±</td>
<td>-</td>
<td>+</td>
<td>±</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Organizational components</td>
<td>-</td>
<td>±</td>
<td>-</td>
<td>±</td>
<td>++</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Organizational approach</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>±</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.3 Comparison of models described based on key success factors

Legend:
++ : key success factor suffices very good
+ : key success factor is sufficient
± : key success factor is partly sufficient
- : key success factor is not sufficient

Peculiarities
None of the five key success factors is considered in the DUneT Management Model. The DUneT Management Model only divides the Network System into five parts. This division facilitates determining the responsibilities of the service providers and
customers. The DUnET Management Model divides layer 0 of the 7-layer OSI model into parts which become components that need to be managed, controlled and maintained. An analogous division is defined by the seven layer OSI-model ([Eveleens95]).

**Comparison using aspects**
The models can also be distinguished by the following aspects:
- **The object of Management, Control, and Maintenance.** The objects of MCM that are handled by the models, e.g. a network or an information system.
- **Focus of the models.** The focus can be technical, organizational or pointed at the processes involved ([Bosma95]).
- **Acceptance and application of the models.** The acceptance and application of the models varies from local to international acceptance and application.
- **States where the models apply.** Six states are distinguished ([Looijjen95]): Information Policy and Planning, Development, Acceptation and Implementation, Maintenance, Utilization, and Exploitation.

**Object of Management, Control, and Maintenance**
OSI Network Management, TMN, and OMNIPoint focus directly on the network in contrast to T-FORce and ITIL, which consider the MCM of a broader object than the network. Nevertheless these models are useful and applicable to organize Network Management, also because of the fact that a network is a part of respectively an Information System and an IT infrastructure. So some concepts of these models can be applied to Network Management.

**Focus of the models**
OSI Network Management is mainly technically oriented, TMN is also mainly technically oriented, where the essence of the organizational aspects is recognized. The organizational aspects will gradually be completed in future. The layers 'network element management' and 'network management' are mainly of a technical nature. These layers have already been filled in by several suppliers of network components and by standardization committees. The additional layers 'service management' and 'business management' are defined to fill in the organizational aspects of Network Management. OMNIPoint is directed at processes, some technical aspects are also considered. T-FORce is oriented mainly towards organizational aspects.

ITIL is directed mainly at the processes required to organize the MCM of the IT Infrastructure. The DUnET Management Model is oriented towards technical aspects.

All six models are based on experiences in practice.

**Acceptance & application of the models**
OSI, TMN, and OMNIPoint have international acceptance and are applied all over the world, unlike ITIL, T-FORce, and DUnET. These last three models are mainly applied in the Netherlands; ITIL is also applied in the United Kingdom, where it was developed.

**States where the models apply**
Unlike the other models discussed in this section, T-FORce also considerers the state Utilization (functional management), and the state Maintenance (application
management) besides the state Exploitation (technical management). The other models focus on the exploitation of the Network Management which equals technical management ([Looijjen93]).

The comparison of the models using the four aspects are illustrated in table 2.4.

<table>
<thead>
<tr>
<th>Model Aspect</th>
<th>OSI</th>
<th>TMN</th>
<th>OMNIPoint</th>
<th>ITIL</th>
<th>T-Force</th>
<th>DUneT MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object of MCM</td>
<td>Network</td>
<td>Network</td>
<td>Network</td>
<td>IT-Infrastructur e</td>
<td>Information system</td>
<td>Network components</td>
</tr>
<tr>
<td>Focus</td>
<td>Technical</td>
<td>Technical</td>
<td>Technical &amp; pointed at processes</td>
<td>Pointed at processes</td>
<td>Organizational</td>
<td>Technical</td>
</tr>
<tr>
<td>Acceptance &amp; application</td>
<td>international</td>
<td>international</td>
<td>international</td>
<td>UK &amp; NI</td>
<td>NI</td>
<td>NI</td>
</tr>
<tr>
<td>State</td>
<td>E</td>
<td>E</td>
<td>E, M related to Technical Management</td>
<td>E, M related to Technical Management</td>
<td>all</td>
<td>E</td>
</tr>
</tbody>
</table>

Table 2.4 Comparison of models considering four aspects

Heterogeneity and evolution
Standards were introduced to cope with the heterogeneity of networks. These standards were mainly of a technical nature. Some of the models, viz. OSI, TMN and OMNIpoint, referred to these standards that cope with the heterogeneity of networks.

None of the models focused explicitly on the evolution of networks and network services. How to cope with the evolution of networks was not considered in the models described.

2.5 Conclusions

Heterogeneity was considered in section 2.2 by focusing on the three kinds of heterogeneity: multi vendor, multi fabric, multi protocol, and multi functionality.

Each vendor defines its own architecture that competes with architectures of other vendors. The architectures of vendors are mostly incompatible, therefore a reference model was created to provide a standard for the communication between two systems made by different vendors. This model, the OSI reference model, consists of 7 layers, where at each layer protocols have been defined to support the communication function. The technical problems with the heterogeneity concerning multi vendor can be reduced using such a reference model. Organization problems concerning multi vendor heterogeneity, however, are not avoided by such a reference model.

The heterogeneity concerning multi protocol and multi fabric were assumed to be a technical problem, with their own technical solutions, therefore these kinds of heterogeneity are not considered in this research.
Evolution was considered in section 2.3 by mentioning the driving forces that result in changing the network or the network services. A way to handle with these forces was not found in literature. The contingency factors that influence an organization and the network management in that organization were also considered in section 2.3. These contingency factors form the basis for the formulation of requirements and preconditions to the network and its network services. These requirements and preconditions form the basis of the NM organization.

Technologies for networks and network services are changing rapidly. Not only is the functionality changing drastically, resulting in new network services, the performance of the network components and the network in total has also improved allowing the new network services to be offered. A way to deal with this evolution was not found in literature.

None of the models described in section 2.4 are adequate to model evolving heterogeneous networks, due to the following deficiencies:

- None of the models presently available deal with the evolution of networks, however, they do deal with heterogeneity. All vendors and users are aware of the necessity for open systems in which hardware and software can be connected and interact. Evolution of the network and network services has received less attention. It is initiated by such driving forces as economics, organizational and technical forces.

- The models described use a top-down approach only instead of a mixture between a top-down and a bottom-up approach. With the top-down approach is meant that an architecture for NM is recognized, without considering the actual realization in detail of that architecture in practice. NM is described at an abstract level, where details are not recognized.

- The models are unfathomable and impracticable for managers at a strategic and tactical level. The models described were selected due to their focus on the organization of NM. Many other models exist besides these models, which focus only on technical aspects of NM. The technical focus of those models implies the influence of the operational level due to the professional knowledge that is required to perform NM. Due to a lack off and the deficiencies of present instruments in providing information for senior management, management is not able to control effectively NM.

The increasing strategic importance of networks, increasing complexity of networks, heterogeneity, speed of developments technical as well as functional, evolution, and the expanding costs mean that the senior management of companies can no longer assess the requisites for Network Management. This lacuna is strengthened because available models focus primarily on the technical aspects of Network Management that are part of the operational Network Management. Strategic and tactical Network Management are barely defined. Decisions concerning the network and its services have to be made by the senior management, because of the huge investments and the strategic importance of the network and its services, however, no models, methods or techniques are available to assist managers with these decisions. It is therefore necessary to construct models and provide methods to fill the lacuna. It is essential that these models allow senior management to understand and control Network Management.
A model is described in chapter 3 that deals with the deficiencies of the models described in this chapter. This model will be validated and considered in detail in the chapters 4 upto 7.
3 Modelling Network Management

3.1 Introduction

The strategic importance of networks, the heterogeneity of networks, and their evolution, technical as well as functional, has led to models being developed to support Network Management (NM). Despite this tendency, none of the models described in chapter two are adequate to model evolving heterogeneous networks and this is due to the following deficiencies:

* None of the models deal with the evolution of networks, however, they do deal with the heterogeneity. Heterogeneity is included because of the awareness of all vendors and users of the need for open systems in which hardware and software can be connected and interact.

* The models described in chapter two do not use a combination of a top-down and a bottom-up approach but only a top-down approach. With the top-down approach an architecture for NM is recognized, without considering the actual realization in detail of that architecture in practice. NM is described on an abstract level, where details are not recognized.

* Strategic and tactical NM are barely mentioned in the models described in chapter 2. These models were selected due to their focus on the organization of NM. Besides these models many other models exist, which focus only on technical aspects of NM. The technical focus of these models implies the influence of the operational level due to the professional knowledge that is required to perform NM. Due to the deficiencies of present instruments for providing information for senior management, managers are not able to control NM effectively.

A model for NM is introduced in this chapter which is intended to cope with the deficiencies of the models described in chapter 2. Before the model is introduced, a NM-taxonomy to consider NM is described in section 3.2. This NM-taxonomy is a detailed version of the management paradigm defined in [Looijen95]. On the basis of this NM-taxonomy, NM and its environment can be described unequivocally, so that NM in a specific company can be compared to NM in another company.

The NM-model is described in section 3.3. The NM-model divides NM into parts which are modelled by several operation paradigms. The NM-model is based on these operation paradigms and it is therefore created in a bottom-up manner, where details
are also recognized. The application of operation paradigms realizes a more structured approach to NM, due to the attention paid to, and subdivision of, the heterogeneity and evolution.

The NM-model is compared in section 3.4 to the models described in chapter 2.

The NM-model is applied to evolution in section 3.5. In this section the emphasis is on the processes that are needed to perform NM especially the two processes that deal explicitly with evolution. The NM-model is further detailed in the chapters 4 and 5 with regard to the two selected processes.

3.2 Taxonomy of Network Management and its environment

NM must be described unequivocally to be able to compare different situations in practice that are considered in the case studies (see chapters 4, 5, 6, and 7). A NM-taxonomy is given in this section to describe a particular NM organization and its environment. The NM-taxonomy is based on the management paradigm defined in [Looijen95]. Three systems are distinguished in the management paradigm: the Real System (RS), the Information System (IS) and the Management System (MS). In case of NM a part of an Information System is considered, which is called the Network System (NWS) (see section 3.2.2).

The mutual relationships among NM, the NWS and the RS are also considered in the Network Management paradigm (figure 3.1). For example the requirements that are formulated by the users of the network services, the preconditions that are derived from the strategy of the company, and the characteristics that are implied by the components of the network.

![Figure 3.1 The network management paradigm](image-url)
Each part of the NM paradigm is analyzed in the remainder of this section viz. NM, the NWS, the RS, and external influences.

3.2.1 Analyzing Network Management

NM can be described by focusing on the following four points of view ([Langefors75], [Welke77], [Sol85], [Mersel95]):

- **Systeological: why.** This point of view concentrates on the goals of NM. The goal of NM is to manage, control and maintain the NWS in accordance to the requirements and preconditions imposed by utilization and the characteristics of the network components.

- **Infological: what.** This point of view concentrates on the tasks that should be performed to achieve the formulated goal of NM.

- **Dutological: how and when.** This point of view concentrates on the processes to realize NM and the timing and speed of these processes. This can be done by formulating procedures that relate the processes and tasks to the resources.

- **Technological: with what resources.** This point of view concentrates on the material, personnel and financial resources that are necessary to realize the goal of NM.

These four points of view are used to consider the NM paradigm in detail (section 3.2.5).

3.2.2 Analyzing the Network System and its heterogeneity

The NWS consists of the following parts:

- **Network.** The network consists of four kinds of components which have specific characteristics ([Looijen95]). These four components are communication devices, links, nodes, and prescriptions (protocols). The heterogeneity of the network can be described in the forms of multi-vendor, multi-protocol, and multi-fabric according to the components distinguished (chapter 1).

  In terms of the OSI reference model the network corresponds to the layers one to six (section 2.2.1).

- **Network services.** The network services are divided into five classes of services (section 2.2.4). Each of these classes can be represented by multiple network services. This kind of heterogeneity is called multi-functionality (chapter 1).

  In terms of the OSI reference model the network services correspond to the layer seven (section 2.2.1).

- **Characteristics.** Both the network and the network services have specific characteristics ([Looijen95]).

- **Users.** Users use the network and the network services. Users can be characterized by number, education, knowledge and experience ([Looijen95]). The kind of user based on the function of that user also has to be considered e.g. a secretary is a different kind of user than an IT specialist.

- **Requirements.** Users formulate their requirements concerning the utilization of the network and the network services ([Looijen95]).

- **Preconditions.** Preconditions concerning the utilization of the network and the network services are formulated by the management of the customer organization ([Looijen95]).
3.2.3 Analyzing the Real System

To analyze the influences of the organization components for the NWS the organization components of the RS must be distinguished. The organization components influence indirectly (via preconditions) the organization of NM ([Galbraith73], [Looijen89]), e.g. when a merger of two companies takes place the NWS also has to change.

- **Strategy and goals.** A company usually has several goals, viz. economic, technical and social. These goals must be translated into strategy, i.e. the abstract goals must be translated into policy with regard to the deployment of people and resources.
- **Organization structure.** Organization structure is the way a company is divided into units and subunits together with their mutual relationships.
- **Staff.** Employees are needed to carry out the tasks required to reach the formulated goals of the company.
- **Systems.** Systems include the technology used, as well as the technical facilities, and procedures. The age of the company must be considered: more formal procedures will exist in an older company.
- **Skills.** Skills indicate how to characterize a company by a description of the competencies of a company. The skill of an organization is dependent on the type/sector of a company, such as industry, banking and insurance enterprises, government, education and research. Each kind of company type/sector has its own application for the network.
- **Culture.** Culture is described as the whole of values, norms (rites and rituals), opinions, attitudes and visions of reality, that have an influence on the behaviour of companies. Usually several cultures can be distinguished in large companies.
- **Management style (related to power).** Power is related to the style of management. Power is of importance when decisions e.g. concerning the NWS must be made; rational choices can be cancelled due to the influence of persons that have more power in the company.

The six organizational components influence each other ([Peters92], [Mantelaers95]). The six organizational components, that characterize the RS, are used to consider the NM paradigm in detail (section 3.2.5).

Preconditions can be derived from these organizational components e.g. the precondition that concerns the concentration/deconcentration of hardware and software, which is, among other things, dependent on the organization structure. The preconditions influence the NM goal.

The organizational factors goals and strategy, organization structure, staff, and systems are considered explicitly, in this thesis, to describe a real system.
3.2.4 Analyzing external influences that cause evolution

Several external influences are distinguished in [Looijen95]. Four of these external influences are managerial, contractual, economic and technical.

Influences of a managerial nature include mergers of companies, the disposal of a part of a company, fusions, and outsourcing, which all can influence the way the network is built. An example of a merger of two networks caused by an outsourcing of a network is considered in the following chapter.

Influences of a contractual nature occur when quality, functionality, and costs of network services are formulated in contracts like Service Level Agreements. NM organizations need to acquire expertise in legal matters, some companies that operate in the NM market have already been threatened with liability suits by their customers ([Verdonck92]).

Influences of an economic nature occur when the economic situation is changing. The reaction to this type of change is to put more or less financial resources at the NM staff's disposal. An example would be when the NM organization is faced with external service providers who state that they can perform NM at lower cost but at the same or even better quality. An NM organization is forced to position its services in relation to the market. The competition among suppliers/vendors of network components also leads to changes in the network and NM. Competition is based on price in proportion to performance.

Influences of a technical nature occur when new technological developments and improvements in price/performance proportion occur. These developments and improvements can be a reason to replace existing network components by new products. Technical conditions change because of new standards, products and services. This extends well beyond the equipment in use currently. This forces the NM organization to broaden its scope and frequently to assess the choices it makes.

A combination of these external influences can also occur, e.g. the outsourcing of a network is primarily a managerial influence, however, the outsourcing can be the result of an economic influence. Outsourcing is usually accompanied by a contractual influence to document the quality, functionality and costs of the outsourced services.

3.2.5 The Network Management paradigm in detail

The NM paradigm will be described in more detail by specifying the NM, the NWS, and the RS using entities that are considered in these systems.
Figure 3.2 Taxonomy of Network Management and its environment
The following entities are considered in NM (section 3.2.1): NM goal, NM tasks and NM processes, NM procedures, NM staff, and NM tools. As can be seen from figure 3.2 these entities are related: the NM goal is based on requirements that are formulated by users of the network services, characteristics of the network and network services, and on preconditions that are formulated by the management. NM tasks are derived from the NM goal to conform to the requirements, characteristics, and preconditions. NM tasks consist of NM processes. These NM processes are described by NM procedures. The NM staff tries to accomplish the NM goal by working via NM procedures and using NM tools.

The following entities are considered in the NWS (section 3.2.2): network, network service, user, procedure for utilization, requirement, characteristic, and precondition. The network and the network services both have their specific characteristics. Users use the network and the network services using procedures. Users also formulate requirements concerning the network and the network services. Preconditions that are derived from the goals and strategy of the RS are also of importance in the NWS.

The following entities are considered in the RS (section 3.2.3): management style, the structure of the company, staff, systems, skills of the company, strategy and goals and the culture of the company. The entities that are distinguished in the RS are all components of an organization ([Peters81]). The mutual relationships of these organization components are not considered in this research.
3.3 The NM-model

A prescriptive model for NM, called the NM-model, is described in this section. The NM-model is built incrementally by focusing on components of the NWS. Beginning with a small part of the NWS and the NM of that part. This small part of the NWS is expanded to the complete NWS and its NM in five steps.

The complexity with regard to controlling the evolution and heterogeneity of the NWS is reduced by this division. The NM-model is built using several operation paradigms that are interwoven using the recursion principle. Each step is modelled using an operation paradigm.

3.3.1 Operation paradigm

The operation paradigm ([Bemelmans87], [Leeuw90] and [Roke94]) models situations where something is operated, this is called an 'operation situation'. An intentional action is performed in these situations, e.g. learning, educating, changing the structure of an organization, automation, convincing, planning, motivating and managing ([Leeuw90]).

The most simple case is an operation situation that is modelled by a control body (CB) and a controlled system (CS) (figure 3.3).

![Figure 3.3 The operation paradigm](image)

Several operation paradigms are needed to model any actual operation situation. These operation paradigms are interwoven using the recursion principle. The recursion principle means that other operation situations are distinguished within the CB or within the CS.

The operation paradigm is specified further by dividing the CB into two layers (figure 3.4, [Roke96]). The first layer is divided into several systems that each control a quality aspect, a cost aspect or a functionality aspect of the CS. All these systems operate autonomously to realize the goal concerning quality aspects, cost aspects or functionality aspects.

The quality aspects concern availability, reliability, continuity, capacity, and security.

The cost aspects can be divided into investments and costs ([Looijen95]).
Investments are expenses that are made once for the purchase of resources that will be used longer than one year. Costs are inevitable expenses that are made either periodically, or for the purchase of resources that will be used for a period less than a year.

The functionality that has to be managed, controlled, and maintained, is dependent on the kind of CS. The basic functionality of an information system can be divided into application, store, and transport of data ([Looijen87]). The basic functionality of a network is the transport of data. The network is used to offer network services that have a specific functionality. Network services can be divided into interactive services and distribution services (chapter 2).

The systems recognized concerning quality, costs and functionality are coordinated and given a priority for the allocation of resources in the second layer.

![Diagram](image)

Figure 3.4 Extension of the operation paradigm

This way of modelling is not illustrated in the following figures for the sake of simplicity. The train of thought however is included in the text that explains the figures.

Each operation situation recognized in the remainder of this section, is described by the controlled system (CS), the control body (CB), the observations, and the possible disturbances. The processes/tasks present at the CB must be translated into procedures which describe how to react to a specific observation. Observations are obtained by tools or immediately by the NM staff. The CS must be changed when a deviation is observed by applying the procedures to conform with the goal of the CB that has been formulated.

A set of procedures should be available in an ideal situation, to handle each deviation, observed by the CB, on a standard way. This set of procedures cannot be given in general due to the specific characteristics of each CS. The resources required to perform the control measures also depend on the specific situation, so no exact filling in of these resources can be given.
3.3.2 Application of the operation paradigm to Network Management

NM can be modelled using one operation situation, when the NWS is considered to be the CS and NM is considered to be the CB. This operation situation is modelled in figure 3.5. The complexity of NM concerning heterogeneity and evolution does not decrease when NM is modelled in this way. There will be various and numerous disturbances, observations and control measures. The CS is therefore divided into smaller parts that are part of the NWS.

Figure 3.5 Operation paradigm applied on Network Management

The following parts of the NWS are considered:

* A product line. A product line consists of network components that are produced by one supplier. These components have similar characteristics (section 3.3.3).
* Several product lines. These product lines form the heterogeneous network, and each network has its own characteristics (section 3.3.4).
* A network service. This service is based upon the network, e.g. electronic mail and video on demand. Each network service has its own specific characteristics (section 3.3.5).
* The heterogeneous network and the network services. The network and the services must be tuned to each other. The requirements concerning the services that are formulated by users, together with the procedures for utilization, must also be considered (section 3.3.6).
* The objectives and strategy concerning NM. The network services should serve to reach the goals of the company, therefore all services are considered to support business processes of the company at a higher layer. The strategic considerations are translated into preconditions for NM (section 3.3.7).

Each of the parts of the NWS is described using interwoven operation paradigms in the remainder of this section.
3.3.3 Layer 1: operation of a product line

Layer 1 is described by the controlled system (CS), the control body (CB), the observations, and possible disturbances.

Controlled System

Only a small part of the NWS is considered in layer 1, consisting of a network that is built by network components of only one specific product line (figure 3.6). The components of a product line have similar characteristics.

One of the characteristics of a product line is that its components are produced by only one supplier, which means that a product line is not multi-vendor. A product line is therefore homogeneous with regard to multi-vendor.

The components of a product line also have the same functionality e.g. CISCO routers, or Newbridge multiplexers, so a product line is homogeneous with regard to multi-functionality.

A product line is heterogenous with regard to multi-protocol: several protocols can be used in a network built by one product line. This kind of heterogeneity is handled by a NM tool which supports the several protocols within a product line.

The heterogeneity concerning the kind of link (multi-fabric) is not considered, due to the scope of this research. There are already technical solutions in the form of network components which convert signals between different kind of links, and these components can be used to cope with multi fabric heterogeneity.

The basic functionality of a product line is the transmission of data. A product line can also support additional functionality aspects such as routing or multiplexing functionalities, besides the basic functionality. The techniques routing and multiplexing increase the use efficiency of a link either by using other links that connect the sender and receiver or by dividing the link into several lower speed links.

![Diagram](image)

Figure 3.6 CB: coordination of the quality, costs and functionality of a product line; CS: a product line.

Control body

The operation goal of layer 1 is to coordinate the quality, costs and functionality of a product line. The coordination of the product line must comply with quality aspects, cost aspects and functionality aspects that are formulated in layer 2.
The control body has to be organized by NM processes to reach the operation goal. These NM processes are described in section 3.5.1.

The NM staff has to reach the formulated operation goal using NM procedures that are derived from the NM processes.

Observations
The operation of one product line is usually supported elaborately by a single NM tool that is designed specifically for the operation of only that product line, e.g. CiscoWorks for the product line Cisco, or 4602 for the product line Newbridge. The behaviour of the product line qua quality, costs and functionality can be checked and controlled by such a NM tool.

Disturbances
A list of possible disturbances is given below.

Technical
- A component does not function (e.g. break down of power supply, burned cards/ports, or logic faults which are mostly configuration faults).
- Loss of links between components.
- The support of a supplier is withdrawn.
- Introduction of components with new characteristics.

Economic
- Introduction of components that cost less but have the same or better characteristics than the present ones.

Managerial
- Loss of qualified personnel.
- A merger with another company or division.
- Outsourcing.

Contractual
- Addition, removal or change of agreements with the supplier of the product line.

Control measures
- Tuning of components.
- Removal of a component.
- Addition of a new type of component.
3.3.4 **Layer 2: operation of a heterogeneous network**

Layer 2 is described by the controlled system (CS), the control body (CB), the observations, and possible disturbances.

**Controlled System**

The object of operation is expanded, namely a network, that is built of several product lines that are coordinated, is considered in layer 2 (figure 3.7). These product lines are connected to each other and form a network that is heterogeneous concerning multi vendor and multi protocol.

This heterogeneous network has specific characteristics such as its topology and its reach.

The functionality of the heterogeneous network is to take care of the transmission of data over a network that consists of several product lines.

![Figure 3.7 CB: coordination of the quality, costs and functionality of a network; CS: the network with its characteristics, which consists of several ranges of products.](image)

**Control body**

The operation goal of layer 2 is to coordinate the quality, costs and functionality of a heterogeneous network. The coordination of the heterogeneous network must comply with quality aspects, cost aspects, and functionality aspects that are formulated on layer 4.

The product lines are considered on this layer with deliberation about the weight of a specific product line in contrast to another product line. This deliberation is based on the quality, costs and functionality of the product lines. The way of coordination is determined according to the priority and the application of the product lines. For example, the NM staff can decide to put less effort to the operation of a specific product line because of the fact that another product line delivers identical functionality at a lower cost.

The control body has to be organized by NM processes to reach the operation goal. These NM processes are described in section 3.5.1.

The NM staff has to reach the formulated operation goal using NM procedures that are derived from the NM processes.
Observations

NM tools to support the operation of several product lines were not available for many years. This lack of suitable NM tools made it difficult to operate a multi-vendor network. Suppliers of NM tools are developing advanced tools that support the operation of a heterogeneous network (e.g. HP Openview, IBM Netview, SUNnet Manager). Such an advanced NM tool has links with the separate NM tools for the product lines to realize an integrated view of the complete network.

Disturbances

The following disturbances may occur:

Technical

* A link between product lines is not available.
* A product line does not function.
* The support of a supplier of is withdrawn.
* Introduction of a product line with new characteristics.
* Logic faults (mostly configuration faults).

Economic

* Introduction of a product line that has the same or better characteristics and is less expensive.

Managerial

* Loss of qualified personnel.
* Take over of another company or division.
* Outsourcing.

Contractual

* Tuning of agreements of the different suppliers of the product lines.
* Addition, removal or change of agreements with suppliers that deliver the interfaces between product lines.

Control measures

* Addition or removal of a product line.
* Mutual tuning of product lines.
* Change the Control Body at layer 1 (NM goal, NM processes, NM procedures, NM staff, NM tools).
* Initiate disturbances at layer 1.
3.3.5 Layer 3: operation of a network service

Layer 3 is described by the controlled system (CS), the control body (CB), the observations, and possible disturbances.

Controlled System

In layer 3 a network service is considered to be a controlled system (figure 3.8). A network service has its own characteristics.

A network service can be categorized based upon its characteristics into five classes: conversational services, messaging services, retrieval services, distribution services without user individual presentation control, and distribution services with user individual presentation control (see chapter 2).

![Diagram](image)

Figure 3.8 CB coordination of the quality, costs and functionality of a network service;
CS a network service with its characteristics.

Control body

The operation goal of layer 3 is to coordinate the quality, costs and functionality of a network service. The coordination of a network service must comply with quality aspects, cost aspects, and functionality aspects that are formulated in layer 4.

The control body has to be organized by *NM processes* to reach the operation goal. These NM processes are described in section 3.5.1.

The *NM staff* has to reach the formulated operation goal using *NM procedures* that are derived from the NM processes.

Observations

The operation of one network service is usually supported by a *NM tool*. The behaviour of the network service qua quality, costs and functionality can be checked and controlled by such a NM tool.

Disturbances

The following disturbances can occur:

*Technical*

- Service is not available or does not function.
- The support of a supplier is withdrawn.
- Introduction of a network service with new characteristics/functionality.
Economic
* Introduction of network services which have the same or better characteristics at a cheaper price.

Managerial
* Loss of qualified personnel.
* Take over of another company or division.
* Outsourcing.

Contractual
* Addition, removal or change of agreements with the suppliers that deliver the hardware and software that is needed to implement a network service.

Control measures
* Addition or removal of a network service.
* Initiate disturbances at layer 1.
* Initiate disturbances at layer 2.
3.3.6 Layer 4: operation of the heterogeneous network and the network services

Layer 4 is described by the controlled system, the control body (CB), the observations, and possible disturbances.

Controlled System
The heterogeneous network, consisting of several product lines, and the network services are considered to be an integral part in this layer (figure 3.9). The users with their requirements and the procedures for utilization are also part of the controlled system.

![Diagram](image)

Figure 3.9 CB: the coordination of the quality, costs and functionality of the tuning of the network and the services;
CS: the network, the network services; the users of the services together with their requirements and the procedures for utilization.

Control body
The operation goal of layer 4 is to coordinate the quality, costs and functionality of the network and the network services. This coordination has two goals. The first goal is to conform to the requirements of the users. Users of the network services formulate their requirements concerning quality, costs and functionality in contracts. The second goal is the tuning of the network and the network services to each other. The coordination of the heterogeneous network and the network services must comply with quality aspects, cost aspects, and functionality aspects that are formulated on layer 5.

The control body has to be organized by NM processes to reach the operation goal. These NM processes are described in section 3.5.1.

The NM staff has to reach the formulated operation goal using NM procedures that are derived from the NM processes.

Observations
The actual state of the quality of the network and the network services must be checked continually in relationship to the requirements and preconditions formulated in the contracts. NM tools are not yet available to perform this task. When the quality,
the cost or the functionality of the network services deviates from the agreed requirements, actions are initiated to provide a remedy for the deviation. Deviations are observed by users that signal and mention them to the help desk, or/and by analyzing utilization trends of particular network services.

**Disturbances**
The following disturbances may occur:

**Technical**
- New functionality can be supported by the present technology (technology push).

**Economic**
- Introduction of a network service which has the same or better characteristics at a cheaper price.

**Managerial**
- New requirement.
- New precondition.
- Take over another company or division.
- Outsourcing.
- Addition or removal of a customer.

**Contractual**
- Tuning of agreements of the different suppliers of the product lines, heterogeneous network and the network services.
- Addition, removal or change of a contract.
- Second service provider.
- Liberalisation of the market.

**Control measures**
- Tuning of the network and the services.
- Change the Control Body at layer 2 (NM goal, NM processes, NM procedures, NM staff, NM tools).
- Change the Control Body at layer 3 (NM goal, NM processes, NM procedures, NM staff, NM tools).
- Initiate disturbances at layer 1.
- Initiate disturbances at layer 2.
- Initiate disturbances at layer 3.
3.3.7 Layer 5: operation of objectives and strategy concerning Network Management

Layer 5 is described by the controlled system (CS), the control body (CB), the observations, and possible disturbances.

Controlled System
The total NWS is considered in this layer with the emphasis on the objectives and a strategy that must be formulated to exploit a evolving heterogeneous network (figure 3.10).

![Diagram: Coordination: Strategy & policy](image)

Figure 3.10 CB: the coordination of the quality, costs and functionality of the Network Management organization:
CS: the preconditions that also include the market for Network Management.

Control body
The operation goal of layer 5 is to coordinate the quality, costs and functionality of the network services in relation to network services of other service providers. The heterogeneous network and the services based upon it, serve to support the realization of the business goal. The business goal must be transformed into objectives and a strategy concerning the network and its operation.

The actual quality, cost, and functionality of the heterogeneous network and the network services must comply with quality aspects, cost aspects, and functionality aspects that are formulated in the business plan that defines the policy concerning the network.

The control body has to be organized by NM processes to reach the operation goal. These NM processes are described in section 3.5.1.
The NM staff on a strategic level has to reach the formulated operation goal. Usually there are no NM procedures formulated to support the achievement of these tasks.

Observations
Quality, functionality and costs of services of other service providers have to be observed. Cost aspects like profit and turnover, share in the market, and possible
competitors especially are essential to formulate a business plan. No *NM tools* are available to perform these tasks.

**Disturbances**
The following disturbances may occur:

*Technical*
- Creation of flexibility to make it possible to react to actions in the market (Technology push).
- Customer requests for the latest solutions for using the network and its services.

*Economic*
- Changes in competition (supply).
- Changes in demand towards network services (demand).

*Managerial*
- Take over of another company or division.
- Outsourcing.

*Contractual*
- Forced truck system (In Dutch: winkelnering): The customer is forced to buy from specific suppliers.
- Fixed SLA.

**Control measures**
- Tune the objectives and strategy according to the observations of the market.
- Change the Control Body at layer 4 (NM goal, NM processes, NM procedures, NM staff, NM tools).
- Initiate disturbances at layer 1.
- Initiate disturbances at layer 2.
- Initiate disturbances at layer 3.
- Initiate disturbances at layer 4.
3.3.8 Outline of the NM-model

The NM-model is based on operation paradigms and is created bottom-up allowing the fine meshed structure to be recognized. The NM-model consists of five layers that each focus on a specific part of the NWS. These part are modelled in figure 3.11.

figure 3.11 Overview of the NM-model
3.4 The NM-model compared

The NM-model is positioned at the site of existing models in section 3.4.1. The NM-model is evaluated in section 3.4.2 using the key success factors defined in chapter 2.

3.4.1 Positioning the NM-model at the side of existing models

The NM-model is positioned at the site of the models described in chapter 2, viz. OSI NM, TMN, OMNIPoint, ITIL, T-FORce and the DUneT Management Model.

OSI Network management does not recognize layers to organize NM. The five functional areas that are distinguished in OSI Network management concern the heterogeneous network which is operated at layer 2 of the NM-model.

The TMN architecture recognizes four layers to organize NM. These four layers correspond to layers 1, 2, 4, and 5 of the NM-model.

The OMNIPoint theory does not recognize layers to organize NM. OMNIPoint distinguishes business areas, which are similar to the processes that are needed to organize NM, therefore the business areas can be used to fill in the control bodies at the layers of the NM-model.

The ITIL module Network Services Management (NSM) recognizes seven layers to organize NM. These seven layers can be used to form a basic for layers 1, 2, 4, and 5 of the NM-model. ITIL also distinguishes processes; ten of these processes can be used to fill in the control bodies at the five layers of the NM-model.

T-FORce does not recognize layers to organize NM. The tasks, task areas, and task fields that are recognized in T-FORce to perform the management, control and maintenance of information systems can be used to fill in the control bodies at the five layers of the NM-model.

The DUneT Management Model recognizes six layers to organize NM. These six layers correspond to layers 1, 2, and 3 of the NM-model.
The positioning of the NM-model at the site of models described in chapter 2 is summarized in table 3.1.

<table>
<thead>
<tr>
<th>Model</th>
<th>OSI NM</th>
<th>TMN</th>
<th>OMNI-Point</th>
<th>ITIL</th>
<th>T-FORce</th>
<th>DUneT</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM-layer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layer 1</td>
<td>-</td>
<td>Element mgmt</td>
<td>-</td>
<td>Network technology NSM tools</td>
<td>-</td>
<td>Cables Connection</td>
</tr>
<tr>
<td>Layer 2</td>
<td>Configuration Fault Performance Accounting Security</td>
<td>Network mgmt</td>
<td>-</td>
<td>NM standard NSM tools NSM mechanisms</td>
<td>-</td>
<td>Network architecture</td>
</tr>
<tr>
<td>Layer 3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Application architecture Application Services</td>
</tr>
<tr>
<td>Layer 4</td>
<td>-</td>
<td>Service mgmt</td>
<td>-</td>
<td>NSM mechanisms NSM disciplines NSM</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Layer 5</td>
<td>-</td>
<td>Business mgmt</td>
<td>-</td>
<td>Business mgmt</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(\* indicates the NM-layer is not recognized by the model, that is described in chapter 2.)

Table 3.1 Relating the NM-model to the models found in literature
3.4.2 Evaluation of the NM-model using key success factors

The NM-model is evaluated in this section with regard to the key success factors that were used to determine the similarities and differences of the models found in the literature (section 2.4.7).

The key success factors in relation to the NM-model are (table 3.2):

- **Network Management architecture**: the framework of subsystems such as configuration, problem, change, and capacity management together with their mutual relationships are defined in the next section.
- **Network Management functions/tasks**: the specific functions/tasks supporting the framework of subsystems that must be performed by either the NM tools or the NM staff are specified by the control measures at each layer of the NM-model.
- **Network Management instrumentation**: an NM tool is required at each layer of the NM-model to support the functions/tasks that have to be performed to reach the formulated operation goal at that layer.
- **Organizational components**: the organizational structure put in place to carry out the NM tasks is implicitly interwoven in the NM-model: layers 1, 2 and 3 equate to the operational level of NM, layer 4 equates to the tactical level of NM, and layer 5 equates to the strategic level of NM.
- **Organizational approach**: factors such as personnel skills and education are not mentioned in the NM-model.

<table>
<thead>
<tr>
<th>Key success factor</th>
<th>NM-model</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM architecture</td>
<td>++</td>
</tr>
<tr>
<td>NM functions/tasks</td>
<td>++</td>
</tr>
<tr>
<td>NM instrumentation</td>
<td>+</td>
</tr>
<tr>
<td>Organizational components</td>
<td>+</td>
</tr>
<tr>
<td>Organizational approach</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 3.2 The NM-model related to the key success factors

Legend:

++ : key success factor very good
+
: key success factor sufficient
± : key success factor partly sufficient
- : key success factor is not sufficient
3.5 The NM-model applied to evolution: demarcation on two processes

Several control measures and observations have to be distinguished according to the NM-model to organize NM. These control measures and observations can be related to ten different processes. The processes required for the organization of NM together with their mutual relationships are described in section 3.5.1. In this section the processes are also related to the layers of the NM-model. The focus in section 3.5.2 is on two of these processes that are related to evolution.

3.5.1 Processes for Network Management

The central process when performing NM is the Network Services Management (NSM) process ([ITIL95], [Hemmen95]). The performance, costs and functionality of the network and the network services are checked in this process on the basis of input of the processes Cost Management, Capacity Management, Contingency Planning, and Availability Management. If a deviation is observed by either the NSM process or by the Service Level Management (SLM) process, other processes are started by the NSM process to conform to the performance, costs and functionality that has been agreed with the customers in contracts.

In total ten processes have to be recognized to organize NM ([Hemmen95]): NSM, SLM, Cost Management, Capacity Management, Contingency Planning, Availability Management, Help Desk, Change Management, Problem Management, and Configuration Management.

The relationships between these ten processes are described in this section. The disturbances that occur at all five layers of the NM-model are handled by one or more of the following processes: Help Desk, Problem Management, Change Management, and/or Service Level Management. The Help Desk is informed when a customer has a question or a problem. The Help Desk tries to answer the question or to solve the problem (first line support); if the attempt of the Help Desk fails, the question or problem is redirected to the Problem Management process (second line support). In the Problem Management process can be requested for a change if necessary. The change is handled by the Change Management (CM) process, which includes activities to determine the impact of a change. The impact on the quality of the network services must be determined together with the impact on the existing Service Level Agreements. This relates the CM process to the Service Level Management (SLM) process. The SLM process is also started when a customer initiates a new or changed requirement. This will lead to a change of existing Service Level Agreements.

The Configuration Management process is related to the NSM process to provide an actual configuration of the network. Both of these processes get information concerning changes from the process CM. The NSM process is also related to the Problem Management process for the enrolment of a fault that was detected by NM tools present for the support of the NSM process.

The processes Capacity Management, Availability Management, Contingency Planning, and Cost Management are related to:

- The NSM process to offer data concerning the quality and costs of the network and the network services to be able to signal deviations.
- The SLM process to offer data concerning network services that have to be
realized with a specific quality, functionality and costs as formulated in the Service Level Agreements.

* The CM process to offer data for the determination of the impact of changes that are requested.

A model illustrating the relationships between the processes as described above, is given in figure 3.12 ([Moens95], [Hemmen95]).

Figure 3.12 Network Management processes and their mutual relationships.
The ten processes required to perform NM have to be included in the control bodies that are recognized in the NM-model. All ten processes are related to specific layers of the NM-model in table 3.2.

<table>
<thead>
<tr>
<th>NM-model</th>
<th>Layer 1</th>
<th>Layer 2</th>
<th>Layer 3</th>
<th>Layer 4</th>
<th>Layer 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM Process</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Level Management</td>
<td>$x^1$</td>
<td>$x^1$</td>
<td>$x^1$</td>
<td>$x$</td>
<td>$x$</td>
</tr>
<tr>
<td>Cost Management</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
</tr>
<tr>
<td>Capacity Management</td>
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<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
</tr>
<tr>
<td>Contingency Planning</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
</tr>
<tr>
<td>Availability Management</td>
<td>$x$</td>
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<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
</tr>
<tr>
<td>Help Desk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$x$</td>
</tr>
<tr>
<td>Network Services Management</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
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</tr>
<tr>
<td>Change Management</td>
<td>$x$</td>
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<td>$x$</td>
</tr>
<tr>
<td>Problem Management</td>
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<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
</tr>
<tr>
<td>Configuration Management</td>
<td>$x$</td>
<td>$x$</td>
<td>$x$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2 Relating the ten NM processes to the layers of the NM-model

1 In layers 1 up to 3 the SLM process is of importance between service provider and suppliers, at layers 4 and 5 the SLM process is of importance between the service provider and the customers.

3.5.2 Service Level Management and Change Management

The focus of this research is on the evolution and heterogeneity which both influence the NM organization. Heterogeneity is comprehended in the NM-model by starting with the homogeneous parts of a heterogeneous network. Evolution is recognized by the various disturbances that are distinguished in the NM-model. These disturbances initiate changes that make the network and the network services evolve.

The changes in the network and the network services are handled primarily by two processes: Service Level Management (SLM) and Change Management (CM). These processes handle with changes that make the network evolve. The SLM process takes care of the changing requirements and preconditions (demand pull) and the CM process takes care of the changing characteristics of network components (technology push).
The NM-taxonomy and the NM-model are further detailed and expanded with regard to the SLM process in chapter 4, and to the CM process in chapter 5 (figure 3.13).

The detailed NM-taxonomy and the detailed NM-model are validated in chapters 6 and 7. The focus of chapter 6 is on the validation of the NM-model concerning the Service Level Management process and the focus of chapter 7 is on the validation of the NM-model concerning the Change Management process.

Figure 3.13 The taxonomy, the NM-model and the models support processes CM and SLM
4 Modelling the outsourcing of the VROM network

4.1 Introduction

The models outlined in chapter 2 were shown to be insufficient to support NM, therefore, the NM-model was introduced in chapter 3. The NM-model is a theoretical model: it was developed without using practical situations, therefore the NM-model had to be tested empirically using a case study approach. Two empirical case studies are described in chapters 4 and 5 using the NM-model.

These case studies position the NM-model in practice. The NM-model was detailed to facilitate Network Management, based on experiences gained during the case studies. In chapter 4 the focus is on the research question that deals with changes caused by outsourcing of a network. In chapter 5 the focus will be on the research question that deals with the handling of particular changes in a specific situation in practice.

Outsourcing of a network and its services initiates several changes. These changes concern managerial, economic, technical, and contractual aspects. In this case study the focus was on managerial and contractual aspects, which placed the emphasis on the Service Level Management (SLM) process (figure 4.1).
The outsourcing of the VROM network and its services is analyzed in this chapter, using the NM-model. Experience gained from this analysis was used to consider the NM-model in detail with regard to the outsourcing of a network.

The NM-model is refined and expanded using the experience gained from the analysis of the outsourcing of the VROM network. The research question:

*How can management be supported with regard to changes in the network and network services caused by outsourcing?*

is concerned with this refinement and expansion of the NM-model.

Chapter 4 consists of the following sections:

* 4.2 Application of the NM-taxonomy to position the VROM and RCC networks before the outsourcing agreement.
  Two organizations, VROM and RCC, their networks and the NM of these networks are described in this section using the NM-taxonomy given in chapter 3.
* 4.3 Application of the NM-model to the outsourcing of the VROM network.
  The outsourcing of the VROM network is analyzed using the five layers of the NM-model. The application of the NM-model to this outsourcing leads to a critical reflection of the practicability and the completeness of the NM-model. The experience gained during this critical reflection is used to consider the NM-model in detail with regard to the outsourcing of a network.
* 4.4 Findings of application of the NM-model.
  The application of the NM-model resulted in findings with regard to two different kinds of inferences, namely the inferences that have implications for the NM-model and inferences that have implications for the situation in practice at RCC.
4.5 The NM-model in detail concerning outsourcing.
The NM-model is further detailed and expanded in this section concerning
the SLM process, with a division of the outsourcing into phases, a process
description of the SLM process, a division of contracts, and with entities
that are part of the process. The phases recognized in literature are related to
the layers of the NM-model in section 4.5.2. The SLM process is positioned
in the NM-model using this relationship.

4.6 The NM-taxonomy in detail the Service Level Management process.
The SLM process can be characterized by specific entities that extend the
NM part of the NM-taxonomy.

4.7 Conclusions.
This section contains the overall conclusions of this chapter.

4.2 Application of the NM-taxonomy to position the VROM and RCC
networks before the outsourcing agreement

Two organizations, VROM and RCC, their networks and the NM of these networks
are described in this section using the NM-taxonomy given in chapter 3.

4.2.1 The real system of the VROM department

The Real System concerning the VROM department is described using entities that
are recognized in the NM-taxonomy in chapter 3. The goal/strategy of VROM, its
organization structure and its staff are described below to give an impression of the
real system of VROM. The entities style, system, skill, and culture were not
considered in this explorative case study.

Goal/strategy
The goal/strategy involve services concerning the management of the environment,
housing for the dutch population, management of buildings where civil servants work,
parceling out of land, and the planning of the infrastructure and buildings in the
Netherlands.

Organization structure
The ministry of housing, spatial order and environment, (in Dutch: Ministerie van
Volkshuisvesting, Ruimtelijke Ordening en Milieu (VROM)) consists of five
departments (figure 4.2):

★ Centrale Sector (CS).
★ Directoraat Generaal Milieu Beheer (DGM).
★ Directoraat Generaal van de Volkshuisvesting (DGVH).
★ Rijksgebouwdienst (RGD).
★ Rijks Planologische Dienst (RPD).
**Staff**
The staff of VROM consists of approximately 4500 people, each member of the staff has their own PC, which is connected to the Local Area Network (LAN) ([Eveleens95]).

### 4.2.2 The real system of RCC

The Real System concerning the RCC organization is described using entities that are recognized in the NM-taxonomy in chapter 3. The goal/strategy of RCC, its organization structure and its staff are described below to give an impression of the real system of RCC. The entities style, system, skill, and culture were not considered in this explorative case study.

**Goal/strategy**
RCC is a service provider of automated, information intensive, processes. These services were primarily offered to the Dutch government. Automation in particularly was based on huge personnel and financial systems.

**Organization structure**
In 1994 RCC consisted of three parts (figure 4.3):

- **General affairs**, which includes the departments personnel, finance, secretarial, and legal affairs.
- **Marketing and sales**, which is divided into two departments account management and product management.
- **Service department**, which is divided into three departments Competence Centre (CC) for consultancy, System Development and Maintenance (SBO), and Exploitation (EXPL).
Staff
In 1994 RCC had approximately 750 employees located in Apeldoorn, Zoetermeer, and Groningen.

4.2.3 The network system at the VROM department

Goal
The goal of the VROM network is to support the primary business processes of VROM with communication facilities. These facilities enable the employees of VROM to communicate via electronic mail, to use services that are present at different locations, to consult bulletin board systems and phone books, and to send faxes.

Topology
The VROM network was founded by merging the networks of four departments which were integrated to form the VROM Computer Centre (VCC).

The basis of the VROM network was the network of the department RGD which had a mixed topology, in contrast to the other networks, which had a star topology. The VROM network had thirteen nodes that were located primarily at locations of the RGD, forming the topology shown in figure 4.4.
The VROM network was built from Codex multiplexers and Cisco routers. The Codex multiplexers were connected by leased lines, which mostly had a capacity of 64 kbit/sec. The function of these multiplexers was to join the data traffic that came from links that were not part of the backbone, and to transport that data via an own proprietary protocol over the backbone. The data had to be converted into the proprietary protocol by software at the nodes, causing data delays. The Cisco routers were used to realize LAN/LAN, and serial connections.

4.2.4 The network system at RCC

Goal
The goal of the RCC network is to support the primary business processes of RCC with communication facilities. These facilities enable the employees of RCC to communicate via electronic mail, to use services that are present at different locations, to consult bulletin board systems and phone books, and to realize telephone links over the network. As well as the utilization of the network by employees of RCC, the network is also exploited to offer network services to customers of RCC. At first the network was deployed mainly for the transmission of data based on SNA for mainframe applications.

Topology
The historical topology of the RCC network was determined by the important role of the mainframe which was the centre of the network. The RCC network consisted of three subnetworks; two subnetworks having a star topology. These subnetworks were connected by another subnetwork with a mixed topology. The two star networks were located in Apeldoorn and The Hague (figure 4.5).
Figure 4.5 The topology of the RCC network before outsourcing

The RCC network consisted of a backbone with four nodes and a number of links from Front End Processors (FEP's) to customers. The nodes were located at Apeldoorn (2x), Zoetermeer (1x) and The Hague (1x).

The data was not modified in the nodes, so the data transport was transparent and suffered almost no delay.

The backbone consisted of least lines (2 Mbits/sec) from the PTT and Time Division Multiplexers (TDM) from Newbridge. The TDM-multiplexers divided the 2 Mbits connections into thirty-two 64 kbps or connections with a speed that is less than 64 kbps. The application of multiplexers meant that several customers could use a fast 2Mbps connection simultaneously.

4.2.5 Network Management at VROM

Goal
The goal of NM at VROM was to manage, control, and maintain the network in accordance with the requirements and preconditions imposed by utilization and the characteristics of the network components. The requirements and preconditions were in this case formulated by the secretary general of the VROM department. These requirements and preconditions were not included into contracts.

Processes/tasks
An overall view of tasks and processes that should be performed for NM was lacking; no standard model was used to recognize tasks and processes.

Procedures
No procedures were formulated for NM, due to the merger of the computer centres.
and the integration of the networks of the VROM departments.

Tools
The management tool 'Codex 9800' was used for the NM concerning multiplexers and modems. The Cisco routers were managed, controlled and maintained via the protocol SNMP, using 'Spectrum' as a SNMP manager and 'Netdirector' for other routers. NM was performed centrally in Leidschendam.

The logical paths were determined by software. This termination could be influenced by a system of cost factors and priorities. The reconfiguration was done by software when disturbances occurred.

Staff
The staff of the NM department at VROM consisted of 12 persons, which were located in The Hague. Two of these persons had the function of network advisor, the other 10 persons held the function of employee.

4.2.6 Network Management at RCC

Goal
The goal of NM at RCC was to manage, control, and maintain the network in accordance with the requirements and preconditions imposed by utilization and the characteristics of the network components. The requirements and preconditions were in this case formulated by users of the RCC network.

Processes/tasks
NM was performed as an extension of the services that were offered using the mainframe. The supplier of the mainframe was IBM, and therefore the IBM view on performing NM was used.

Procedures
No procedures were formulated specifically for NM, due to the small scale and its specific nature of the network, however, general procedures for tasks concerning the management, control and maintenance of the mainframe environment were used as far as it concerned the network.

Tools
The management tools 'Netview' (SNA), 'Newbridge 4602' (backbone) and 'Codex 9300' (modems) were used for NM. NM was performed centrally in Apeldoorn. The management tool 'Meridian Manager' was used for NM of the PABX.

The network components were configured from a central point. The configuration was changed when disturbances occurred. The configuration could be changed via predefined alternatives, or by defining a new configuration using an NM tool.

Staff
The staff of the NM department at RCC consisted of 12 persons, which were located in Apeldoorn. One of these persons was the leader of the NM department, two of these persons held the function of network advisor, 10 persons held the function of employee, and 3 persons held the function of network analyst.
4.3 Application of the NM-model to the outsourcing of the VROM network

The outsourcing of the VROM network is analyzed using the five layers of the NM-model. The application of the NM-model to this outsourcing led to a critical reflection of the practicability and the completeness of the NM-model. The experience gained during the critical reflection is used to consider the NM-model in detail with regard to the outsourcing of a network.

The VROM policy concerning NM and the objectives and strategy of RCC with regard to network services changed when the VROM network was outsourced. These changes involved layer 5 of the NM-model, and had consequences for the lower levels of the NM-model, application of the NM-model therefore starts at layer 5.

4.3.1 Disturbance at layer 5: change in the policy concerning NM

Disturbance
VROM decided to outsource its network. The outsourcing of a network is a disturbance of a managerial kind. The outsourcing concerned the ownership of the network and the way it was managed. The responsibilities for NM and the network described in layers 1 up to 4 was placed with the service provider RCC.

The decision to outsource the VROM network was based on the following points:
- The departments of VROM were moved to a central location.
- VROM wanted to concentrate on essential tasks for VROM; this excluded tasks concerning NM.

Observations
The information needed to decide whether or not a network is outsourced is obtained by the processes availability management, contingency planning, capacity management, cost management, and service level management. Observations concerning quality, costs and functionality of the VROM network also showed that the NM had to change. The costs of the network services increased to keep the quality of the network services at a constant high level.

RCC was selected as the service provider for the outsourcing of the VROM network due to an existing relationship with VROM. RCC already delivered automation services to the VROM departments, therefore RCC was acquainted with the requirements, the preconditions and problems that were part of the VROM situation.

Control measures
The policy concerning the network and its NM within VROM and RCC were changed.

The VROM policy excluded operational and tactical affairs that concern the network and its services. Managers at strategic level must still decide which services (functionality) are needed at what price and quality. Management control and maintenance concerning the functionality of network services and support of users also remains of importance for VROM. This is called Functional Management ([Looijen95]).

The objectives and strategy of RCC was expanded, due to the variety of the services
that were added. The objective concerning network services was ([Jonkers93]): to
fulfil the need of customers by offering an integrated set of services:

* Transport services.
* Realize connections between networks.
* Value added network services.
* Network Management of LAN's and WAN's.
* Outsourcing of networks.
* Consultancy.

The strategy concerning network services was derived from this objective.

The outsourcing had consequences for the lower layers of the NM-model at the
service provider RCC, in addition to the changes in policy and objectives:

* Increasing number of users and their specific requirements (layer 4).
* Increasing complexity for the coordination the product lines (layer 2).
* Increasing number of product lines (layer 1).

These consequences of the outsourcing are discussed in the following four sections.

4.3.2 Consequences for layer 4: change in user population and requirements

**Disturbance**
This layer was confronted with a disturbance concerning new users and their
requirements that were introduced as consequence of outsourcing the VROM network.

**Observations**
RCC had to reckon with the employees of VROM which were in this case, new users
of the network. These users demanded specific requirements for the network.

**Control measures**
These requirements had to be formulated in contracts that described the services
required with regard to functionality, quality and costs. The Service Level
Management (SLM) process is therefore the most important process. This process
involves formulating, monitoring and reporting the requirements of the users. The
information needed to formulate, monitor and report is obtained by the processes:
problem management, change management, network services management,
availability management, contingency planning, capacity management, and cost
management.

4.3.3 Consequence for layer 3: change in services

**Disturbance**
This layer was confronted with a disturbance concerning new network services
introduced as consequence of the outsourcing of the VROM network.

**Observations**
The processes that observe and react to a disturbance that changes or introduces
services are change management, configuration management, and problem
management. The services are characterized by a certain quality, cost and
functionality. Quality is controlled by the processes availability management,
contingency planning, and capacity management. Cost is controlled by the cost management process. Functionality is controlled by the Service Level Management process.

**Control measures**
The network services that are provided by RCC are divided into three categories ([Jonkers93]):

- **Transport Services.** RCC offers transport facilities to customers. The services can be used by customers using any of the other services as well as a separate service.
- **Network Services.** RCC manages its SNA and DECnet based networks and provides NM services to customers that are protocol dependent. Interconnection facilities and remote or on site NM are also part of Network Services.
- **Telematics Services.** RCC offers electronic mail services (X.400) to its customers. In addition a conversion facility is available to convert documents and messages into the format required by customers. RCC has implemented a directory service agent (X.500) to provide directory services.

Transport Services and Network Services are realized in layers 1 and 2 of the NM-model. These services were already provided before the outsourcing of the VROM network, however, the outsourcing led to an expansion towards a national range for the network. Before the outsourcing these services were restricted mainly to data transport based on the protocol SNA. The outsourcing introduced transport services, which were independent of the transport protocol.

Telematics Services are recognized at this layer, however, none of these services were introduced.

### 4.3.4 Consequence for layer 2: change in product line coordination

**Disturbance**
This layer was confronted with a disturbance concerning the coordination of the new product lines and their mutual connections introduced as consequence of the outsourcing of the VROM network.

![Figure 4.6 Network Management of R-net](image-url)

Figure 4.6 Network Management of R-net
Observations
The most important processes that observe and react on the disturbance that introduces new product lines and their mutual connections are change management, configuration management, and problem management. These processes introduce a new way of coordinating the product lines. The heterogeneous network, built by the product lines, is characterized by a certain quality. This quality is controlled by the processes availability management, contingency planning, and capacity management. Cost is controlled by the cost management process.

Four product lines are recognized in layer 1: Newbridge, IBM, Cisco, and Codex. These product lines show clear differences in functionality.

Management tool
The configuration of R-net put high requirements on NM. Eight management tools were being used for the management of the different product lines (see tables below these show the management tools that were present on 12 july 1994). These management tools were not able to exchange data, which resulted in a complex NM. The need for an integrated management tool was recognized. It was however, not introduced in this phase of the outsourcing. A management tool that could be used to control the heterogeneous network was not available at that time.

Table 4.1 Management tools on the location Apeldoorn:

<table>
<thead>
<tr>
<th>management tool:</th>
<th>Managed network components:</th>
<th>Supplier:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netview 6000</td>
<td>SNA hardware</td>
<td>IBM</td>
</tr>
<tr>
<td>Codex 9300</td>
<td>Codex modems</td>
<td>HP</td>
</tr>
<tr>
<td>Newbridge 4602</td>
<td>Newbridge network components</td>
<td>SUN</td>
</tr>
<tr>
<td>Meridian Manager</td>
<td>PABX</td>
<td>Northern Telecom</td>
</tr>
<tr>
<td>LAN Manager</td>
<td>LAN (present at RCC)</td>
<td>IBM</td>
</tr>
</tbody>
</table>

* Netview is used to perform NM of data transport based on SNA.
* Codex 9300 is used to manage Codex modems.
* Mainstreet 4602 is used to manage Newbridge network components.
* Meridian Manager is used to manage the PABX.
* LAN Manager is used to manage the LAN present at the location Apeldoorn.
Table 4.2 Management tools on the location The Hague:

<table>
<thead>
<tr>
<th>management tool:</th>
<th>managed network components:</th>
<th>supplier:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codex 9800</td>
<td>Codex multiplexers,</td>
<td>HP</td>
</tr>
<tr>
<td></td>
<td>Codex modems</td>
<td></td>
</tr>
<tr>
<td>Netdirector</td>
<td>Routers (SNMP)</td>
<td>Ungermann Bass (UB)</td>
</tr>
<tr>
<td>Spectrum</td>
<td>Cisco routers</td>
<td>Cabletron</td>
</tr>
</tbody>
</table>

- Codex 9800 is used to manage Codex-multiplexers and modems. This management tool has more functionality than the management tool Codex 9300.
- Netdirector is used for the management of UB components, which are located decentrally. Netdirector can also monitor Cisco routers using the protocol SNMP.
- Spectrum is used for the management of Cisco routers within VROM.

Control measures
The product lines showed clear differences in functionality, therefore service partitioning was used. This meant that a common infrastructure was divided into several logical subnetworks, each having its own functionality. The product lines also showed an overlap in functionality, therefore the product lines had to be tuned to use the functionality optimally.

RCC has appointed the following application of the product lines in the R-net:
- The product line Newbridge leads, realizing the backbone.
- Cisco is the standard product line for routers.
- Existing network components and product lines have to continue to realize their functionality.

The TDM-technique (see layer 1) forms the basis of the R-net. This technique is realized by the Newbridge network components in the backbone on digital leased lines from the PTT. Dynamic optimization is not possible within this technique, therefore, this technique will be used for connections that have a high level of occupation.

Several logical subnetworks are defined on the backbone (TDM-technique). These subnetworks are base on the four product lines Newbridge, IBM, Cisco, and Codex.

Connections between product lines (Topology)
The R-net is based on a backbone which consists of connections with a high capacity; 2 Mbps leased lines. These connections connect five nodes, which were located in Apeldoorn (2x), The Hague (1x), Amsterdam (1x) and Zoetermeer (1x). The implementation of the R-net, in mid-1992, led to a network with a mixed topology instead of a star topology. This network will be expanded to serve present and future customers of RCC.
Figure 4.7 The topology of R-net (September 1994)

The integration of the RCC and VROM network has led to a revised topology for the following reasons:

* A mixed topology was no longer so necessary. The mixed topology was required in the former VROM network, which consisted mostly of Codex components, to prevent disturbances. When the connections of Codex components are redirected through Newbridge network components, the mixed topology is no longer as conclusive. Disturbances are solved by Newbridge network components. These disturbances are not noticed by the upper Codex-layer. This means that some connections became superfluous.

* The transition of a network with a star topology into a mixed topology. The RCC network which had a star topology was integrated with the mixed VROM network. The mixed network was used as basis of the integrated network, and named R-net. Several links could be shortened by realizing a connection to a node of the mixed network that was near the end point.

A necessary result of the revised topology was that the connection between The Hague, Zoetermeer and Apeldoorn was always available. This was realized using independent double connections, that could handle a disturbance.

Two important issues should be considered when using this topology: the gathering of dataflows in Apeldoorn and/or The Hague, which are both logical starpoints, and the peak load, which means that there is an overcapacity when the network is less occupied (e.g. at night).

Preconditions for the integration
The management of RCC formulated preconditions for the integration of the VROM network and the R-net with regard to NM:

* Independence with regard to suppliers to handle the heterogeneity of the R-net.
Cost effectiveness as a result of tuning the way of working at the two NM locations: e.g. flexible division of labour, and avoidance of disturbances.

Concentration of NM activities when possible e.g. during hours that the network is not used intensively.

A protocol that is independent of any network architecture.

Research into the possibilities of applying new techniques e.g. ISDN and Frame Relay in the R-net.

4.3.5 Consequence for layer 1: introduction of product lines

Disturbance

This layer was confronted with a disturbance concerning the product lines that were introduced as consequence of the outsourcing of the VROM network.

RCC recognized two product lines: Newbridge and IBM. Network components from Newbridge were introduced in the R-net, independently of the takeover of the VROM network. IBM network components were traditionally the basis of the network of RCC, due to the importance of the (IBM) mainframes.

The takeover of the VROM network added two product lines: Codex and Cisco. The characteristics of the product lines are described below. The integration of the networks of VROM and RCC has led to an increase in the heterogeneity of network components: communication devices from several suppliers have been connected.

The operation of the product lines has not been changed and must be continued in the situation after the outsourcing of the VROM network. The product lines must be tuned and coordinated on layer 2. The real operation of the product lines is not described because of the many details that play a part in the operation. The product lines are therefore only described by mentioning their functionality. The four product lines are described successively starting with the Newbridge product line and ending with the Cisco product line.

The Newbridge product line

Newbridge network components have an additional functionality called Time Division Multiplexing (TDM), which means that a 2 Mbps connection can be divided into thirty-two 64 kbps connections or even more connections with a speed that is less than 64 kbps. The application of these multiplexers enables simultaneously use of the fast 2 Mbps connection. Several customers can be served and communicate at the same moment over a single connection using this technique.

This product line is also characterized by its prevention and handling of disturbances: favourable Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR), and logical paths that can be protected against the influences of network disturbances.

The utilization of Newbridge network components for specific data transport (e.g. SNA-data transport) requires that the bandwidth needed is reserved one to one. The occupation of the connection is therefore low.

Newbridge network components are used where a fixed high bandwidth is required, preferably for connections with a high occupation, and therefore Newbridge network components are used in the backbone of the R-net. The Newbridge network components are also used to realize protocol independent data transport, which can be
an advantage for protection against network disturbances.

The management tool Mainstreet 4602 is used to manage Newbridge network components.

*The IBM product line*

The Front End Processors (FEP) of IBM are characterized by a functionality to concentrate and reroute data based on SNA. A FEP achieves a statistical division over the data transport.

The remote FEP's are connected point-to-point to the mainframe in Apeldoorn.

The management tool Netview is used to perform NM of data transport based on SNA.

*The Codex product line*

Network components of Codex are characterized by the possibility to handle data transport based on different protocols. A conversion is required to convert the incoming protocols into an own protocol. This conversion requires some time, which results in a delay of the data in the nodes.

Statistical division is used to realize the same occupation for all connections in the Codex-network. The time for this operation is less important for the total duration of data in the network when low speed connections are used.

The Codex components are used to realize serial connections for data transport.

The management tool Codex 9300 is used to manage Codex-modems. The management system Codex 9800 is used to manage Codex-multiplexers and modems. This management tool has more functionality than the management tool Codex 9300.

*The Cisco product line*

The Cisco routers are characterized by a high speed, high processor capacity and the possibility to use open standards. Functionality to connect singular serial connections is also provided. The connection of Cisco routers is realized via TCP/IP over serial connections.

The Cisco routers are used to connect LAN's where a high speed is required. Frame Relay can be used with this product line in the long term for connection and gateway protocol, the statistical division can then be used optimally.

The management tool Netdirector is used for the management of UB components, which are located decentrally. Netdirector can also monitor Cisco routers using the protocol SNMP. The management tool Spectrum is used for the management of Cisco routers within VROM.

4.4 Findings of application of the NM-model

The application of the NM-model resulted in findings with regard to two different kinds of inferences, namely the inferences that have implications for the NM-model and inferences that have implications for the situation in practice with RCC.

4.4.1 Inferences drawn from the application of the NM-model

The outsourcing of the VROM-network to RCC was an disturbance caused by a managerial influence. As well as this managerial influence that concerned the
outsourcing of the network, other influences that caused disturbances were also present simultaneously at RCC. These disturbances were caused by managerial, technical, contractual, and economic influences.

Managerial influences:
* Privatisation RCC. The privatisation of RCC led to a marketing strategy that aimed at an expansion into new businesses and new markets outside the area of the Dutch government. The privatisation also led to the commercialization of all services; emphasis was placed on a reduction of costs.
* Reorganization of the NM department. The departments at VROM and at RCC, that were responsible for the NM of the resulting network, had to be integrated into one unit at RCC, which was realized by a reorganization. This reorganization was needed to coordinate activities, to determine a strategy, to deploy the NM tools and NM staff, to survey the financial aspects, and to survey and control at a management level. Besides these arguments, an emphasis was also put on business concerning networks, which asked for a special department to be responsible for the NM.
* Conformity to ITIL. Processes concerning the management, control and maintenance of all infrastructure components had to conform to the directives of the IT Infrastructure Library (ITIL). The NM processes at RCC were part of the processes that had to conform to ITIL.

Technical influences:
* Shortcomings of the management tools. NM of the integrated network was supported by several management tools each having its own area of application. The management tools could not be connected which led to a fragmented NM, and this led to problems for all NM processes (see table 4.3 below).
* Introduction and utilization of new techniques. New technologies, like Frame Relay and ATM, had to be introduced within the integrated network to anticipate future developments. The staff of RCC had to acquire knowledge concerning unfamiliar technical concepts.

Contractual influences
* Formulation of Service Level Agreements (SLA). RCC was unfamiliar with detailed descriptions of services for customers in contracts when the VROM network was outsourced in 1992. SLA's were introduced to describe the details of a service. These details concerned the quality and functionality of services. The agreements included sanctions that were to come into effect when the agreed norms were not fulfilled.

Economic influences
* Decreasing costs of communication devices. The costs of communication devices are decreasing constantly due to new techniques and higher sales of the products.
* Tariffs based on the amount of utilization. The utilization of new techniques like Frame Relay enables the calculation of the costs on the basis of the amount of utilization. The bandwidth can also be allocated dynamically by the application of Frame Relay.
* Collective utilization of the infrastructure. It was necessary to use the integrated
network collectively for other purposes and other customers to exploit the network economically and to reduce costs.

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<thead>
<tr>
<th>NM process</th>
<th>Problem due to the shortcomings of the management tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration Management</td>
<td>The overall configuration of the network was not available due to the spread of the configuration data over several databases of the management tools.</td>
</tr>
<tr>
<td>Help Desk</td>
<td>The incidents that occurred were not documented in a database that could be consulted in a simple way. The tool present was not suitable: it lacked user friendliness.</td>
</tr>
<tr>
<td>Problem Management</td>
<td>A problem that was detected by a management tool could not be associated to problems that were detected in other management tools, which caused an inadequate problem solving.</td>
</tr>
<tr>
<td>Change Management</td>
<td>The impact of a change could not be estimated due to the lack of a suitable management tool.</td>
</tr>
<tr>
<td>Availability Management</td>
<td>The availability of the total network could not be viewed and controlled by the present NM tools. Trend analysis for the complete network concerning availability was not possible.</td>
</tr>
<tr>
<td>Contingency Planning</td>
<td>Dynamic possibilities to evade were not supported for the total network. These possibilities could only be used within the product lines.</td>
</tr>
<tr>
<td>Capacity Management</td>
<td>The network was designed for a peak load, which meant that most of the time an overcapacity was present. A trend analysis for the complete network could not be achieved with the management tools that were present.</td>
</tr>
<tr>
<td>Cost Management</td>
<td>RCC and the users of the network did not have an overview of the extent to which the network was used. The extent of utilization could not be settled with the users. The users of the network paid periodic fixed prices for the utilization of a connection, depending on the length of the connection.</td>
</tr>
<tr>
<td>Service Level Management</td>
<td>The measuring and reporting of the performance of the total network was time consuming due to the lack of connections between the management tools. The time consuming and expensive reporting consisted of manual import of data concerning performance of the total network.</td>
</tr>
</tbody>
</table>

Table 4.3 Problems of the management tools categorized by NM processes

Another complication with the NM-model was caused by the processes that are distinguished in the NM-model. The processes were only mentioned, without working out their relationships. The processes at a specific layer were not related to processes on other layers.

4.4.2 Implications for the NM-model

Outsourcing has to be divided into phases and steps to avoid nuisance caused by the various disturbances that occurred. The phases of outsourcing, that are recognized in the literature, and their division into steps, are related to the layers of the NM-model in section 4.5.1.

The processes have to be described in detail. Two processes are considered in this
research: Service Level Management (SLM) and Change Management (CM). Attention will be paid in this chapter to the SLM process and in the next chapter to the CM process to deal with the evolution of heterogeneous networks. The SLM process is the most important process when a network is outsourced, and this process is described in sections 4.5.2 and 4.5.4.

The processes at a specific layer have to be tuned to processes on other layers.

4.4.3 Inferences drawn from the outsourcing of the VROM network according to the NM-model approach

The outsourcing of the VROM network to RCC was analyzed using the NM-model. This analysis led to conclusions concerning this specific situation in practice. If the NM-model had been used to realize the outsourcing, a different approach would have been taken with regard to the emphasis placed on organizational aspects of the control bodies of the layers distinguished in the NM-model. The organization of the control bodies depends on: the formulated operation goal, the processes, the tasks, the procedures, the staff and the management tools. Each layer is analyzed for these aspects in this section.

Some general remarks that concern all layers are made before analyzing the separate layers; these concern the aspects processes, tasks and procedures:

- *Tasks* as defined in the NM-model were not recognized.
- *Processes* as defined in the NM-model were not recognized.
- Only general *procedures* concerning management, control and maintenance of the computer centre were available. These procedures were not tuned to the management, control and maintenance of network services.

Layer 1

Little or no changes were made to the operation goal for the coordination of the product lines.

The staff of RCC was expanded by the employees that performed the NM at the VROM location. Single product lines could be managed well by the staff that had sufficient knowledge. The staff had management tools at its disposal that were made specially for the management, control and maintenance of each specific product line.

Layer 2

The operation goal of layer 2 was changed because of the introduction of new product lines. A complete overview of the total network is necessary to realize the coordination of the heterogeneous network, however such an overview was not present which resulted in a fragmented coordination of the heterogeneous network. This fragmented coordination was also caused by the lack of suitable management tools to oversee the total network and by staff that individually had very specific knowledge concerning technical details of parts of the network.

Layer 3

The services to be provided by RCC, concerned transport and network services. These services are handled in layers 1 and 2, therefore, no deviations were found at this layer.
Layer 4

The operation goal of layer 4 concerned the heterogeneous network and the network services that had to be tuned to the requirements of the (new) users of the network services. The requirements must be formulated in contracts containing agreements on the quality, costs and functionality of the services offered. The staff had no experience concerning formulation of contracts and agreements at the service level at the time of the outsourcing of the VROM network. The outsourcing of the VROM network was the first time that RCC formulated service levels for network services. The resulting Service Level Agreements were complete with regard to the necessary aspects of the services to be offered to VROM ([Hemmen94]).

The operation of the heterogeneous network and the network services was not supported by management tools, this was impossible because of a lack of management tools aimed at the lower layers of the NM-model.

Layer 5

The operation goal of layer 5, concerning the coordination of the strategy and policy, was aimed mainly at controlling cost. There was no policy to expand the network services and little attention was paid to this aspect.

The staff that was responsible for the formulation of the policy made considerable effort to reorganize the NM department. The policy to expand network services and reach other markets was subordinate to the reorganization. A business plan that described the challenges and new possibilities was present at RCC, but it was not used for its purpose.

Management tools to support this layer were not available.

4.4.4 Implications for the RCC organization

The following actions were recommended or had already been signalled and started:
- Conformation of the way of working to organize the NM processes as defined by ITIL (all layers).
- Formulation of procedures (all layers).
- Introduction of a management tool for layer 2.
- Introduction of a management tool for layer 4.
- Utilization of the business plan (layer 5) at layers 1 to 4 of the NM-model to expand the network services and reach other markets.

These actions were implemented in the department RCC Network Services in April 1996.

4.5 The NM-model in detail concerning outsourcing

The outsourcing of networks has occurred frequently in the last years. Outsourcing of networks is stated to be a growing trend in chapter 1. Outsourcing brings about a rearrangement of tasks, such as happened with the outsourcing of the VROM network. These tasks are performed by service providers on the basis of contracts. Functionality, quality and costs should be formulated unequivocally between the customer and service provider in the contracts, which have to be guarded continually. The focus of this section is therefore on the Service Level Management (SLM) process that plays an important role when a network is outsourced.
The NM-model is further detailed and expanded in this section concerning the SLM process, with a division of the outsourcing into phases (4.5.1), and a process description of the SLM process (4.5.3). The phases recognized in literature are related to the layers of the NM-model in section 4.5.2. The SLM process is positioned in the NM-model using this relationship.

4.5.1 The NM-model and outsourcing phases recognized in literature

The focus in chapter 2 was on literature that concerned the concepts heterogeneity, evolution, and models that support NM: outsourcing was only mentioned in relation to the evolution of networks. It appears from this chapter that outsourcing of a network is a complex affair that results in many changes, technical as well as organizational. Literature concerning the concept of outsourcing is referenced and used in this section.

Outsourcing has been analyzed by various researchers ([Cushman93], [Feringa91], [Hovers72], [Huyzer91], [Rietberg93], [Verdonck93]). These researchers distinguish phases and steps that can be used to prescribe and describe outsourcing. Five phases are recognized when a network is outsourced ([Hemmen94]), namely:

* **Change of strategy by the customer (phase 1).** A company ('the customer') decides to outsource its network. A suitable service provider is selected that is able to take care of the NM. The decision making concerning the selection of a service provider is outside the scope of this research (see [Looff96]). Data must be gathered to make the right choice of supplier. This data involves the network services required and the ability of the service provider to offer these network services at the right cost in proportion to the quality. Several service providers should be approached to gather the required data.

<table>
<thead>
<tr>
<th>Phase 1: change of strategy by the customer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1.1</strong> Change in customer strategy</td>
</tr>
<tr>
<td><strong>Step 1.2</strong> Describe the present network services</td>
</tr>
<tr>
<td><strong>Step 1.3</strong> Define the network services required</td>
</tr>
<tr>
<td><strong>Step 1.4</strong> Explore the market</td>
</tr>
<tr>
<td><strong>Step 1.5</strong> Formulation of offer</td>
</tr>
</tbody>
</table>

Table 4.4 Steps in phase 1

* **Shift of responsibilities for the network and the organization of NM (phase 2).** The agreements made between customer and the selected service provider are formulated in contracts. The service provider becomes responsible for NM involving the network and the network services when the contract is signed.
Chapter 4: The Outsourcing of the VRM Network

Table 4.5 Steps in phase 2

<table>
<thead>
<tr>
<th>Phase 2: shift of responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2.1 Initial consultation</td>
</tr>
<tr>
<td>Step 2.2 Commitment</td>
</tr>
<tr>
<td>Step 2.3 Research</td>
</tr>
<tr>
<td>Step 2.4 Contract negotiation</td>
</tr>
<tr>
<td>Step 2.5 Agreement takeover</td>
</tr>
</tbody>
</table>

*Technical integration of the network (phase 3a).* The network is changed during this phase to use the network cost-effectively, leading to changes in topology, the network components and the NM-tools.

The networks of the customer and the service provider are connected, if necessary, during this phase. This connection makes it possible to perform NM at a distance, this is called remote management.

Table 4.6 Steps in phase 3a

<table>
<thead>
<tr>
<th>Phase 3a: technical integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 3a.1 Formulation of a plan of approach</td>
</tr>
<tr>
<td>Step 3a.2 Adaptation the topology</td>
</tr>
<tr>
<td>Step 3a.3 Adaptation the network components</td>
</tr>
<tr>
<td>Step 3a.4 Adaptation the NM-tools</td>
</tr>
</tbody>
</table>

*Organizational integration of the organizations of NM (phase 3b).* The service provider is responsible for tuning NM performed by the customer to the way of working of the supplier. Unnecessary double execution of tasks should be eliminated to realize effective NM.

Table 4.7 Steps in phase 3b

<table>
<thead>
<tr>
<th>Phase 3b: organizational integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 3b.1 Distribution of tasks and functions</td>
</tr>
<tr>
<td>Step 3b.2 Revision of conditions of employment</td>
</tr>
<tr>
<td>Step 3b.3 Retraining of personnel</td>
</tr>
<tr>
<td>Step 3b.4 Reorganization of the NM organization</td>
</tr>
</tbody>
</table>

*Exploitation of NM (phase 4).*

The day to day activities of NM must be performed to reach the goal of NM: to conform to the formulated requirements, taking into account the formulated preconditions and characteristics of the network (components). As well as performing the actual NM the outsourcing must also be evaluated as a whole.
These phases are modelled in figure 4.8.

Figuur 4.8 Phases in outsourcing: the rectangles model companies, and the ellipses model the networks that are managed, controlled and maintained by these companies.
The steps in the phases recognized in literature concern specific layers of the NM-model, as mentioned in the table given below.

<table>
<thead>
<tr>
<th>NM Layer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Change in customer strategy</td>
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<td>*</td>
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<tr>
<td>1.2 Describe the present network services</td>
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<tr>
<td>1.3 Define the network services required</td>
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<tr>
<td>1.4 Explore the market</td>
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<td>*</td>
</tr>
<tr>
<td>1.5 Formulation of offer</td>
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<td>*</td>
</tr>
<tr>
<td>2.1 Initial consultation</td>
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<td>*</td>
</tr>
<tr>
<td>2.2 Commitment</td>
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<td></td>
<td>*</td>
</tr>
<tr>
<td>2.3 Research</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>2.4 Contract negotiation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>2.5 Agreement takeover</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>3a.1 Formulation of a plan of approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>3a.2 Adapting the topology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>3a.3 Adapting the network components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>3a.4 Adapting the NM-tools</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>3b.1 Distribution of tasks and functions</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>3b.2 Revision of conditions of employment</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>3b.3 Retraining of personnel</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3b.4 Reorganization of the NM organization</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>4.1 Exploitation</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>4.2 Total evaluation of the outsourcing</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

Table 4.9 Steps related to the layers of the NM-model

4.5.2 Service Level Management process description

The Service Level Management (SLM) process is defined in [ITIL90] as the process of negotiating, defining, contracting, monitoring and reviewing the levels of users service, both the required and cost justified.

The following activities can be recognized in the SLM process ([ITIL90], [Aart94]):

* **Initiate SLA negotiations.** A customer and a service provider agree on a commitment concerning a service, which must be formulated in a SLA.
* **Formulate an initial SLA.** The service level requirements are documented in Service Level Agreements (SLA).
Negotiate contents of the SLA. The management of the customer and the management of the service provider have to reach agreement on the requirements and translate these into operational requirements and contracts with suppliers and maintainers.

Formal acceptance of the concept SLA. The service provider and the customer must agree upon the formulated contract.

End negotiation. No agreement between customer and service provider can be realized: the SLM process will be stopped.

Change of the SLA. The SLA is changed according to the outcome of negotiations between customer and service provider

Monitor requirements. Constant control of the actual Quality of Service (QoS).

Report. The customer must be informed about the service levels achieved.

Deviation. Actions, as defined in SLA’s, are initiated when deviations are detected to requirements concerning the QoS.

Initiate NM processes. NM processes are initiated to remove and prevent deviations.

Exceeding norms. If norms are exceeded, negotiations between customer and service provider are started to change the SLA or to end the existing services. SLA’s must be updated regularly to reflect changing business needs and user requirements.

These activities and their relationships are modelled in figure 4.9.

Figure 4.9 The procedure Service Level Management
4.6 The NM-taxonomy in detail concerning the Service Level Management process

The NM-taxonomy is considered in detail concerning the SLM process by dividing the contract into four parts and by the entities that play a role in the SLM process.

4.6.1 Contract division

Contracts between service providers and customers are used to establish all rights and obligations of the service provider as well as the customer. Formulating contracts, that contain detailed agreements between customers and service providers, has become common in the last five years. Companies have been persuaded of the usefulness of the contracts that describe the quality of the services and the support that must be provided by the service provider.

The contracts are divided into four parts. Each part of the contract is related to a specific area of attention which can be coupled to a specific department within a company:

- The document Service Agreement (SA). This document deals with legal and strategic aspects. General arrangements are formulated in this document. These arrangements are generic for a specific service, such as arrangements concerning the management of the projects, service level reporting and the duration of the contract.
  This document involves layer 5.

- The document Service Level Agreement (SLA). This document deals with tactical aspects. Guarantees concerning the quality of the services are formulated in this document. Service quality is defined with respect to service availability, reliability, performance, capacity for growth, levels of users support, contingency planning and security. Guarantees are assimilated in a SLA concerning the following processes Problem Management, Change Management, Capacity Management, Availability Management and Contingency Planning.
  This document involves layer 4.

- The document Arrangements and Procedures. This document deals with operational aspects and is used to describe the procedures required for the operation of the activities as formulated in the Service Level Agreement. These procedures are primarily of an operational nature. Examples include the frequency of conference, authorization and procedures for escalation, contact persons and forms of reporting. These arrangements concern the Network Services Management process.
  This document involves layers 1, 2, 3.

- The document Financial Aspects. This document deals which financial aspects; costs and tariffs are specified in this document, and it is related to the Cost Management process.
  This document involves layer 4 which depends on input from layers 1, 2, and 3.

In practice it appears that the formulation of an SLA is a difficult affair. Companies are confronted with the question of what kind of information has to be included in the SLA's. [Verdonck92] and [Aart94] have performed research into the contents of SLA's. The outcome of this research is a checklist of the contents of a SLA. Within
the framework of this research the checklist is transformed using the processes that are distinguished in ITIL ([Hemmen95]).

4.6.2 Entities in the Service Level Management process

The SLM process can be characterized by specific entities. These entities are: service level manager, Service Level Management, service level report, contract (NM goal), kind of requirement, service agreement, service level agreement, financial aspects, arrangements and procedures, NM staff, NM task, NM process, NM procedure, and NM tool (figure 4.10).

![Figure 4.10 Entities in the Service Level Management process](image)

Some of the relationships between these entities are explained below. The function service level manager is part of the NM staff. This function has responsibilities concerning the coordination of the SLM process. The SLM process is based on contracts that can be divided into four parts according to the kind of requirement. These four parts are: Service Agreement, Service Level Agreement, Financial Aspects, and Arrangements and Procedures. The output of the SLM process are service level agreements and service level reports that report on the formulated requirements. These service level reports are generated automatically by the NM tools. The frequency of reporting is formulated in the Service Agreement. Contracts which describe the network services that are agreed upon between two organizations: the service provider and the customer.
Conclusions

The NM-model was used in this chapter to describe the outsourcing of the VROM network. Changes were implemented at each layer of the NM-model, to integrate the VROM network with the RCC network and the NM at VROM with the NM at RCC.

Based on the experiences gained during the application of the NM-model to the outsourcing of the VROM network, the NM-taxonomy and the NM-model were expanded to deal with the research question below:

*How can management be supported with regard to changes in the network and network services caused by outsourcing?*

The NM-taxonomy considered in detail can be used by management to compare different situations concerning Service Level Management based on the entities recognized. Shortcomings of the situation present concerning Service Level Management can also be found by going through the added entities, which can be used as a checklist.

The expansion makes the NM-model useful for management by relating it to existing theories concerning outsourcing. This resulted in four phases that were divided into several steps that must be accomplished when a network is outsourced. These steps were related to the control measures at all five layers of the NM-model.

The focus of this chapter was placed on one of the phases of outsourcing, putting the emphasis on the formulation and agreements of contracts that describe the requirements and preconditions concerning network services, quality, functionality and costs. The formulation and agreement is handled by the Service Level Management (SLM) process. This SLM process was modelled using a process description, and the entities in the SLM process to expand the NM-model. The nature of this process is the interaction between service provider and customer which makes the process extremely complicated.

The NM-taxonomy and the NM-model in detail concerning the SLM process is validated in chapter 6 in a case study on the outsourcing of the creation of the GemNet network.
5 Modelling the handling of network changes at RCC

5.1 Introduction

The models outlined in chapter 2 were shown to be insufficient to support NM, therefore, the NM-model was introduced in chapter 3. The NM-model is a theoretical model: it was developed without using practical situations, the NM-model therefore had to be tested empirically using a case study approach. An empirical descriptive case study is described in this chapter using the NM-model.

In chapter 4 the focus was on the research question that deals with changes caused by outsourcing of a network in practice. In this chapter the focus is on the research question that deals with the handling of particular changes in a specific situation in practice:

*How can management be supported when handling changes in the network and network services?*

This case study positions the NM-model in practice. The objective of this case study was to determine how the NM-model supports the handling of changes, based on experiences gained during a case study. The handling of changes involves the Change Management (CM) process (figure 5.1).
The support of the decision making especially with regard to changes was emphasised. To implement or not to implement? That is the question! Data must be obtained to assist managers to make well considered decisions and the consequences of a change should be able to be assessed on basis of this data.

Chapter 5 consists of the following sections:

- **5.2 Application of the NM-taxonomy to position the RCC network.**
  The real system of RCC, the network system at RCC, and the network management at RCC are described in this section using the NM-taxonomy given in chapter 3.

- **5.3 Change Management within RCC.**
  The situation present concerning Change Management at RCC is discussed in this section based on a definition of change, the different kind of change procedures that are distinguished at RCC, and problems that occur with change management in practice at RCC. This reflection is used to model the Change Management process in general and to relate the Change Management process to the NM-model.

- **5.4 Application of the NM-model to the handling of changes at RCC.**
  Change are analyzed on each layer using the NM-model. These changes do not have a mutual relationship in contrast to the changes that were caused by the outsourcing of the VROM network described in chapter 4. This application of the NM-model must show where the NM-model has to be detailed concerning the CM process.

- **5.5 Findings of application of the NM-model.**
  Application of the NM-model resulted in findings with regard to two different kinds of inferences, namely inferences that have implications for the NM-model and inferences that have implications for the situation found in practice at RCC.

- **5.6 The NM-model in detail with respect to handling changes.**
The NM-model is described in further detail and expanded in this section concerning the CM process, with a process description of the CM process, two categories of changes, and entities that are involved in the CM process together with their relationships.

* 5.7 The NM-taxonomy in detail with respect to handling changes. The CM process can be characterized by specific entities that extend the NM part of the NM-taxonomy.

* 5.8 Conclusions. This section contains the overall conclusions of this chapter.

5.2 Application of the NM-taxonomy to position the RCC network

The organization RCC is described in three parts, one the real system of RCC (section 5.2.1), two the network system at RCC (section 5.2.2), and three the network management at RCC (section 5.2.3).

5.2.1 The Real System of RCC

The Real System concerning the RCC organization is described in chapter 4 section 4.2.3.

5.2.2 The Network System at RCC

The Network System at RCC is described using the entities that are recognized in the NM-taxonomy in chapter 3. The following entities were recognized: the user, the preconditions, the requirements, the procedures, the network, and the network services.

Users
The goal of the RCC network is to support the primary business processes of RCC with communication facilities. These facilities enable the customers and employees of RCC to communicate via electronic mail, use services that are present at different locations, consult bulletin board systems and phone books, and to realize telephone links over the network.

Preconditions and requirements
Each customer of RCC has its own preconditions and requirements concerning the network and the services based upon that network. RCC negotiates with each customer which performance at what price is delivered. These agreements are formulated in contracts called Service Level Agreements (SLA).

Network
The RCC network consisted of four basic product lines in 1993: Newbridge, IBM, Cisco and Codex. The topology of the network was a mixed structure and it extended throughout the Netherlands (figure 5.3).
Network services
The following network services are offered for customers of RCC ([Jonkers93]):

- Transport services.
- Realize connections between networks.
- Value added network services.
- Network Management of LAN's and WAN's.
- Outsourcing of networks.
- Consultancy.

5.2.3 Network Management at RCC

Network Management (NM) at RCC is described using the entities that are recognized in the NM-taxonomy in chapter 3. The following entities were recognized: the NM goal, the processes/tasks, the procedures, the NM staff, and the NM tools.

Goal
The objectives of NM is to manage, control, and maintain the network and its network services in accordance with the requirements and preconditions imposed by utilization and the characteristics of the network components. The requirements and preconditions were in this case formulated by customers of the RCC network.

Processes/tasks
NM was performed as extension of the services offered via the mainframe. The mainframe supplier was IBM, and the IBM view on performing NM was used.

Procedures
No procedures specifically for NM had been formulated. due to the small scale of the
network, however, general procedures for tasks concerning the management, control and maintenance of the mainframe environment were used as far as it concerned the network.

**Staff**
The department RCC Network Services consisted of 28 persons in November 1993. These persons had the following functions see table 5.1.

<table>
<thead>
<tr>
<th>Function</th>
<th>Number of persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service manager</td>
<td>1</td>
</tr>
<tr>
<td>Location coordinator</td>
<td>2</td>
</tr>
<tr>
<td>Network advisor</td>
<td>4</td>
</tr>
<tr>
<td>Senior employee</td>
<td>7</td>
</tr>
<tr>
<td>Employee</td>
<td>10</td>
</tr>
<tr>
<td>Network Analyst</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 5.1 Functions at RCC

**Tools**
The management tools 'Netview', 'Newbridge 4602’ and 'Codex 9300' were used to support the NM. 'Netview' to support the NM of SNA data transport, 'Newbridge 4602' to support the NM of the backbone and 'Codex 9300' to support the NM of modems.

5.3 Change Management within RCC

NM involves ten important processes (chapter 3), one of these is Change Management. This is an extremely important process when considering the focus is on the evolution of (heterogeneous) networks. Customers often change their requirements due to the introduction of new applications and to new technological possibilities. Changes in customers requirements require that the network and the services based upon that network have to be changed.

Change management at RCC is discussed in this section based on a definition of change, the different kind of change procedures that are distinguished at RCC, and problems that occur with change management in practice at RCC. This reflection of the process Change Management at RCC is used to model the Change Management process and to relate the Change Management process to the NM-model.

5.3.1 Definition of change by RCC

A change is defined by the Exploitation department at RCC as change that concerns hardware and the installed system software on all mainframes, midrange systems, networks, and at the work places and changes within the infrastructure i.e. air-conditioning, electric, and water supply, that exert an influence on the exploitation
environment.

All changes that occur with the Exploitation department at RCC are distinguished by the object that is changed and the following objects are distinguished by RCC:

* System software e.g. operating systems.
* Hardware that is not part of the place of work.
* Software that is not installed at the place of work.
* Hardware and software that is present at the place of work.
* Datasets that are present at the place of work.
* Documentation which consists of a description of the procedures to maintain the services.
* Infrastructure, which includes air-conditioning, electric, and water supply.

### 5.3.2 Change procedures at RCC

Changes at the RCC department Exploitation are divided into four classes based on the degree of impact to the utilization of the change to IT services. Change procedures for each of these classes have been formulated, the procedures described how a change of a specific class must be implemented.

A division was made into the following four kinds of change procedures ([H85B02]):

* **Problem and change management exploitation** (standard change procedure). This procedure concerns changes that are not visible to or noticeable by internal and external customers, unless it concerns changes that are requested by customers. The risks of this kind of changes can be large, severe or very severe.
* **Minor change procedure.** This procedure concerns changes that are not visible to or noticed by internal and external customers, unless it concerns changes that are requested by customers. The risks of this kind of change are very small.
* **Procedure major changes.** This procedure concerns changes that directly concern the internal customer in a technical and/or financial manner.
* **Procedure change service delivery RCC,** in dutch: Wijziging Dienstverlening RCC (WDR). This procedure covers changes that concern external customers in a technical and/or financial manner.

An **Emergency Change (EC)** is also distinguished. An EC is a change that must be implemented immediately in response to a disturbance in the RCC network service.

### 5.3.3 Tool at RCC to support Change Management

Experiences with changes form the basis for decision making concerning future changes. A database must be kept up to date using a suitable tool and this should be at the disposal of the NM staff. Such a database is usually underestimated in practice ([Terplan89]). When such a database is not available, the NM staff must rely on their mutual experience. This is a risk if someone gets sick, resigns or cannot remember all the details of how a specific change was made the first time.

A database built using the tool 'Infoman', is used at RCC to document data concerning changes. The following data was documented:

* Unique number identifying a change.
* Name of the person or client who requested the change.
* Date concerning the change requested.
CHAPTER 5 THE HANDLNG OF CHANGES

- Initial priority, four categories, indicated by the numbers 1 up to 4, were recognized depending on the priority of the change.
- Description of the change.
- Object of change, the following objects were distinguished: system software, hardware, software, data sets, place of work, documentation, infrastructure.
- Object of change in more detail.
- Department that must implement the change.
- Present priority. After assessment three other priorities can be assigned, namely Major change (M), WDR change (W), and emergency change (E).
- Name of the person to be contacted about the progress of the change.
- Status of the change, the following status were distinguished: initial, opened, closed, or expired.
- Phase of the change, the following phases were distinguished: handling, waiting, hold, test, ready.
- Area of the change, the following areas were distinguished: development, test, acceptance, exploitation, other areas.
- Date of implementation.
- The outcome of the change: success, rejected, fault, partial, other.

This data was not consulted when deciding whether or not to implement a change. The reason for this lacking of consultation was the management tool 'Infoman'. It was impossible to get a complete overview of the data documented using the tool Infoman. Changes were documented after completion, which appeared to be the case from the lack of documented changes that were not successful or rejected.

5.3.4 Problems with Change Management at RCC

The change procedures at RCC were originally intended to assist the implementation of changes of objects that were part of the exploitation of the RCC computer centre. These objects included the network that was required mainly to distribute data from the mainframe to the places of work. New network components with different characteristics were introduced independent of the mainframe when the network was expanded. The objects of change that had been distinguished were not differentiated enough for changes concerning the network and its network services.

The standard problem and change procedure and the emergency change were used for almost all problems and changes, thus the four categories of change procedures could not be said to work in practice. The two procedures given above were used in stead of the other procedures because it was easier to gain permission for a change. It also took less time between the request and the implementation of the change using the standard and emergency change procedures in contrast to the other two change procedures categories. The NM staff lacked familiarity with the change procedures, and this led to misunderstandings.

A final but important problem concerned the management tool 'Infoman' used to support the Change Management process. This tool was found to be unsuitable, due to a lack of user friendliness, specialized knowledge was required to use the tool. It was

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1 768 changes were registered in the tool INFO during the period 1 January 1993 to 9 September 1994. Only three of these 768 changes were major changes and no WDR-change were made.
impossible to get an overview of the documented data when data was registered in the database using 'Infoman', and this led to undetected faults in the management database. This in turn resulted in a lack of motivation on behalf of the NM staff to use the management tool. Changes were documented after completion, which was shown by the lack of documented changes that were not successful or rejected.

An overview of actual and realized changes can be abstracted from documented data, however, a manager cannot make a decision concerning a change based on only this data, therefore, other data must be documented for realized changes. This data should describe:
- Impact in relation to the kind of maintenance: corrective, preventive, perfective, additive, and adaptive maintenance (see also section 5.6.3).
- Consequences/influences foreseen and unforeseen.
- Deviation from the planning of the dedication of resources.
- Realized costs with regard to investments as well as efforts of the NM staff.
- Reasons why changes were rejected and not realized successfully.

5.4 Application of the NM-model to the handling of changes at RCC

Changes will occur at each layer of the NM-model. The NM-model consists of five layers, therefore, five classes of changes spring from the application of the NM-model. Different objects, that are part of the Network System (NWS) will be changed on each layer.

A change is analyzed on each layer using the NM-model given in this section. These changes do not have a mutual relationship in contrast to the changes that were caused by the outsourcing of the VROM network described in chapter 4.

5.4.1 Changes to a product line (layer 1)

Layer 1 of the NM-model is related to changes of a specific product line. The operation goal of layer 1 is to coordinate the quality, costs and functionality of the product line, and this results in changes in the components of a product line. The following changes can occur in layer 1:
- Tuning of a component.
- Removal of a component.
- Addition of a new type of component.

The addition of a new type of component, namely the introduction of Codex Multimedia Periphery (MP) 6520 routers is an example of a change on layer 1 that occurred at RCC. The impact on functionality, costs and the quality of the product line must be determined when such a change is implemented.

The functionality of the Codex MP routers is primarily a X.25 and Frame Relay switch and secondarily performing a routing function.

These components were selected on a basis of the low costs per possible connection and the possibility for modular construction.

MP routers are not constructed to carry a high load, however, price in proportion to performance is well balanced. The MP routers were therefore applied in the access network where the load is not as high as it is in the backbone.
5.4.2 Changes to a heterogeneous network (layer 2)

Layer 2 of the NM-model concerns changes of the heterogeneous network. The operation goal of layer 2 is to coordinate quality, costs and functionality of a heterogeneous network. Coordination of quality, costs and functionality results in changes to the heterogeneous network. The following changes can occur in layer 2:

- Addition or removal of a product line.
- Tuning of product lines.
- Change the control body at layer 1 (goal, processes, procedures, staff, tools).
- Initiate changes (disturbances) at layer 1.

An example of a change on layer 2 that occurred at RCC was the addition of a completely new product line Newbridge. The impact on functionality, costs and the quality of the heterogeneous network must be known when such a change is implemented. This product line was introduced because of its unique functionality and its performance.

Newbridge network components have an additional functionality called Time Division Multiplexing (TDM), which means that a 2 Mbps connection can be divided into thirty-two 64 kbps connections or even more connections at a speed of less than 64 kbps. The application of these multiplexers enables simultaneous use of the fast 2 Mbps connection. Several customers can be served and communicate at the same moment over a single connection using this technique.

This product line is also characterized by how it prevents and handles disturbances; its favourable Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR), and its logical paths that can be protected against the influences of network disturbances.

The costs of the components of the Newbridge product line were high, therefore these components were only applied for frequently used and constantly occupied connections.

5.4.3 Changes to a network service (layer 3)

Layer 3 of the NM-model concerns changes in a specific network service. The operation goal of layer 3 is to coordinate the quality, costs and functionality of a network service. The coordination of the network service must comply with quality aspects, costs, and functionality aspects that are formulated on layer 4. The coordination of quality, costs and functionality results in changes that concern network services. The following changes can occur on layer 3:

- Addition or removal of a network service.
- Initiate changes (disturbances) at layer 1.
- Initiate changes (disturbances) at layer 2.

An example of a change on layer 3 that occurred at RCC was the introduction of new network services like electronic mail facilities based on X.400, and internet access. The impact on functionality, costs and the quality of the network service must be known when such a change is implemented. These network services introduce new functionality for the users of the RCC network.

The quality and costs of the utilization of these network services depends on the
network that is used to offer these services, however, the applications that are used to offer the required functionality must comply to a minimum quality.

5.4.4 Changes to the heterogeneous network and the network services (layer 4)

Layer 4 of the NM-model concerns changes in the heterogeneous network and the network services as a whole. The operation goal of layer 4 is to coordinate the quality, costs and functionality of the network and the network services. This coordination has two goals. The first is the tuning of the network and the network services to each other. The second is to conform to the requirements of the users. Users of the network services formulate their requirements concerning quality, costs and functionality in contracts and coordinating this will lead to changes in the heterogeneous network and the network services. The following changes can occur on layer 4:

- Tuning of the network and the services.
- Change the control body at layer 2 (goal, processes, procedures, staff, tools).
- Change the control body at layer 3 (goal, processes, procedures, staff, tools).
- Initiate changes (disturbances) at layer 1.
- Initiate changes (disturbances) at layer 2.
- Initiate changes (disturbances) at layer 3.

An example of a change on layer 4 that occurred at RCC was the upgrade of the capacity of the connections due to an increasing use of the network caused by newly offered network services (e.g. the introduction of the network service World Wide Web (WWW) to "surf" on the Internet). The impact on functionality, costs and the quality of the integrated network and the network services must be known when such a change is implemented.

This change was implemented to offer the required functionality for the network services at an acceptable level of performance. The costs of such an upgrade are invoice to the users of the network services that cause high loading on the network. An example of such a network service at RCC was the internet access which caused an high loading on the network. Intensive use of a network service like internet results in adaptions to the heterogeneous network.

This change initiated changes at layer 2, where the connections had to be upgrade to realize higher capacity to produce a suitable performance from the network services in combination with the heterogeneous network.

5.4.5 Changes to the strategy and objectives (layer 5)

Layer 5 of the NM-model concerns changes in the strategy and objectives. The operation goal of layer 5 is to coordinate quality, costs and functionality of the network services in relation to network services of other service providers. The heterogeneous network and the services based upon it, serve to realize or to support a business goal. This business goal must be formulated in objectives and a strategy concerning the network and its operation. A network can be used to realize predefined turnovers and profits, therefore supply and demand must be considered. Coordination of quality, costs and functionality results in changes concerning strategy and objectives with regard to a network and the services based upon that network. The following changes can occur on layer 5:
Tune the objectives and strategy according to market insight.
* Change the control body at layer 4 (goal, processes, procedures, staff, tools).
* Initiate changes (disturbances) at layer 1.
* Initiate changes (disturbances) at layer 2.
* Initiate changes (disturbances) at layer 3.
* Initiate changes (disturbances) at layer 4.

An example of a change on layer 5 that occurred at RCC was the tuning of the objectives and strategy concerning Local Area Network (LAN) services. The value added functionality of the RCC network in the form of the LAN services were placed outside the department RCC Network Services, because a daughter company of RCC, Pink Elephant, provided such services. The impact on the functionality, the costs and the quality of the integrated network and the network services must be known when such a change is implemented.

This change to restrict the network services to the Wide Area Network (WAN) had to lead to a cost effective result without losing functionality and the quality of the network services. This cost effective result improved the position of RCC and its daughter organization Pink Elephant in the market of network services.

This change at layer 5 initiated changes at all lower layers, namely all activities concerning LAN services were stopped.

5.5 Findings of application of the NM-model

Application of the NM-model resulted in findings with regard to two different kinds of inferences, namely inferences that have implications for the NM-model and inferences that have implications for the situation found in practice at RCC.

5.5.1 Inferences drawn from the application of the NM-model

The NM-model distinguishes five layers where changes can be implemented. These changes are a result of disturbances or control measures that can be found in the NM-model. The NM-model was only described in broad outlines in chapter 3, therefore, there was no focus on specific processes, such as the Change Management process that can be used to coordinate and implement a specific change. No way of handling of disturbances and control measures was given in chapter 3, it was only stated that quality, functionality and costs of the controlled system must be coordinated.

The NM-model was found to be incomplete. A shortcoming of the NM-model was that it lacked an overall process description to handle changes.

In chapter 3 only changes concerning the controlled system were considered, though it is also possible that the control body is changed.

5.5.2 Implications for the NM-model

The goal of this case study was to support managers to decide whether or not to implement a change. Three aspects were considered using the NM-model: quality, costs and functionality of the controlled system, which is the Network System (NWS). The way of handling the disturbances and control measures must be worked out in detail, therefore the NM-model is outlined in detail in section 5.6.
The change management process is of importance when coping with evolution, this process is therefore described in the next section by formulating the way of handling changes in a process description. Determining the impact of changes is very important in this process and this is dependent on experience that has to be gained with previous changes. Different kinds of changes based on the implications for NM are distinguished in this process.

### 5.5.3 Inferences drawn from the handling of changes at RCC according to the NM-model approach

The objects of change recognized in the change management procedures at the Exploitation department at RCC were found to be unsuitable to depict changes concerning a network and its services.

The existing change procedures were confusing for the staff that had to use these procedures. Most members of the staff were unfamiliar with the existing procedures, and if they knew the procedures they were not clear about how to use them.

The WDR change procedure mainly concerns changes on layer 4 of the NM-model. The other three change procedures do not focus specifically on one of the layers of the NM-model.

### 5.5.4 Implications for the RCC organization

The following actions were recommended or had already been signalled and started:

- **Conformation to ITIL**: one change management process, or to introduce a procedure per layer to handle the specific changes, which is a deviation from ITIL. The management of RCC has chosen to conform to ITIL, so only one procedure for change management was introduced. Impact and resource assessment were also implemented with the conformation to the change management process according to ITIL.

- **Training/education of the NM staff** with regard to the new Change Management process.

- **Introduction of an adequate management system** for the handling of changes. Implementation of these actions was started in April 1996 in the department RCC Network Services (RNS).

### 5.6 The NM-model in detail with respect to handling changes

The NM-model was introduced in chapter 3 to structure NM, where it was used to model NM on outlines. The processes needed for NM were coupled to the layers of the NM-model but these processes were not specified. In this section the NM-model is considered in detail concerning the Change Management (CM) process. The focus on the CM process is explained in section 5.6.1. The CM process is described in section 5.6.2.

#### 5.6.1 Focus on the Change Management process

Networks and network services are changing rapidly due to the new possibilities provided by technological advances and due to the more demanding requirements of
users. Changes to a network and network services must be administered and implemented without disturbing service levels, and when this is not possible the inconvenience to the user of the network services should be kept to a minimum.

The quantity of changes is large, which makes it difficult to oversee all the changes that are performed in the network and the network services. In general it is not possible to keep up with all the changes, especially for the senior management of a company, yet senior management must decide whether or not a change should be implemented. This implies that a standard form of handling of changes is necessary together with a management information database that contains information about changes that have been implemented in the past.

The process should be supported by a change management system because without a comprehensive change management system, network services, and the business that depends upon them, are at risk [ITIL90].

5.6.2 Change Management process description

The Change Management process consist of the following activities:
* Filter and record RFC. The Requests For Change (RFC) are filtered and the remaining changes are recorded with an initial priority.
* Rejection. Changes that are considered in advance to be impracticable and unfeasible are rejected.
* Inform of rejection. The person who requested the change is told why the change was rejected.
* Assess. The urgency, impact and priority of a change must be determined and registered. If the change is urgent no registration is made during planning, developing, acceptance, and implementation of the change; registration is performed when the change has been implemented successfully. In this activity the changes are divided into categories, depending on the layer concerned, and the object that is being changed (see section 5.6.3).
* Rejection. A change is rejected when it is decided not to develop and implement the change. The person who requested the change is informed why the change was rejected.
* Plan and develop. The change is scheduled and the resources needed to build the change are determined. The change is developed according to the formulated schedule.
* Working. The change developed is tested for possible errors.
* Implement. The change is implemented on basis of the schedule formulated.
* Acceptance.
* Evaluate. The change is reviewed after an elapsed time that can vary in accordance with the kind of change.

These process activities are illustrated in figure 5.4.
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BEGIN
Filter and record RFC negotiations

Yes

Rejection

No

Inform of rejection

Assess

Yes

Rejection

No

Plan and Develop

Working

No

Accept and implement

Yes

Acceptance

No

Yes

Evaluate

END

Figure 5.4 Change Management process
The ITIL module Change Management distinguishes some more activities in the CM process. In broad outlines the process and its activities described are similar to the ITIL process description only the accent is placed on other aspects. The ITIL process description tries to be as complete as possible in one process diagram, which decreases the readability of the diagram, therefore, some activities are grouped resulting in the process diagram given in figure 5.4.

The CM process is validated in chapter 7 using two case studies at the Getronics organization and at the Robeco Group.

5.7 The NM-taxonomy in detail with respect to the handling of changes

The NM-taxonomy is considered in detail concerning the CM process by a division of changes into two categories and by the entities that play a role in the CM process.

5.7.1 Division of changes

NM is divided into five parts according to the layers of the NM-model. On each of these layers changes have to be implemented, so five kinds of changes can be distinguished. Besides these five kinds of changes another division can be distinguished: changes to the control body and changes to the controlled body.

This division is further described in [Looijen95] and [Looijen93]. A distinction is made between two kinds of changes: M1 and M2 changes. This distinction is based on the kind of maintenance, the consequences for requirements, characteristics and preconditions, decision-making, and the consequences for utilization and exploitation.

Kind of maintenance

[Looijen95] distinguishes five kinds of maintenance based on their specific characteristics (table 5.1).

<table>
<thead>
<tr>
<th>Kind of maintenance</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>corrective maintenance</td>
<td>repairing faults/errors</td>
</tr>
<tr>
<td>preventive maintenance</td>
<td>preventing faults/errors</td>
</tr>
<tr>
<td>perfective maintenance</td>
<td>improving performance</td>
</tr>
<tr>
<td>adaptive maintenance</td>
<td>adaptations due to alterations (changing environment)</td>
</tr>
<tr>
<td>additive maintenance</td>
<td>additions due to more demanding or extra requirements of users</td>
</tr>
</tbody>
</table>

Table 5.1 Kinds of maintenance and their characteristics

In this research perfective maintenance is differentiated to make a distinction between M1 and M2 changes. This perfective maintenance is differentiated into perfective maintenance (1), which stands for improving performance utilizing present devices, and perfective maintenance (2), which stands for improving performance using new
devices. The distinction between M1 and M2 changes can be defined on basis of the kind of maintenance: M1 changes are carried out using corrective, preventive and perfective (1) maintenance, and M2 changes are carried out using perfective (2), adaptive and additive maintenance.

Requirements, preconditions and characteristics
M1 changes are performed as a result of shortcomings in the functionality of the network. These shortcomings should have been detected when the network was accepted and implemented. M1 changes are necessary to fulfil the unchanged requirements of users without altering the characteristics of the network components.

M2 changes alter the network and are due to additional requirements and/or a changing environment. When at least one of the three aspects requirements, preconditions or characteristics alter it is called a M2 change.

Decision-making
M1 changes have to be altered directly in connection with support of the network service to cope with the requirements in the service level agreements. No decision is required at management level before altering a M1 change, an operational level decision can be made to realize the M1 change.

M2 changes have an impact on the exploitation and/or the utilization of the network, therefore, a decision at tactical or strategic level must be taken.

Consequences for utilization and exploitation
The state utilization and the state exploitation will not be, or will be hardly, altered as a result of an M1 change. An M2 change, however, will alter either the state utilization or the state exploitation or both states. At least one of these states is altered with regard to organization or tasks that must be performed in this specific state (figure 5.5).

![Diagram of the extended state model](image-url)

Figure 5.5 The extended state model


**NM-model**

This division into M1 and M2 changes can also be explained using the NM-model: with an M1 change none of the control bodies in the NM-model is changed, in contrast to M2 changes where at least one of the control bodies is changed.
5.7.2 Entities in the Change Management process

The CM process can be characterized by specific entities: Change Management, change manager, influence, request for change, resource, planning, kind of maintenance, change (M1, M2), NM staff, NM task, NM process, NM procedure, NM tool, and contract (NM goal).

Some of the relationships between these entities are: someone who submits a request for change is triggered by a particular influence. If the request for change is accepted the type of change (M1 or M2) is determined on basis of the type of maintenance that is needed to perform the change. The change is implemented by the NM staff using a plan determined in advance. Tasks that have to be performed and the resources to be used by the NM staff are predefined. NM staff perform the tasks and use NM tools and NM procedures to implement the change (figure 5.6).

Figure 5.6 Entities in the Change Management process
These entities are related to the activities in the process description like mentioned in table 5.2.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Entities related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter and record RFC</td>
<td>Influence</td>
</tr>
<tr>
<td></td>
<td>Request for change</td>
</tr>
<tr>
<td></td>
<td>Change Management</td>
</tr>
<tr>
<td></td>
<td>Change manager</td>
</tr>
<tr>
<td>Rejection</td>
<td>Request for change</td>
</tr>
<tr>
<td></td>
<td>Change Management</td>
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<tr>
<td></td>
<td>Change manager</td>
</tr>
<tr>
<td>Inform of rejection</td>
<td>Request for change</td>
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<td></td>
<td>Change Management</td>
</tr>
<tr>
<td></td>
<td>Change manager</td>
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<tr>
<td>Assess</td>
<td>Change</td>
</tr>
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<td></td>
<td>Change Management</td>
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<td>Change manager</td>
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<td></td>
<td>Kind of maintenance</td>
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<tr>
<td></td>
<td>M1/M2 change</td>
</tr>
<tr>
<td>Rejection</td>
<td>Change</td>
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<tr>
<td></td>
<td>Change Management</td>
</tr>
<tr>
<td></td>
<td>Change manager</td>
</tr>
<tr>
<td>Plan and develop</td>
<td>Change</td>
</tr>
<tr>
<td></td>
<td>Change Management</td>
</tr>
<tr>
<td></td>
<td>Change manager</td>
</tr>
<tr>
<td></td>
<td>Resources</td>
</tr>
<tr>
<td></td>
<td>Planning</td>
</tr>
<tr>
<td>Working</td>
<td>Change</td>
</tr>
<tr>
<td></td>
<td>Change Management</td>
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<td></td>
<td>Change manager</td>
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<tr>
<td></td>
<td>Resources</td>
</tr>
<tr>
<td></td>
<td>Planning</td>
</tr>
<tr>
<td>Implement</td>
<td>Change</td>
</tr>
<tr>
<td></td>
<td>Change Management</td>
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<tr>
<td></td>
<td>Change manager</td>
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<tr>
<td></td>
<td>Resources</td>
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<tr>
<td></td>
<td>Planning</td>
</tr>
<tr>
<td>Acceptance</td>
<td>Change</td>
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<td></td>
<td>Change Management</td>
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<td></td>
<td>Change manager</td>
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<tr>
<td>Evaluate</td>
<td>Change</td>
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<td></td>
<td>Change Management</td>
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<td></td>
<td>Change manager</td>
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<tr>
<td></td>
<td>Resources</td>
</tr>
<tr>
<td></td>
<td>Planning</td>
</tr>
</tbody>
</table>

Table 5.2 Activities related to the entities in the CM process
5.8 Conclusions

The NM-model is founded on a theoretical model: the operation paradigm. The NM-model was applied in practice at RCC Network Services (RNS), a network service provider in the Netherlands. This application is described in this chapter. The focus was on the Change Management (CM) process based on the following research question:

*How can management be supported when handling changes in the network and network services?*

The CM process was evaluated at RNS, where some problems were observed. These problems could be solved using the NM-model, however, the NM-model was found to be incomplete. A shortcoming of the NM-model was that it lacked an overall process description to handle changes (section 5.5.1).

The NM-model was therefore considered in detail in this chapter to describe the handling of changes in a network system on all five layers of the NM-model. The NM-model was expanded with a process description of the CM process, based on the experiences gained at RNS, to handle all kind of changes.

Several activities were recognized in the process description (section 5.6.2). The most important activity of the CM process was considered to be the determination of the impact of a change. The impact of a change can be determined using the NM-model. The impact of a change has to be determined at all five layers of the NM-model. The consequences of the change have to be considered for each layer with regard to quality, functionality and costs.

The NM-taxonomy recognized the entities that play a role in the CM process. These entities are connected to the activities in the process description. Changes were divided into two kinds of changes: M1 and M2 changes. M1 changes influence the controlled system and M2 changes influence the controlled system and the control body.

The NM-taxonomy considered in detail can be used by management to compare different situations concerning Change Management based on the entities recognized. Shortcomings of the situation present concerning Change Management can also be found by going through the added entities, which can be used as a checklist.

The expansion makes the NM-model useful for management by a process description of the activities in the CM process. The activities are related to the kind of information that is required to make decisions whether or not the implement a change. The standard handling of changes based on the NM-model and a suitable management tool should deliver enough suitable information for managers to decide whether or not to implement a change.

The NM-taxonomy and the NM-model considered in detail with regard to the CM process are validated in chapter 7 with respect to the handling of changes in two more organizations, namely Getronics Network Services and the Robeco Group.
6 Validation of the NM-model on the outsourcing of GemNet

6.1 Introduction

Network Management (NM) was modelled in chapter 3 using an NM-taxonomy to describe unequivocally NM and its environment, and using the NM-model NM was divided into five layers. Each of these layers has its own area of application with specific characteristics.

The NM-model was considered in detail with regard to the evolution of heterogeneous networks in chapters 4 and 5. The focus of chapter 4 was on the outsourcing of the VROM network, where the Service Level Management (SLM) process was of huge importance. SLM is required to control the agreements between service provider and customer concerning performance, functionality, and costs of the network and its services. The focus of chapter 5 was on the handling of changes at RCC, where the Change Management (CM) process was considered.

The focus of chapter 6 is on the research question that deals with the validation of the NM-model as considered in detail with regard to the SLM process. This research question is:

*Are the models developed applicable in general to other situations outside the research environment?*

In this chapter a real-life situation is considered at the GemNet organization. The GemNet organization decided to outsource its network and this had to be build from scratch.

The focus of this case study was therefore on the validation of the NM-model with regard to the SLM process (figure 6.1). The validation was performed to check the practicability, correctness, and completeness of the NM-model.
Chapter 6 consists of the following sections:

- **6.2 Application of the NM-taxonomy to position the GemNet network.**
  The NM-taxonomy described in chapter 3 is applied in this section to describe the real system of the organization GemNet, the network system of the GemNet network and the NM of that network.

- **6.3 Application of the NM-model to the creation of the GemNet network.**
  The NM-model was applied to the outsourcing of the creation of the GemNet network and its NM. This application was executed to determine if the NM-model was practical, correct, and complete.

- **6.4 Application of the NM-model and the NM-taxonomy to Service Level Management at RCC.**
  Service Level Management at RCC is discussed in this section on the basis of SLM activities, the division of contracts, and the entities in the SLM process.

- **6.5 Findings of the application.**
  The findings of the application of the NM-taxonomy and the validation of the NM-model are described in this section.

### 6.2 Application of the NM-taxonomy to position the GemNet network

The NM-taxonomy described in chapter 3 is applied in this section to describe the real system of the organization GemNet, the network system of the GemNet network and the NM of GemNet. The application of the NM-taxonomy must validate the practicability, correctness, and completeness of the NM-taxonomy.

#### 6.2.1 The Real System of the GemNet organization

The Real System concerning the GemNet organization is described using the entities recognized in the NM-taxonomy in chapter 3. The following entities were recognized: style, structure, staff, system, skill, goal/strategy, culture.
An impression of the GemNet organization is given by describing its goal/strategy and its staff. The entities style, structure, system, skill and culture could not be described at this stage due to the development of the new GemNet organization.

**Goal/strategy**
The Association of Dutch Municipalities\(^1\), and the Dutch Bank Municipalities Inc.\(^2\), agreed to organize a joint project under the name Collective Network, in Dutch: Gemeenschapelijk Netwerk, abbreviated to GemNet.

The goals of the GemNet organization are to:
- Provide effective communication between municipalities and service providers.
- Provide network services that fail to future requirements such that no investments are lost.
- Realize dedication to the core business for employees of municipalities.
- Provide a single service window to increase the accessibility of network services.
- Decrease and control costs.
- Standardize data communication to avoid uncontrolled growth (figure 6.2a).

![Diagram showing communication between municipalities and service providers.](image)

**Figure 6.2a** Specter concerning the communication between municipalities.

To realize these goals it was necessary to create a network for data communication between the municipalities and the service suppliers that offer network services on the network (figure 6.2b).

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\(^1\) The Association of Dutch Municipalities is in Dutch: Vereniging van Nederlandse Gemeenten (VNG). The VNG is an independent organization of local authorities. All 636 municipalities in the Netherlands are voluntary members of the VNG. The VNG has various functions: looking after and protecting the interests of its members with regard to government, parliament and government departments. The VNG also offers its members an extensive package of services.

\(^2\) The Dutch Bank Municipalities Inc. is in Dutch: nv Bank Nederlandse Gemeenten (BNG). The BNG is a specialized bank providing an optimal financial service to local, regional and functional governments and related agencies in the sectors of housing, public health, welfare, culture, education and recreation. The BNG is a leader in this specialized part of the financial market. The main points of interest are credit grants and payment handling.
**Staff**
The staff of the GemNet organization consisted of 10 persons in November 1995. These persons were primarily responsible for the sales of the services. The operation of the network was not performed by the GemNet staff, and was outsourced to a service supplier that could deliver the required network services. The GemNet staff consisted of the functions given in Table 6.1.

<table>
<thead>
<tr>
<th>Function</th>
<th>Number of persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>1</td>
</tr>
<tr>
<td>Deputy manager</td>
<td>1</td>
</tr>
<tr>
<td>Secretary</td>
<td>1</td>
</tr>
<tr>
<td>User support</td>
<td>2</td>
</tr>
<tr>
<td>Administrative support</td>
<td>1</td>
</tr>
<tr>
<td>Account manager</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 6.1 Functions at the GemNet organization

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### 6.2.2 The Network System concerning the GemNet network

The Network System of the GemNet network is described using the entities recognized in the NM-taxonomy in Chapter 3. The following entities were recognized: the user, the preconditions, the requirements, the procedure, the network, and the network services.

### Users

The GemNet network and its services are used by employees of the Dutch municipalities, the VNG, the BNG, and BNG associates. These users formulated their requirements for the network and the network services. The management of the user population formulated some preconditions.
Preconditions concerning the network services
The following preconditions were formulated:

* **Centralization.** All activities for the design of the GemNet network and its NM must be centralized, under the responsibility of the service supplier selected for the outsourcing of the design and the NM.

* **Cost.** The cost and the complexity of the connectivity and interoperability between municipalities and service providers and between municipalities must be reduced by the GemNet network.

* **Standardization.** The GemNet network must connect to the most important hardware and software used by the Dutch municipalities. The GemNet network must also connect to the infrastructures of VNG, BNG, and service suppliers. The network service electronic mail must be based on the CCITT standard X.400, and directory services must be based on the CCITT standard X.500. The transport services must be based on the protocols X.25 and TCP/IP.

* **Flexibility.** The GemNet network must anticipate future requirements. The GemNet organization must be able to anticipate technical, organizational, and managerial influences. The data transport must be transparent; this means that the network should not impose constraints on the data to be transported.

* **Security.** The GemNet network will be used to transmit highly sensitive data. The risks of eavesdropping, unauthorized changes, and simulation of the traffic over the GemNet network must be minimized by effective security measurements. BNG uses smartcards to identify authorized users. At first this kind of identification will be used only for BNG applications. The smartcards will be used to secure access to the network and to encrypt data transport for other services.

The GemNet network must be accessible for each service supplier, under conditions determined by the steering committee of the GemNet organization.

Requirements concerning the network
The GemNet organization formulated the following requirements for the network concerning:

* **Capacity.** The capacity of the network is described by the data traffic expressed in Mbytes. The data traffic was expected to be circa 139,000 Mbytes for 1995, with an annual growth of circa 20,000 Mbytes.

* **Possibilities to expand.** The number of connections and the volume of the data traffic will increase in the period up to the year 2000, therefore, suitable hardware and software must be used to anticipate the enormous growth.

* **Availability.** Availability of the transport services must be at least 99.5%, 24 hours per day, seven days a week.

* **Performance.** Performance is expressed and tested in terms of network delay times with terminal data traffic and in terms of other data traffic:
  a) Terminal data traffic with less than or equal to five characters per packet or frame. Per active terminal an average of three packets per second must be transmitted. The delay allowed for interactive terminal traffic is 300 msec.
  b) Terminal data traffic with more than five characters per packet or frame. Per active terminal an average of five blocks of 1000 characters per second must be transmitted. The transmission of a block of 1000 characters may
have a maximum duration of four seconds for users with a 9.6 Kbps access
to the network, at a maximum of two seconds for users with 19.2 Kbps and
a maximum of one second for users with a connection speed of 48 Kbps
access.
c) Other data traffic, for this data traffic a transmission per entry of at least
90% of the capacity of the connection, decreased by the load caused by
group a) and group b) is required.

★ Reliability. The maximum allowed Bit Error Rate (BER) is one error on a billion
bits. The BER is measured on the traffic between two arbitrarily connections in
the network.
The meantime between failures (MTBF) must be at least 200 days.

★ Invoice. Information is necessary to invoice for utilization of the GemNet
network and to charge network users for their usage. This information is required
on a monthly basis.

★ Friendliness of utilization. User friendliness is extremely important to the
GemNet organization. The network has to be transparent for users. The user
interface must increase network recognition of the GemNet network by the user.
This means:
 * One simple procedure to log in.
 * One user name for all network services.
 * A level of security that is not higher than required (as few passwords as
   possible).
 * Tools to find a service supplier (navigation services).
 * Interface and documentation in the dutch language.
 * Online help functions.
 * Use of colour.

★ Flexibility. The user interface must be modified in a simple way for new services
and new classes of services.

Flexibility is also required to facilitate the expected growth of the GemNet
network. An estimation for the growth of the GemNet network is given in the
table below.

<table>
<thead>
<tr>
<th>point of time</th>
<th>number of connected municipalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 june 1994</td>
<td>0</td>
</tr>
<tr>
<td>1 january 1995</td>
<td>100</td>
</tr>
<tr>
<td>1 june 1995</td>
<td>300</td>
</tr>
<tr>
<td>31 december 1995</td>
<td>600</td>
</tr>
</tbody>
</table>

Table 6.2 Estimated growth for the GemNet network

Network
The GemNet network had not been created at the time of this research, so the network
did not exist, only preconditions and requirements had been formulated by the GemNet
organization for the network and its services.
Network services
The network is intended to offer network services that are characterized by a certain functionality. The following functionality is required:

- Exchange of notes and letters between users (electronic mail).
- Support of meetings at different locations using the network (conferencing).
- Amass information, like news, messages and reports, at a central point that is available to all users (bulletin board systems).
- Guidance of users when they search for certain information and services (navigation service).
- Exchange of files between users of the GemNet network and service suppliers. This exchange of data must be realized by the applications FTAM and FTP (file transfer).
- Access to other networks like DataNet1 (the national X.25 network), Internet and mobile networks (gateway-services).

6.2.3 Network Management for GemNet

The GemNet network had to be built from the scratch, so the NM had to be organized. The GemNet organization formulated some requirements for the NM of GemNet that had to be realized by a service supplier like the RCC organization.

Requirements to NM formulated by the GemNet organization
Requirements concerning the organization of the NM of the GemNet network were formulated. These requirements involve the NM goal, the NM processes, and the NM tasks for installation and maintenance:

- **NM goal.** The NM goal included the management, control, and maintenance of GemNet in accordance with the requirements and preconditions imposed by utilization and the characteristics of the network components. These requirements and preconditions were given in the previous section.

- **NM processes.** The GemNet organization distinguished five NM processes, based on the OSI network management model: configuration management, performance management, fault management, security management, and accounting management. Outlines describing how these processes should be organized were drawn up for each of these NM processes. Requirements concerning these NM-processes were formulated, e.g. with regard to the process fault management: the maximum time to react to a problem and a maximum time in which to solve a problem. These maximum times to react to and solve a problem depend on the urgency of the problem.

  A help desk had to be organized for the GemNet network and the services based upon the network; education and documentation must also be provided by the service provider designated to realize the GemNet network.

- **NM tasks.** The service supplier had to describe how present services would be integrated with the required services. The requirements concerning maintenance were linked with the way the network was realized and the way the NM was realized. The GemNet organization limited maintenance to preventive and corrective maintenance.

The entities procedure, staff and tool were not specified by the GemNet organization.
The service supplier had to organize these entities to reach the formulated goals that were based on the requirements and preconditions.

6.3 Application of the NM-model to the creation of the GemNet network

The NM-model was applied to the outsourcing of the creation of the GemNet network and its NM. This application was executed to determine if the NM-model was practical, correct, and complete (covers all relevant elements).

The decision to outsource the creation of the GemNet network and its NM initiated changes at layer 5 of the NM-model. These changes had consequences for all lower levels of the NM-model that describes the NM at RCC: changes in user population and their specific requirements were initiated at layer 4; changes in the network services were initiated at layer 3; changes in the overall coordination of the product lines were initiated at layer 2; changes in the coordination of a product line were initiated at layer 1. These consequences of the outsourcing are discussed in the following four sections.

The control measures for the outsourcing of the GemNet network were based on the steps of the four phases for the outsourcing of a network and its NM as formulated in chapter 4. These four phases are (figure 6.4):

- Phase 1: Change of strategy by the customer.
- Phase 2: Shift of responsibilities for the network and the organization of NM.
- Phase 3a: Technical integration of the network.
- Phase 3b: Organizational integration of the NM organizations.
- Phase 4: Exploitation of NM.
Figuur 6.4 Phases in outsourcing of the creation of the GemNet network and its NM; the rectangles model companies, and the ellipses model the networks that are managed, controlled and maintained by the companies.
Each of these four phases was divided into steps as described in chapter 4. The steps of each phase are related to the layers of the NM-model and applied in this section as control measures.

<table>
<thead>
<tr>
<th>Step</th>
<th>NM Layer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Change in customer strategy</td>
<td></td>
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<tr>
<td>1.2 Describe the present network services</td>
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<tr>
<td>1.3 Define the network services required</td>
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<tr>
<td>1.4 Explore the market</td>
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<tr>
<td>1.5 Formulation of offer</td>
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<td></td>
<td>*</td>
</tr>
<tr>
<td>2.1 Initial consultation</td>
<td></td>
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<td>*</td>
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<tr>
<td>2.2 Commitment</td>
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<tr>
<td>2.3 Research</td>
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<tr>
<td>2.4 Contract negotiation</td>
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<tr>
<td>2.5 Agreement takeover</td>
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<tr>
<td>3a.1 Formulation of a plan of approach</td>
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<tr>
<td>3a.2 Adapting the topology</td>
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<tr>
<td>3a.3 Adapting the network components</td>
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<tr>
<td>3a.4 Adapting the NM-tools</td>
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<tr>
<td>3b.1 Distribution of tasks and functions</td>
<td></td>
<td>*</td>
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<td>*</td>
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<td>*</td>
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<tr>
<td>3b.2 Revision of conditions of employment</td>
<td></td>
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<td>*</td>
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<tr>
<td>3b.3 Retraining of personnel</td>
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<tr>
<td>3b.4 Reorganization of the NM organization</td>
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<td>*</td>
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<tr>
<td>4.1 Exploitation</td>
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<tr>
<td>4.2 Total evaluation of the outsourcing</td>
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<td>*</td>
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</tbody>
</table>

Table 6.3 Layers of the NM-model related to the steps for outsourcing

6.3.1 Disturbance at layer 5: operation of objectives and strategy concerning Network Management

Disturbance
A decision was made by the GemNet organization to develop and provide a network for communication between the Dutch municipalities and service providers. The intention of this network was to realize:

- Effective communication between municipalities and service providers.
- Avoid future investment that make the network services inflexible.
- Dedication to core business for employees of municipalities.
★ One service window to increase the accessibility of network services.
★ Decrease and control of costs.
★ Standardization of data communication to avoid uncontrolled growth.

The GemNet organization decided to outsource the creation of the network and its NM. The outsourcing of a network and its NM is a managerial disturbance ([Looijen95]).

Observations
The market was researched by the staff of the GemNet organization for potential service providers that were able to supply network services with the required quality, cost and functionality.

Control measures
The following steps must be performed at layer 5 according to table 6.3:
★ Step 1.1 Change in customer strategy.
★ Step 1.4 Explore the market.
★ Step 2.1 Initial consultation.
★ Step 2.2 Commitment.
★ Step 3b.1 Distribution of tasks and functions.
★ Step 3b.2 Revision of conditions of employment.
★ Step 3b.4 Reorganization of the NM organization.
★ Step 4.1 Exploitation.
★ Step 4.2 A total evaluation of the outsourcing.

Step 1.1 Change in customer strategy
The GemNet organization wanted to create a network to realize data transport for municipalities and to provide Value Added Network Services (VANS). This network should prevent uncontrolled grow of nationwide infrastructures for municipalities and provide greater accessibility and user friendliness at reduced cost.

The policy of the GemNet organization was to outsource operational and tactical activities that concerned the network and its services. These activities were placed outside the GemNet organization. The strategic management of the GemNet network was part of the GemNet organization; the GemNet organization had to decide which network services (functionality) were required at what price and quality.

Step 1.4 Explore the market
A Request For Information (RFI) was sent to forty potential service providers. The network and the network services that must be provided for users of the network were described in the RFI. RCC was one of the suppliers that was approached by the GemNet organization to respond to the RFI.

Step 2.1 Initial consultation
A combination of two organizations viz. RCC and Getronics was selected as they produced the best concept for the creation of the GemNet network, despite the fact that this offer was not the cheapest one. Later it was found that the GemNet organization had selected RCC because it was considered to be the service supplier that was best able to phrase the requirements.
Step 2.2 Commitment
A letter of intent, stating that RCC would provide services to realize the GemNet network, providing a pilot study was completed successfully, was signed by the managing directors of RCC and the VNG on 7 July 1994.

Step 3b.1 Distribution of tasks and functions
The NM at a strategic level at RCC is organized in a specific way which is caused by the creation of the GemNet network and its NM. The resulting network had to be used efficiently, therefore other customers had to be found to use the full extent of the network.

Step 3b.2 Revision of conditions of employment
The conditions of employment at this layer were not changed, because the GemNet network and its NM had to be created.

Step 3b.4 Reorganization of the NM organization at layer 5
A separate part of the organization was founded for commercial tasks, this part of the organization consisted of sellers of network services.

The reorganization of the NM organization was not performed analogous to the NM-model, because the five layers of the NM-model were not distinguished at the RCC organization.

Step 4.1 Exploitation
The day to day NM activities had to be achieved after the creation of the GemNet network to realize the network services at the required functionality, quality and costs. The following processes had to be supported by procedures, staff, and tools according to the NM-model:
availability management, contingency planning, capacity management, cost management, and service level management. These processes were not used at RCC for the organization of NM in January 1996, which led to ad hoc activities.

Step 4.2 A total evaluation of the outsourcing
The GemNet organization imposed some preconditions on the speed of the creation of the GemNet network, only these aspects were evaluated by the GemNet organization and RCC. A total evaluation of the outsourcing of the creation of the GemNet network and its NM was not performed.

6.3.2 Consequences for layer 4: operation of the heterogeneous network and the network services

Disturbance
This layer was confronted with a disturbance concerning new users and their requirements that was introduced as consequence of outsourcing the creation of the GemNet network and its NM. The GemNet network and its services were used by the employees of the dutch municipalities, the VNG, the BNG, and clients of the BNG.
Observations
RCC had to take into account the employees of the Dutch municipalities, the VNG, the
BNG, and BNG clients, who were all, in this case, new users of the network. The
users had specific requirements for the network services (see section 6.2.2), e.g. an
availability of 99.2% and at most four periods of non availability per year.

During the pilot project the quality and functionality of the network services being
used was observed and compared to the formulated requirements.

These observations were important for RCC and the GemNet organization as it
allowed them to determine the exact requirements for the GemNet network and their
feasibility.

Control measures
The following steps must be performed at layer 4 according to table 6.3:

- Step 1.5 Formulation of offer.
- Step 2.4 Contract negotiation.
- Step 2.5 Agreement takeover.
- Step 3a.1 Formulation of a plan of approach.
- Step 3b.1 Distribution of tasks and functions.
- Step 3b.2 Revision of conditions of employment.
- Step 3b.4 Reorganization of the NM organization.
- Step 4.1 Exploitation.

Steps 2.4 and 2.5 are part of the Service Level Management process which is
considered in detail in section 6.4.

Step 1.5 Formulation of offer
The GemNet organization selected seven potential service suppliers, including RCC,
based on the information that was required by the reactions to the RFI. These seven
service suppliers were asked to make an offer on basis of a Request For Proposal
(RFP).

The offer had to contain information concerning the following subjects:

- The products and services offered.
- Experiences concerning these products and services.
- Costs.
- Financing.
- Flexibility.
- Education.
- Documentation.
- Scheme for implementation.
- Contract clauses.

The procedure for the tender was based on European Community (EC) directives. The
tender was published in the EC magazine. Potential service suppliers could react to
the call for tender.

Step 2.4 Contract negotiation
The initial requirements were already formulated in contracts that described the
network services required with regard to functionality, quality and costs. There was no
negotiation over the contents of the services offered. VNG/BNG accepted the
realisation described in the offer made by RCC, only legal and economic negotiations
took place: legal negotiations regarding ownership of the GemNet network and
economic negotiations concerning tariffs for the network services.

The required quality and functionality were adjusted by the GemNet organization in
consultation with RCC on a basis of the pilot project.

The absence of research (step 2.3) resulted in extended contract negotiations (step
2.4) with the GemNet organization. The formal agreement of the take over (step 2.5)
took nearly one year (7 july 1994 - 1 march 1995).

**Step 2.5 Agreement takeover**

No formal agreement for the creation of the GemNet network was signed at the end of
the pilot project. Until the formal agreement was made (1 march 1995), principle
agreements formed the basis of the way of working. These agreements were
formulated in the concept Service Level Agreement (SLA) and the concept document
Agreements and Procedures (AP).

The SLA and AP were derived from the SLA and AP produced for the network
services for VROM a dutch government department.

The important subjects in these contracts were:

- Support of developments concerning network services in future.
- Competitor condition.
- Adjustment of tariffs when KPN, the dutch communications supplier, decreases
  its tariffs.
- Duration of the contract of three years.
- Cancelling of the contract, if on 31 December 1996, less than 200 municipalities
  were connected.

The creation of the GemNet network and responsibility for NM, was placed with the
RCC as the contractor and Getronics as a subcontractor when the contracts were
signed.

**Step 3a.1 Formulation of a plan of approach**

The plan of approach for the implementation of the GemNet network was described in
broad outlines in the document 'Projectplan Beheer en Datatransport' ([Jansen94]).

The plan of approach was divided into three parts:

- NM organization. The processes problem management, change management, and
  service level reporting were described, the activities of the help desk were also
described elaborately.
- Implementation data transport services (layers 1 and 2 of the NM-model).
- Implementation Value Added Network Services (layer 3 of the NM-model).

The NM tools required for the implementation of NM were also described.

The plan of approach was only formulated in broad outlines which led to ad hoc
activities.

**Step 3b.1 Distribution of tasks and functions**

The NM at RCC is organized in a specific way which is a result of the creation of the
GemNet network and its NM, however no new tasks were introduced.

**Step 3b.2 Revision of conditions of employment**

The conditions of employment at this layer were not changed, because the GemNet
network and its NM had to be created.
Step 3b.4 Reorganization of the NM organization
The organization of this layer was not found explicitly in the RCC organization.

The reorganization of the NM organization was not performed analogous to the
NM-model, because the five layers of the NM-model were not distinguished in the
RCC organization.

Step 4.1 Exploitation
The day to day NM activities had to be achieved after the creation of the GemNet
network to realize the network services with the required functionality, quality and
costs. The following processes had to be achieved with procedures, staff, and tools
according to the NM-model:
problem management, change management, network services management,
availability management, contingency planning, capacity management, cost
management, and service level management. These processes, except the processes
Change Management and Problem Management, were not used at RCC for the
organization of NM in January 1996, which led to ad hoc activities.

6.3.3 Consequence for layer 3: operation of a network service

Disturbance
This layer is confronted with a disturbance concerning new network services
introduced as consequence of the outsourcing of the creation of the GemNet network
and its NM. The Value Added Network Services (VANS) included electronic mail,
directory services, conferencing, bulletin board systems, file transfer, navigation
service, and gateways to other networks.

Observations
The quality, cost and functionality of each network service were observed to decide
which control measures must be performed.

Control measures
The following steps must be performed at layer 3 according to table 6.3:

★ Step 1.2 Describe the present network services.
★ Step 1.3 Define the network services required.
★ Step 2.3 Research.
★ Step 3a.4 Adaptation the NM tools.
★ Step 3b.1 Distribution of tasks and functions.
★ Step 3b.2 Revision of conditions of employment.
★ Step 3b.3 Retraining of personnel.
★ Step 3b.4 Reorganization of the NM organization.
★ Step 4.1 Exploitation.

Step 1.2 Describe the present network services
The ongoing network services consisted mainly of the exchange of data using a
diversity of technical solutions for connections between municipalities. The BNG
exploited connections and delivered services to circa 350 municipalities and 100 other
institutions.
Step 1.3 Define the network services required

The network services were divided into transport services and Value Added Network Services (VANS).

The transport services had to be based on the protocols X.25 and TCP/IP. These services are realized at layers 1 and 2 of the NM-model concerning a product line and the heterogeneous network respectively. The technical details formulated by the GemNet organization were conspicuous. These technical details prescribed the creation of the GemNet network.

The Value Added Network Services (VANS) included electronic mail, conferencing, bulletin board systems, file transfer, navigation service and gateways to other networks (figure 6.5).
Figure 4.5: The domain of GemNet

Users

- Municipalities
- VNG
- BNG
- BNG-relation

GemNet network

Network services

- E-Mail
- Conferencing
- Bulletin Board
- File Transfer
- Navigation Service
- Gateway Services

Service Suppliers

- VNG
- BNG
- TWINFO
- Departements
- Publishers
- Provinces
- RDW
- Kadaster
- NCCW
- GBA

X.25
TCP/IP
FR
A help desk also had to be organized for the GemNet network and the services based upon this network, education and documentation also had to be provided by the service provider that realized the GemNet network.

**Step 2.3 Research**
RCC did not performed research into the correctness of the data that was formulated by the VNG/BNG; however another daughter organization of Roccadile (L&T) was consulted. The organization L&T provided services for several municipalities, therefore it was possible to verify the data in broad outlines.

**Step 3a.4 Adaptation the NM-tools**
New NM tools had to be bought to manage, control and maintain the new network services.

**Step 3b.1 Distribution of tasks and functions**
The NM at RCC is organized in a specific way which is caused by the creation of the GemNect network and its NM.

The staff at the operational level was confronted with new tasks that had to be performed to manage, control and maintain the new network services.

**Step 3b.2 Revision of conditions of employment**
The conditions of employment of employees at RCC with the function network analyst had to be revised, shift work was introduced to cover 7 days a week 24 hours a day operational network services.

**Step 3b.3 Retraining of personnel**
The NM staff had to be educated when new network services were introduced.

**Step 3b.4 Reorganization of the NM organization**
The number of persons at RCC that were responsible for NM activities increased in 1995. These persons were spread over several departments at RCC. All NM activities were centralized with the reorganization in the department RCC Network Services (RNS) under the guise of change in control.

RNS was divided into three parts: an operational part, a commercial part and project part.
The operational part consisted of a manager, 2 location coordinators, 1 logistic employee, 23 (senior) employees, 1 administrative employee and 4 network analysts. The (senior) employees were placed in eight teams with one team, the telematica team, responsible for the management, control and maintenance of the Value Added Network Services. The network service electronic mail was provided by Getronics Network Services (GNS). The other network services had to be developed, maintained, controlled and managed as required by the GemNet organization.

The reorganization of the NM organization was not performed analogous to the NM-model, because the five layers of the NM-model were not distinguished in the RCC organization.

**Step 4.1 Exploitation**
The day to day NM activities had to be achieved after the creation of the GemNet
network to realize the network services at the required functionality, quality and costs. The following processes had to be achieved with procedures, staff, and tools according to the NM-model: configuration management, problem management, change management, network services management, availability management, contingency planning, capacity management, and cost management. These processes, except the processes configuration management, change management and problem management, were not used at RCC for the organization of NM in January 1996, which led to ad hoc activities.

6.3.4 Consequence for layer 2: operation of a heterogeneous network

Disturbance
This layer is confronted with a disturbance concerning the coordination of the product lines and their mutual connections. This coordination has to be changed as consequence of the outsourcing of the creation of the network GemNet and its NM.

Observations
Two product lines formed the basis of the GemNet network: Newbridge and Codex. The quality, cost and functionality of these product lines were observed using two separate tools to decide which control measures must be performed to coordinate the product lines. No integrated tool were available to observe the two product lines.

Control measures
The following steps have to be performed at layer 2 according to table 6.3:

- Step 2.3 Research.
- Step 3a.2 Adaptation the topology.
- Step 3a.4 Adaptation the NM-tools.
- Step 3b.1 Distribution of tasks and functions.
- Step 3b.2 Revision of conditions of employment.
- Step 3b.3 Retraining of personnel.
- Step 3b.4 Reorganization of the NM organization.
- Step 4.1 Exploitation.

Step 2.3 Research
RCC did not performed research to the correctness of the data formulated by the VNG/BNG; however a daughter organization of Roccade (L&T) was consulted. The organization L&T provided services for several municipalities, therefore it was possible to verify the data in broad outlines.

Step 3a.2 Adaptation the topology
A network had to be built to realize the exchange of data between all 636 municipalities of the Netherlands (figure 6.6). The topology of that network had to be able to realize a performance that at least matched the formulated requirements.
Before a network was developed with a nationwide reach, a pilot project was started to determine the quality required for the network and its cost. This pilot project ran from 15 January until 15 March 1995 ([Telecommunication Magazine, February 1996, 11e jaargang]). The pilot project consisted of eight municipalities that were connected by a network: Den Helder, Vlissingen, Heerlen, Hattem, Rotterdam, Voorburg, Deventer, Schijndel. In the pilot the network delivered five Value Added Network Services (VANS). These VANS were supplied by BNG, VNG, RDW (drivers licences), L+T (service- and information menus) and Varel (alarms for security).

At first the GemNet network was built separately from the RCC network. The RCC network was intended to form the basis for the GemNet network. At a later stage, after the pilot period, the networks had to be integrated to realize a reduction of costs, because of this intended integration the GemNet network was built of network components that had similar characteristics to components used in the RCC network.

The integration was based on a specific structure of the network. The network was divided into several logical subnetworks, each having its own characteristics. The GemNet network is divided into three subnetworks: a back bone network, a concentration network and an access network (figure 6.7).
Centrally positioned municipalities were connected directly on the RCC network, which is the backbone network. Other municipalities were connected, via these centrally positioned municipalities, to form the concentration network. The data of these five municipalities was concentrated using Frame Relay switches. These connections were not mixed due to the costs of extra connections. A telephone connection was used to provide availability when the connection was disturbed.

A Frame Relay Assembler/Disassemblers (FRAD's) was placed at decentralized municipalities, that formed the access network. The function of these FRAD's was to convert the data provided via the different access protocols into the Frame Relay protocol. After the conversion the data could be transported over the network.

The product lines used in the blueprint of the GemNet network showed clear differences and also a certain overlap in functionality, therefore service partitioning was used. The product lines had to be tuned to use the functionality optimally.

RCC appointed the following application of the product lines in the GemNet network:

- The product line Newbridge was applied in the backbone network.
- Multimedia Periphery (MP) routers of Codex were applied in the concentration network and also in the access network.

Step 3a.4 Adaptation the NM-tools

Due to the expected growth of the GemNet network (50 entries per month from March 1995) more precise requirements were made of the available NM tools. These NM tools would not be able to support the NM in the near future. An NM tool must be able to deal with the growth of the GemNet network.

A project group Integrated Network Management (INM) was put together, to make the necessary investigations required before purchasing a new NM tool, as this involves a high investment. The NM tool Netdirector was used temporarily to support the NM of the GemNet network until a definite decision was taken to purchase a suitable tool; however the restrictions of Netdirector meant that a choice of a new NM tool had to be made before the GemNet network really started to grow with 50 entries in a month. The adaptation of the NM tools was performed in a (too) late stadium, namely when the GemNet network was already partly created and growing by 50 connections per month.
Step 3b.1 Distribution of tasks and functions
The help desk and the network analysts were confronted with new tasks that had to be performed to realize the NM of the GemNet network.

The primary task of the help desk was to be the contact point for the GemNet users and service providers. The help desk staff registered, guarded, followed and prioritized incidents and known problems. Operational management was consulted to solve the problems and implement required changes. The help desk was therefore also responsible for the coordination of problems and changes and also for the periodic reporting of the service levels.

The network analysts had to guard the network 7 x 24 hours a week, as formulated in the contracts. In association with the help desk the network analysts had to solve the problems that were detected by the NM tools. If the NM tools were able to deliver periodic reports these were handed over to the help desk to formulate the service level reports for the customers.

Step 3b.2 Revision of conditions of employment
The conditions of employment of the persons at RCC with the function network analyst had to be revised. The persons had to do shift-work due to a heterogeneous network that had to be operational 7 x 24 hours a week.

Step 3b.3 Retraining of personnel
The NM staff had to be given training to operate the new hardware and software. One of the new network components was the Codex 6520 Multimedia Periphery Router. The staff at the help desk also needed training to help them deal with the other tasks they had to perform: reporting and coordination of problems and changes.

Step 3b.4 Reorganization of the NM organization
The number of persons at RCC that were responsible for NM activities was increasing. These persons were spreaded over several departments at RCC. All NM activities were centralized with the reorganization in the department RCC Network Services (RNS) under the guise of change in control.

RNS was divided into three parts: an operational part, a commercial part and a project part.
The operational part consists of a manager, 2 location coordinators, 1 logistic employee, 23 (senior) employees, 1 administrative employee and 4 network analysts. The (senior) employees were placed in eight teams with one team, the NM systems team, responsible for the integrated NM tools to manage, control and maintain the network which consists of several product lines as an integrated whole.

Step 4.1 Exploitation
The day to day NM activities had to be achieved after the creation of the GemNet network to realize the network services at the required functionality, quality and costs. The following processes had to be achieved with procedures, staff, and tools according to the NM-model: configuration management, problem management, change management, network services management, availability management, contingency planning, capacity management, and cost management.
These processes, except the processes configuration management, change
management and problem management, were not used at RCC for the organization of NM in January 1996, which led to ad hoc activities.

6.3.5 Consequence for layer 1: operation of a product line

Disturbance
This layer was confronted with a disturbance concerning the coordination of single product lines, namely new network components were introduced. The creation of the GemNet network was based on two product lines: Newbridge and Codex.

Observations
The product lines Newbridge and Codex each have their own specific characteristics.

The Newbridge product line
Newbridge network components have an additional functionality called Time Division Multiplexing (TDM), which means that a 2 Mbps connection can be divided into thirty-two 64 kbps connections or even more connections with a speed that is less than 64 kbps. The application of these multiplexers enables simultaneous use of the fast 2 Mbps connection. Several customers can be served and communicate at the same moment over a single connection using this technique.

This product line is also characterized by its prevention and handling of disturbances: favourable Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR), and logical paths that can be protected against the influences of network disturbances;

The quality, cost and functionality of the Newbridge product line can be observed by the management tool Mainstreet 4602 for Newbridge network components.

The Codex product line
Codex network components are characterized by the possibility to handle data transport based on different protocols. A conversion is required to convert the incoming protocols into an own protocol. This conversion requires some time, which results in a data delay at the nodes.

The Motorola Codex 6520 Multimedia Periphery Router is a component from the Codex 6500 product line. This 6520 MPRouter is a platform based on software, that can integrate existing time critical terminal to host applications and enable bandwidth intensive client/server applications. The data transmission of different types is realized in an efficient way via a single physical connection using Multimedia Periphery Routing. This can be realized by the 6520 MPRouter using the Frame Relay protocol.

The MPRouter is used in the GemNet network to configure the access protocols as Frame Relay Assembler/Disassemblers (FRAD) and routers, which transforms the X.25 and the IP-router data traffic in the Frame Relay protocol. At locations where no LAN is present, the MPRouter is only applied as a FRAD, to concentrate and convert the X.25 data traffic to the Frame Relay protocol.

In the concentration network the MPRouter was also applied as concentrator for the data traffic of surrounding municipalities. The MPRouter is not only used specifically as a FRAD, but also as Frame Relay Switch to concentrate the data traffic of the surrounding municipalities.

The different 14.4 Kbps connections in the access network are realized with Codex
3266 modems which realize the option for a back up facility for a higher availability using a telephone line.

The quality, cost and functionality of the Codex product line can be observed using the management system Codex 9800 for Codex multiplexers and Codex modems.

Control measures
The following steps have to be performed at layer 1 according to table 6.3:

☆ Step 2.3 Research.
☆ Step 3a.3 Adaptation the network components.
☆ Step 3a.4 Adaptation the NM-tools.
☆ Step 3b.1 Distribution of tasks and functions.
☆ Step 3b.2 Revision of conditions of employment.
☆ Step 3b.3 Retraining of personnel.
☆ Step 3b.4 Reorganization of the NM organization.
☆ Step 4.1 Exploitation.

Step 2.3 Research
RCC did not perform research into the correctness of the data that was formulated by the VNG/BNG; however a daughter organization of Roccade (L&T) was consulted. The organization L&T provided services for several municipalities, therefore it was possible to verify the data in broad outlines.

Step 3a.3 Adaptation the network components
A large diversity of hardware and software was present at the municipalities, and few connections were observed. The hardware and software had to be enumerated.

An indication of the diversity appears from research that was performed in 1992. This research found that 87% of the municipalities had PC's at theirs disposal, 82% had mini-computers, 38% had multi-user micro computers and 2% of the municipalities had a mainframe. 39% had a Local Area Network (LAN) with PC's only and 41% had a LAN with multi user systems. The diversity of platforms present with the municipalities was also large.

The municipalities were characterized by a huge diversity of hardware and software, which used different kind of protocols that had to be transformed into protocols used in the GemNet network. Data based on the protocol X.25 had to be concentrated and the GemNet services had to use the protocol TCP/IP. The data based on this protocol had to be connected to terminal-environments and to LAN environments.

An universal method was used to connect these different kind of environments. This universal method promotes uniformity between the municipalities. Moreover this method makes the installation, management, control and maintenance less expensive and better organized.

The following network components were introduced with the creation of the GemNet network: Codex 6520 MP_Routers, Codex 3266 modems, and Cisco 500 communication server that enabled a facility to call in centrally.

Step 3a.4 Adaptation the NM-tools
Due to the expected growth of the GemNet network (50 entries per month from March 1995) more conclusive requirements were required of the present NM tools. These
NM tools were not able to support the NM in the near future. An NM tool must be able to deal with the growth of the GemNet network. The management, control and maintenance of each product line must be supported by an NM tool.

The adaption of the NM tools was performed at a (too) late stadium, namely when the GemNet network was already partly created and growing by 50 connections per month.

**Step 3b.1 Distribution of tasks and functions**
The help desk and the operational management were confronted with new tasks that had to be performed to realize the NM of the GemNet network.

The primary task of the help desk was to act as a contact point for the GemNet users and service providers. The help desk staff registered, guarded, followed and prioritised the incidents and known problems. Operational management was consulted to solve the problems and implement the required changes. The help desk was therefore also responsible for the coordination of problems and changes and also for the periodic reporting of the service levels.

The network analysts had to guard the network 7 x 24 hours per week, as formulated in the contracts. In association with the help desk the network analysts had to solve the problems that were detected by the NM tools. If the NM tools were able to deliver periodic reports these were handed over to the help desk to formulate the service level reports for the customers.

**Step 3b.2 Revision of conditions of employment**
The conditions of employment for employees at RCC with the function network analyst had to be revised. Shift-work was introduced to cover 7 x 24 hours a week operation of the network.

**Step 3b.3 Retraining of personnel**
The NM staff had to be given training to operate the new hardware and software. One of the new network component was the Codex 6520 Multimedia Periphery Routers. The staff at the help desk also needed training to help them deal with the other tasks they had to perform: reporting and coordination of problems and changes.

**Step 3b.4 Reorganization of the NM organization**
The number of persons at RCC that were responsible for NM activities was increasing in 1995. These persons were spreaded over several departments at RCC. All NM activities were centralized with the reorganization in the department RCC Network Services (RNS) under the guise of change in control.

RNS was divided into three parts:

- An operational part, which consisted of a manager, 2 location coordinators, 1 logistic employee, 23 (senior-)employees and 1 administrative employee and 4 network analysts.

- A commercial part, consisting network services sales personnel.

- A project part, consisting of 6 network advisors.

The operational part consisted of 30 persons, that were placed in teams each with its own area of application. At this level the following teams were recognized: WAN/router team (13 persons), LAN team (4 persons), Gateway team (4 persons), SNA team (4 persons), and decentral systems team (3 persons).
6.4 Application of the NM-taxonomy and the NM-model to Service Level Management at RCC

Service Level Management at RCC is discussed in this section on basis of SLM activities, the division of contracts, and the entities in the SLM process.

6.4.1 Service Level Management activities

The SLM process was applied on the outsourcing of the creation of the GemNet network to formulate the requirements and preconditions of the GemNet organization. Each activity is described if relevant.

- **Initiate SLA negotiations.** Negotiations concerning the SLA were initiated in phase 2 step 2.2 when commitment was agreed for the outsourcing of the creation of GemNet and its NM.

- **Formulate an initial SLA.** In phase 2 step 2.3 research was performed to obtain input for the formulation of the initial SLA. RCC formulated an initial SLA that was based on the Request For Proposal and previous experience with network services.

- **Negotiate contents of the SLA.** In phase 2 step 2.4 the contents of the SLA formulated by the staff of RCC was discussed with the staff of the GemNet organization.

- **Formal acceptance of the concept SLA.** In phase 2 step 2.5 the SLA between RCC and GemNet was accepted formally when the network had already been in use for two months.

- **End negotiation.** Not relevant in the GemNet case (at this stage).

- **Change of the SLA.** Not relevant in the GemNet case (at this stage).

- **Monitor requirements.** The network was monitored 7 days a week 24 hours a day. The requirements that were formulated in the SLA were compared with the realized service performance when interruptions of the network services occurred.

- **Report.** In the GemNet case a report of the realized performance was drawn up on a monthly basis.

- **Deviation & Initiate NM processes.** When deviations occurred NM processes were initiated as agreed in the document Arrangements and Procedures.

- **Exceeding norms.** If the norms formulated in the SLA are exceeded new negotiations will be initiated in the form described in the SLA.
6.4.2 Division of contracts

RCC formulated contracts that describe the quality, cost and functionality of the network and the network services. The GemNet organization agreed with the contracts that RCC formulated after negotiations concerning the contents of these contracts. The contracts are divided into four parts. Each part of the contract is related to a specific area of attention which can be coupled to a specific department within a company:

* The document Service Agreement (SA) deals with legal and strategic aspects. General arrangements are formulated in this document.
* The document Service Level Agreement (SLA) deals with tactical aspects. Guarantees concerning the quality of the services are formulated in this document.

Contents SLA between RCC and the GemNet organization

1. General affairs (demarcation, exclusions, ...)
2. Performance management
   2.1 Levels of user support
   2.2 Availability
   2.3 Reliability
   2.5 Response time
3. Problem management
   3.1 Help desk
   3.2 Reaction time and resolution time
   3.3 Services supplier
   3.4 Private security services
4. Change management
5. Configuration management
6. Security management

* The document Arrangements and Procedures (AP) deals with operational aspects by means of procedures required for the operation of the activities as formulated in the Service Level Agreement.

Contents AP between the organizations RCC and GemNet

1. Introduction
2. Procedures
   2.1 Conference structure and frequency of conference
   2.2 Incident notice & escalation procedures
   2.3 Change facilities and change opening hours
3. Reporting
   3.1 Object of reporting
   3.2 Standard reporting, periodic, annual, incidental

* The document Financial Aspects (FA) deals with financial aspects; costs and tariffs of the network services for GemNet are specified in this document.
6.4.3 **Entities in the Service Level Management process**

The SLM process can be characterized by specific entities. These entities are:

* **Service Level Management (SLM).** This process is not recognized within the RCC organization. Only the formulation of SLA's and the reporting of the process SLM was considered. The foundation of the SLA and the reports on other NM processes were missing.

* **Service level manager.** This function was not recognized by RCC.

* **Service Level Report (SLR).** A periodic report on the quality, functionality and costs of the offered network services. These service level reports are generated automatically by NM tools. The frequency of reporting is formulated in the Service Agreement.

* **Contract.** The contract was divided into three subcontracts based on the kind of requirements, as described in the previous section.

The formulation of contracts and the periodic reporting were the only SLM activities performed at RCC. The processes availability management, capacity Management, contingency planning, and cost management were not recognized and defined at RCC, therefore, the SLM process could not be defined because of the dependency of this process to these processes.

The SLM process gets information from these processes concerning the quality and costs of the network and the network services.

6.5 **Findings of the application of the NM-taxonomy and the NM-model**

The focus of this chapter was on the application of the NM-taxonomy and the NM-model with regard to the SLM process in relation to the outsourcing of a network. The following research question was the central issue in this chapter:

Are the models developed applicable in general to other situations outside the research environment?

The findings of the application of the models developed are described in this section.

6.5.1 **Application of the NM-taxonomy**

The NM-taxonomy consists of three parts: the Real System (RS), the Network System (NWS), and Network Management (NM). Each of these three parts is considered on the basis of the entities as defined in chapter 3.

In the RS of GemNet only two entities were mentioned, namely the goal/structure and the staff of GemNet; the other five entities could not be described due to the development of the new GemNet organization (section 6.2.1).

In the NWS of GemNet the entities requirements, preconditions, users and network services were distinguished. The procedures for utilization of the GemNet network were not present at the GemNet organization. These procedures had to be created to support the users with the utilization of the network. The characteristics of the network and the network services were not known at this stage, only the functionality was specified (section 6.2.2).

In the NM of GemNet requirements concerning the entities goal, task and process were distinguished. The other entities procedure, staff and tool were not specified due
to the dependency of the service supplier that had to be selected to deliver network services as formulated in the contracts (section 6.2.3).

The NM-taxonomy gave an overview of the most important entities that involved the NM of the GemNet network in the GemNet organization. It was not possible to describe all entities in the case of the outsourcing of the creation of the GemNet network due to the quick development of the organization GemNet.

6.5.2 Application of the NM-model

Based on the application of the NM-model, this model was validated using the outsourcing of the creation of the GemNet network. The validation of the NM-model was performed to check the usefulness (practicability), correctness, and completeness of the NM-model. These validation factors are described in the remainder of this section.

Usefulness
The NM-model was found to be applicable for the outsourcing of the creation of the GemNet network and its NM. The practicability of the NM-model was shown in section 6.3.

With the outsourcing of the creation of the GemNet network it was shown that a disturbance on layer 5 had consequences for all lower layers of the NM-model. Changes were initiated on all five layers when the creation of the GemNet network was outsourced. These changes had to be handled by the service supplier(s).

The agreements with the customer, the GemNet organization, were important with the outsourcing of the creation of the GemNet network, therefore, the Service Level Management process was the most important process in this case study. The Service Level Management process was further emphasised at layer 4 in section 6.3.2.

The complexity of NM was reduced using the NM-model because it divides NM into smaller parts that are more detailed. This led to a better control of activities that had to be performed.

The division into phases was shown to be applicable to the outsourcing of an existing network (VROM case study) and also to the outsourcing of a network that has to be built or expanded (GemNet case study).

Some difficulties that occurred with the outsourcing of the creation of the GemNet network and its NM could have been prevented if all steps of the phases had been applied:

* The definition of the network services (step 1.3, layer 3) involved technical aspects with should not be of importance to the customer/user, they should only concern the functionalities of the network and its services.
* The absence of research (step 2.3) resulted in extended contract negotiations (step 2.4) with the GemNet organization. The formal agreement of the take over (step 2.5) took nearly one year (7 July 1994 - 1 March 1995).
* The plan of approach was only formulated in broad outlines (step 3a.1) which led to ad hoc activities.
* The adoption of the NM tools (step 3a.4) was performed at a (too) late stadium, namely when the GenNet network was already partly created and growing by 50 connections per month.
* The reorganization of the NM organization (step 3b.4) was not performed analogous to the NM-model, because the five layers of the NM-model were not distinguished in the RCC organization.
* The absence of the processes: service level management, cost management, contingency planning, capacity management in the final exploitation of the network and its services (step 4.1) at RCC led to ad hoc activities. The function service level manager was not distinguished at RCC, due to the fact that the SLM process was not recognized.
* The absence of a total evaluation of the outsourcing (step 4.2) led to a repetition of faults made by the outsourcing of the creation of GenNet with other projects that were performed after the GenNet project. These faults could have been avoided if a total evaluation had been performed.

**Correctness**

No incorrect parts were found in the NM-model, only deviations were found in the steps that were part of the control measures. The following distinction had to be made to the phases and their steps corrected:
* The revision of conditions of employment (step 3b.2 at all five layers) of the staff that are taken over by the outsourcing of a network is a difficult affair, especially when it concerns a large number of employees. It is therefore essential to pay attention to the conditions of employment of the staff at an early stage of the outsourcing e.g. already in phase 1.

**Completeness**

All aspects of the outsourcing of the creation of the GenNet network and its NM could be placed within the control measures as distinguished in the NM-model by steps. The NM-model is incomplete with regard to the control measures for NM of the GenNet network. Processes other than Service Level Management and Change Management must be placed in the NM-model.

The phases appear to be complete and therefore no lacunae were found, however, some steps must be described in further detail on a basis of the findings of the application of the phases that are divided into steps.
* The change in customer strategy (step 1.1) can be considered in detail. This aspect falls outside the scope of this research.
* The adoption of the network components (step 3a.3) should be carefully prepared e.g. in a pilot project. This prevents the occurrence of unexpected events due to characteristics of new network components that were not known to the NM staff.
* The formulation of a plan of approach (step 3a.1) is related to this aspect. A plan of approach should be formulated in detail to prevent ad hoc activities.
* The reorganization of the NM organization (step 4.1) can be realized using the NM-model: the recognizing of five layers that are characterized by specific processes. At present only two processes are described elaborately, the other eight processes should also be described to organize NM.
* A total evaluation of the outsourcing (step 4.2) can be realized by formulating a questionnaire in advance.
7 Validation of the NM-model for handling changes: two case studies

7.1 Introduction

Network Management (NM) was modelled in chapter 3 using an NM-taxonomy and the NM-model. The NM-model was considered in detail in chapters 4 and 5 to deal with the evolution of heterogeneous networks. The focus of chapter 4 was on the outsourcing of the VROM network, where the process Service Level Management (SLM) was of huge importance. The focus of chapter 5 was on the handling of changes at RCC, where the process Change Management (CM) was considered.

The focus of this chapter is, like that of chapter 6, on the research question that deals with the validation of the NM-model.

**Research question third part: focus on the testing of the models developed:**

*Are the models developed applicable in general to Network Management in other situations outside the research environment?*

In this chapter two case studies were described that are used to validate the NM-model with the focus on the Change Management process on practicability, correctness, and completeness (figure 7.1).
Two case studies are described in this chapter, that were performed at two different organizations: Getronics and the Robeco Group. The focus of the Getronics case study was primarily on the validation of the CM process description in relation to the NM-model. The focus of the Robeco case study was on the validation of the NM-model with regard to the CM process, therefore, two changes that occurred at the Robeco Group were considered.

Chapter 7 consists of the following sections:

- **7.2 Application of the NM-taxonomy to position the networks at Getronics.** The NM-taxonomy described in chapter 3 is applied in this section to describe the organization Getronics, the network system concerning the Getronics networks and the NM of these networks.

- **7.3 Change Management at Getronics.** Change Management present at the GNS department is discussed in this section on basis of a definition of a change, the Change Management procedure, the tool to support Change Management, and problems that occur with Change Management in practice.

- **7.4 Application of the NM-model concerning Change Management at Getronics.** The NM-model concerning Change Management is applied at the GNS department on network changes. This application concerns the division of changes, the data required for the decision making concerning changes, and the Change Management process in detail.

- **7.5 Application of the NM-taxonomy to position the Robeco network.** The NM-taxonomy described in chapter 3 is applied in this section to describe the Robeco Group, the network system concerning the Robeco network and the NM of this network.

- **7.6 Change Management at the Robeco Group.** Change Management present at the Robeco Group is discussed in this section on basis of the Change Management procedure that was
distinguished at the Robeco Group, and problems that occur with Change Management in practice.

* 7.7 Application of the NM-model to the handling of two changes at the Robeco Group.
Two changes were considered using the NM-model at the Robeco group to validate the NM-model in relation to the CM process.

* 7.8 Findings of the validation.
The findings of the application of the NM-taxonomy and the validation of the NM-model are described in this section.

7.2 Application of the NM-taxonomy to position the networks at Getronics

The NM-taxonomy described in chapter 3 is applied in this section to describe the organization Getronics, the network system concerning the Getronics networks and the NM of these networks. The application of the NM-taxonomy must validate the practicability, correctness, and completeness of the NM-taxonomy.

7.2.1 The Real System of Getronics

The Real System concerning the Getronics organization is described using the entities that are recognized in the Real System in chapter 3. An impression of the Getronics organization is given by describing its goal/strategy, organization structure, and its staff.

Goal/strategy
The goal of the Getronics is to offer a complete automation and telecommunication service by means of system integration, support and management of information systems and networks. Getronics offers customers the possibility to use a broad scale of solutions of only one supplier. The combination and integration of different techniques of a brand independent position characterizes Getronics.

Organization structure
The Getronics Group consists of several complementary organization units that are specialized on a specific area of the information and telecommunication technology. These organization units are grouped in eight specific competence centres:

* IT consultancy.
* Software and continuance services.
* Telecommunication.
* Management of information systems.
* Industrial automation.
* Networks and Network Services.
* Installation of value added services.
* Automation of place of work.

The competence centre Networks and Network Services consists of the following departments: Getronics Networks, Getronics Networks Projects, Databram, and Getronics Network Services (GNS). The focus in the remainder of this chapter is on the GNS department.
Staff
The Getronics Group consists of 5,400 employees. The organization units are located in the Benelux, Germany, Scandinavia, Spain, and England.

7.2.2 The Network System at Getronics

The Network System concerning the Getronics networks is described using the entities that are recognized in the Network System in chapter 3. The following entities were recognized: the user, the preconditions, the requirements, the procedure, the network, and the network services.

Goal
The goal of the network where Getronics is responsible for the NM is to support the primary business processes of client organizations (customers of Getronics) with communication facilities.

Network services
The following network services were offered by Getronics:

- Installation and support of standard and specific software for communication purposes.
- Installation and support of communication devices.
- Transport and conversion of files.
- Realization of Value Added Network Services e.g. electronic messages services (X.400 and X.500) and EDI.
- Integration of voice, images and text. This service is called Multi Media Services.

Networks and their specific network services
Getronics was responsible for (parts of) the NM of four networks (may 1995):

- **SURFnet** (in Dutch: Samenwerkende Universiteiten Reken Faciliteiten). SURFnet was created to connect education and research organizations like universities. This network is used daily by 20,000 to 30,000 users. The network is used intensively to transport a variety of information. The GNS department is responsible for the support of the network service by means of the help desk (12 hours a day) and the operational tasks to keep the network available, and is also responsible for the reporting, detection and solution of disturbances, system management, and the coordination of third parties (manufacturer, PTT, or Getronics Service) in case of calamities.

- **SENS network** (in Dutch: Stichting Exploitatie Nederlandse Staatsloterij). The SENS network connects 1500 stores that sell lottery tickets for the national lottery, tickets for soccer matches are also sold using the SENS network. The GNS department is responsible for the system management, management of applications and operational network management of the SENS network.

- **ComboNet**. ComboNet is a mobile network for the transmission of data and voice between traffic control and the 'mobiles' of the public transport organizations. The GNS department is responsible for operational network management.
∗ Insurance Data Network (in Dutch: Assurantie Data Network (ADN)). This network was primarily used for data transmission of EDI data. Data concerning insurances, payment information, and registration of registration numbers was transported using the ADN. ADN is used by large insurance companies, software houses and insurance agent, therefore ADN had a topology that was nation wide. The GNS department is responsible for the operational network management and the reporting towards the strategic management of ADN.

Users/requirements/preconditions
Each network has a specific user population with its own requirements and preconditions that are formulated in Service Level Agreements. However, not for all networks exact requirements and preconditions have not been formulated for all of the networks. For example for the network ComboNet was stated that the network should have a high availability, the support by the help desk should be available 7 x 24 hours a week, and the reliability of the network components should be high.

7.2.3 Network Management at Getronics

The Network Management of the Getronics networks is described using the entities that are recognized in the Network System in chapter 3. The following entities were recognized: the goal, the processes/tasks, the staff, the procedures present, and the tools present.

Goal
The goal of NM is to manage, control, and maintain the network and its network services in accordance with the requirements and preconditions imposed by utilization and the characteristics of the network components. The requirements and preconditions were in this case formulated by customers of Getronics who used the networks.

Staff
The GNS department was responsible for the NM of the four networks mentioned in the previous section. This department consisted of thirty persons in may 1995. These persons had the following functions: manager GNS, manager operations, supervisors, network manager, system manager, application manager, project manager, development & marketing employee, and help desk employee.

The GNS department was structured as a matrix organization: employees with a specific expertise were grouped by functional areas (unlike ITIL), and they are deployed in project-teams that are related to the different kinds of networks (figure 7.2).
NM was performed centrally in Amsterdam.

**Processes/tasks**
The ITIL philosophy according the organization of NM processes was being introduced. The operational processes: Help Desk, Configuration Management, Problem Management, and Change Management, as recognized by ITIL, were reorganized. This reorganization was initiated and performed by the management of Getronics Network Services.

**Procedures**
Procedures based on ITIL were being researched and introduced in a way that was specific to the GNS department. These procedures were introduced for the NM of all four networks.

**Tools**
The management tools 'SunNet Manager', 'CiscoWorks', 'UIS', 'NM-expert' were used to support NM. The management tools SunNet Manager and CiscoWorks were used to manage network components on basis of the management protocol SNMP. The management tool UIS was used to support the functions of the help desk. The management tool NM-expert was evaluated to support NM with an expert system for automated reaction on events on the basis of artificial intelligence.
7.3 Change Management at Getronics

Change Management at the GNS department is discussed in this section on basis of a definition of a change, the Change Management procedure, the tool to support Change Management, and problems that occur with Change Management in practice.

7.3.1 Definition of change

A change is defined at the GNS department as a change that concerns network components or network services. Those changes are divided into two categories at the GNS department: standard and non standard changes.

Standard changes are changes that are reckoned with in advance, only the time of occurrence is not known on beforehand. The costs of standard changes was known, so these changes did not need an interference of the tactical or strategic management.

Non standard changes were not foreseen, and the costs and impact of such changes were not known on beforehand. The implementation of a non standard change is not documented in Service Level Agreements with customers, because of these reasons, decisions about those changes have to be made at tactical, or even at strategic level (table 7.1).

<table>
<thead>
<tr>
<th>Standard changes</th>
<th>Non standard changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>change unforeseen (documented in the SLA)</td>
<td>change not foreseen</td>
</tr>
<tr>
<td>costs are predetermined</td>
<td>costs are dependent on change</td>
</tr>
<tr>
<td>fixed operational procedure present</td>
<td>no fixed operational procedure available</td>
</tr>
<tr>
<td>impact known</td>
<td>impact not known</td>
</tr>
<tr>
<td>decision on operational level</td>
<td>decision on tactical or strategic level</td>
</tr>
</tbody>
</table>

Table 7.1 Characteristics of standard and non standard changes.

7.3.2 Change Management procedure

Standard changes at the GNS department were handled by predefined operating instructions that were agreed upon in contracts by the GNS department and its customers. These operating instructions were not sufficient to handle all changes in the CM process. Especially the more sophisticated changes that have a larger impact on the network service could not be handled with the agreed operating instructions.

7.3.3 Tool to support Change Management

No management tool is used at the GNS department to document data concerning changes in a general change database, however, a management tool was being purchased in near future to support the processes Configuration Management and Problem Management. In [Vrics95] some management tools were evaluated in relation to their ability to support the CM process. This evaluation was also used for
the purchase of the management tool mentioned, in such a way that some Change Management functions were also integrated.

7.3.4 Problems with Change Management

The division of the changes into two categories appeared to be less suitable in practice. For each change that did not fit in the characteristics of a standard change had to be handled as a project, due to the absence of a Change Management procedure for non standard changes.

Another problem concerned the absence of a tool to support the CM process. Experiences concerning realized changes form the basis for the decision making concerning future changes. A database has to be kept up to date to have these experiences at its disposal. Such a database was not present at the GNS department, therefore the NM-staff had to rely on their mutual experiences. This is a risk when someone is sick, resigned or cannot remember all details of a specific change in history. A decision concerning a change cannot be based on data that is collected during and after other similar changes.

7.4 Application of the NM-model concerning Change Management at Getronics

The NM-model concerning Change Management is applied at the GNS department on network changes. This application concerns the division of changes in subsection 7.4.1., the data required for the decision making concerning changes in subsection 7.4.2., and the Change Management process in detail in subsection 7.4.3.

7.4.1 Division of changes

Changes were categorized in the NM-model by the five layers of the NM-model:

- Layer 1: changes on a product range
- Layer 2: changes on the heterogeneous network
- Layer 3: changes on a network service
- Layer 4: changes on users/requirements
- Layer 5: changes on goal and strategy

This division was not recognized at the Getronics Network Service (GNS) department. The GNS department only recognized changes at layer 1 and 2 of the the NM-model. Changes at the other layers were all handled by the management of Getronics.

Besides the categorization by the five layers of the NM-model, another division of changes was made into M1 and M2 changes. The division between M1 and M2 changes was related to the division of changes in standard and non standard changes in [Vries96]. This relationship resulted into four categories of changes:

- Standard (M1) changes.
  An example of this kind of change is the replacement of a network component that is out of order. This is a standard change, because of the predetermination of the costs of such a change, and it has no consequences for the utilization or exploitation of the network. This change is related to corrective maintenance.
- Non standard M1 changes without consequences for the SLA.
An example of this kind of change is the adaption of a network to increase its capacity. This change has to be performed to realize the performance as formulated in the Service Level Agreements. The costs of such a change are usually not predefined, and therefore this kind of change is a non standard change in the definition as formulated by Getronics. This change has no consequences for the utilization and exploitation of the network when no components are used that have other characteristics.

* Non standard M2 changes without consequences for the SLA.
  An example of this kind of change is the adaption of a network to increase its capacity, but with components that have other characteristics. The exploitation or utilization of the network is changed by these network components introduced. The network has to perform like stated in the Service Level Agreements that does not alter due to such a change.

* Non standard M2 changes with consequences for the SLA.
  An example of this kind of change is a change as result of a changing requirement of a network user. e.g. the availability of 99.0% has to increase to 99.5%. This change will alter the exploitation of the network and the Service Level Agreement that is agreed with that user.

This division was introduced at the GNS department ([Vries96]). Standard M1 changes could be handled on the operational level; with all other kinds of changes the management of the GNS department had to be involved whether or not to implement a specific change.

### 7.4.2 Data required for the decision making concerning changes

Three kinds of data are required when a decision concerning a change has to be made ([Vries95]). This data concerns:

* The situation present.
* The situation required.
* The characteristics of the resources required to implement the change.
* Previous situations (experiences that are gained in history).

#### Data concerning the situation present

The NM-taxonomy in chapter 3 can be used to obtain data concerning the situation present. The real system, the network system and the management system have to be known to the managers that must decide whether or not to implement a specific change. These three systems can be described by the entities that are distinguished.

The following entities in the real system have to be recognized: goal/strategy, structure, staff, systems, skills, culture, and style.

The following entities in the network system have to be recognized: users, requirements, network, network services, characteristics, and precondition.

The following entities in the management system have to be recognized: NM goal, NM task, NM process, NM procedure, NM staff, NM tool.

Besides data based on the filling in of the management paradigm data is required concerning the actual performance of the network and the network services. At each layer of the NM-model specific information is required.

At layer 1 of the MM-model the actual costs, the performance realized (by means of
the quality aspects: availability, reliability, delay times, and the capacity (the amount of occupation) and the functionality of the product line have to be known.

At layer 2 of the MM-model the actual costs, the performance realized, and the functionality of the heterogeneous network have to be known.

At layer 3 of the NM-model the actual costs, the performance realized and the functionality of the network service have to be known.

At layer 4 of the NM-model the actual costs, the performance realized and the functionality of the heterogeneous network in combination with the network services have to be known.

At layer 5 of the NM-model the actual costs, the performance realized and the functionality of total service have to be known to compare these aspects with the services of other network service providers.

The data concerning the situation present is obtained by the processes: Configuration Management, Help Desk, Problem Management, Availability Management, Capacity Management, Cost Management and Service Level Management.

**Data concerning the situation required.**

All entities mentioned above can be the object of change dependent on the requirements and preconditions that are formulated by the users of the network. The data concerning the situation required is especially related to the requirements and preconditions that are formulated in (new) Service Level Agreements.

The data concerning the situation required is obtained by the processes: Help Desk, Problem Management, Availability Management, Capacity Management, Cost Management and Service Level Management.

**Data concerning the characteristics of the resources required to implement the change.**

Three kind of resources are considered to implement a change in a network or network service: material resources, personnel resources, financial resources. The characteristics of these resources are mentioned in [Looijen95].

Characteristics of management tools are also of importance when a change is implemented ([Vries96]). These management tools are characterized by:

- The management protocols used.
- The layer of the NM-model that is supported.
- The functional area that is supported.

The CM process has to obtain the data concerning the resources required.

**Previous situations (historical experiences).**

The establishment and maintenance of data concerning experiences concerning changes is important to decide about future changes. This establishment and maintenance is part of the CM process.

Experiences of previous situations have to be documented by the situation before the change, the required situation, the resources required to implement the change. This data has to be documented per change.

The data concerning previous situations is obtained by the processes: Configuration Management, and Change Management.
7.4.3 The Change Management process in detail

Five activities were recognized in the CM process at the GNS department:

* Filter and record.
* Assess.
* Plan, develop and test.
* Accept and implement.
* Evaluate.

These activities were also recognized in the process description in chapter 5. The overall process description of the CM process proved to be suitable and practical in practice at the GNS department.

All five activities were further detailed at the GNS department by subprocess descriptions. The emphasis was on the activity Assess.

This activity was detailed in the following subactivities:

* Analyze situation present. See section 7.4.2.
* Analyze situation required. See section 7.4.2.
* Determine impact of change.

The determination of the impact of a change is again further detailed in the activities:

- Check for consequences for SLA,
- Determination temporarily impact on costs, functionality and quality,
- Check if the change has consequences for the exploitation and utilization of the network (M1 or M2 change).
- Determination of permanent costs and change in functionality and/or quality
- Determination charges concerning the change.
- Confer with the customer/user.
- Adjust situation required.

* Check if such a change is implemented before. See section 7.4.2.

This extension on the process description is supporting managers when they must decide whether or not to implement a change.

7.5 Application of the NM-taxonomy to position the Robeco network

The NM-taxonomy described in chapter 3 is applied in this section to describe the Robeco Group, the network system concerning the Robeco network and the NM of this network. The application of the NM-taxonomy must validate the practicability, correctness, and completeness of the NM-taxonomy.

7.5.1 The Real System of the Robeco Group

The Real System concerning the Robeco Group is described using the entities that are recognized in the Real System in chapter 3. An impression of the Robeco Group is given by describing its goal/strategy, organization structure, and its staff.

Goal/strategy

The goal of the Robeco Group is to provide capital for persons and organizations by save, financial investments and investments in real estate. The goal of these investments is to realize a returns that is higher than the returns of a usual savings
account. The strategy is to be able to react directly on requirements of (potential) customers. This means the time between the development of a new product and the introduction of that product has to be a short period of time (Time To Market).

**Organization structure**
The Robeco Group consists of four divisions:

- Marketing.
- Financial investments.
- Real estate investments.
- Finance and systems.

These four divisions are divided into subdivisions (see figure 7.1).

![Organigram Robeco Group (January 1996)](image)

**Staff**
The Robeco Group had approximately 700 employees; 580 of them are working in the Netherlands. The activities in the Netherlands are centralized in Rotterdam.

### 7.5.2 The Network System at the Robeco Group

The Network System concerning the Robeco network is described using the entities that are recognized in the Network System in chapter 3. The following entities were recognized: the user, the preconditions, the requirements, the procedure, the network, and the network services.

**Goal**
The goal of the Robeco network is to support the primary business processes of the Robeco Group with communication facilities.

These facilities enable the employees of the Robeco Group to communicate via electronic mail, use services that are present at different locations, consult financial
information all over the world, consult phone books, and realize telephone links over the network.

**Network services**
The following network services were offered by the data network:
- Transport services for e.g. exchange of data with the Bank-giro Centrale via Datnet-1 (the national X.25 network).
- Access to applications like word processors and spread sheets.
- Provide actual information concerning rates of stocks.
- Connections with other (external) networks.

The following network services were offered by the voice network:
- Internal and external telephone calls.
- Automatic Call Distribution (ACD).
- Voice mail.
- Fax services.
- Telex services.
- Data communication via the voice network.
- Worldwide Virtual Private Network (WVPN).

**Network**
The Robeco network consisted of two parts: a data network and a voice network. The data network was based on two product lines, namely IBM and Cisco. The voice network was primarily based on one product line, namely Northern Telecom.

The networks were both limited to the two Robeco buildings in Rotterdam. The networks had a topology which consisted of two IBM Token Ring networks at each floor of the buildings. These networks were connected with each other with multiple connections to ensure a high availability.

### 7.5.3 Network Management at the Robeco Group

The Network Management of the Robeco network is described using the entities that are recognized in the Network System in chapter 3. The following entities were recognized: the goal, the processes/tasks, the staff, the procedures present, and the tools present.

**Goal**
The goal of NM is to manage, control, and maintain the network and its network services in accordance with the requirements and preconditions imposed by utilization and the characteristics of the network components. The requirements and preconditions were in this case formulated by employees of the Robeco Group who used the Robeco network.

**Processes/tasks**
NM was performed on a way that was specially created for the Robeco Group. The ITIL philosophy concerning the organization of NM processes was compared with the current way of working. This comparison leaded to minor changes in the organization of NM.
Staff
The NM at the Robeco Group was performed by nine persons in November 1995. The staff that was responsible for NM was spread over three departments (Figure 7.2): two persons at Technical Support, five persons at Production, and two persons at Information Centre. Only the persons at Technical Support had a full time job concerning NM activities.

NM was performed centrally in Rotterdam.

![Figure 7.2 Organigram automation department of the Robeco Group](image)

Procedures
No procedures specifically for NM were formulated, due to the small scale of the network, however, general procedures for tasks concerning the management, control and maintenance of the mainframe environment were used as far as it concerned the network.

Procedures based on ITIL were being researched and introduced in a way that was designed specifically for the Robeco Group. These procedures were introduced for the whole automation department of the Robeco Group.

Tools
The management tools 'Netview' and 'Codex 9300' were used to support the NM. The management tool Netview was used to support the NM of SNA network components. The management tool Codex 9300 was used to support modem management.

7.6 Change Management at the Robeco Group

Change Management at the Robeco Group is discussed in this section on basis of the Change Management procedure that was distinguished at the Robeco Group, and problems that occur with Change Management in practice.

7.6.1 Definition of change

No explicit definition of changes was present at the Robeco Group.
7.6.2 Change Management procedure

A Change Management procedure was available at the Robeco Group, that was applied for all changes that occurred at the automation department of the Robeco Group. The procedure was only used for changes with a low impact. A standardized form for the documentation of these changes was used.

At first the CM procedure was not used at all departments of the automation department of the Robeco Group. The procedure and the standardized form was therefore compelled to use by the management of the automation department.

Larger and more sophisticated changes, that have more impact, were documented in special reports to handle these changes. These changes are handled as a project and supervised and supported by a steering committee.

7.6.3 Tool to support Change Management

No tool was used at the Robeco Group to document data concerning changes in a database, however, the following data was documented in text files:

- Unique number identifying the change.
- Name of the person who requested the change.
- Date concerning the change requested.
- Description of the change.
- Person responsible for the implementation of the change.
- Date of implementation.
- A back out plan in case it was not possible to implement the change at that moment.

This file was used by the Production department Technical Management to support the handling of changes.

7.6.4 Problems with Change Management

The Change Management procedure was originally intended to implement changes that occurred at the automation department of the Robeco Group. Changes concerning the network were a small part of all changes that were handled by the Change Management procedure. No separate Change Management procedure was available for changes concerning the network. Considering the scale of the network no separate procedure was introduced, however, changes concerning the network must have considerable attention due to the important role for the financial services of the Robeco Group.

Another problem concerned the absence of a tool to support the CM process with a knowledge database. Experiences concerning realized changes are the basis for the decision making concerning future changes. A database has to be kept up to date to have these experiences at its disposal. Such a database was not present at the Robeco Group. A decision concerning a change cannot be based on data that is collected during and after other similar changes. The NM staff had to rely on their mutual experiences. This is a risk when someone is sick, resigned or cannot remember all details of a specific change in history. This problem is recognized at the management of the automation department, all the more the fact that the knowledge concerning changes performed is available with only some persons of the NM-staff.
Another problem that was recognized was a lack of comprehensive criteria for the acceptance of changes. These criteria were formulated when this research was performed (January 1996). The criteria were related to the platforms present at the Robeco Group.

7.7 Application of the NM-model to the handling of two changes at the Robeco Group

Two changes were considered at the Robeco group to validate the NM-model in relation to the CM process. These changes concerned the renewal of the data network and the integration of the data and voice network.

7.7.1 The renewal of the data network

The renewal of the data network at the Robeco Group consisted of the replacement of the present network by a network that is faster, more efficient, more reliable, and less sensitive. Besides these quality aspects, also the functionality concerning NM had to increase to integrate the management of all network components. These improvements were realized by replacing the 4 Mbyte links by faster 16 Mbyte links and replace network components that were not able to support the transport protocol Frame Relay.

The renewal of the data network at the Robeco Group is described by the CM process, the entities related, and its position in the NM-model.

The Change Management process

The Change Management process described in chapter 5 was applied to the renewal of the Robeco network. The activities mentioned below were applied and recognized in the CM process in case of this change.

Filter and record RFC

The request for change (RFC) for the renewal of the Robeco network had an initial high priority due to a decreasing performance. The renewal of the Robeco network had therefore be implemented on short term.

Rejection

The renewal of the Robeco network was essential to keep offering the functionality of the network services at the same (or higher) quality, so the change was not rejected.

Inform of rejection

This activity did not apply in case of the renewal of the Robeco network.

Assess

Four alternatives were formulated to realize the renewal of the Robeco network. The urgency, impact and priority of the four alternatives were determined and registered in the Change Management meeting.

The alternatives were judged on the following criteria:

- Ability to offer all network services all work places.
- Minimal requirements for the performance of the network.
- A high reliability of the network.
Possibilities to migrate to new technologies.
* Ability to separate the data transmission by routable protocols.
* Ability to perform NM from one NM platform.

One alternative was selected based on the criteria formulated.

The impact of this change was very high because of a total replacement of the network present that was of strategic importance for the primary processes of the Robeco Group.

Rejection
This activity did not apply in case of the renewal of the Robeco network.

Plan and develop
The renewal of the Robeco network was scheduled and the resources needed to build the change were determined. The change was developed and formulated in an extensive document 'The renewal of the Robeco network' together with the schedule and the resources needed.

Working
The change developed on the Robeco network was tested elaborately for possible errors using a pilot project. A small network that had to simulate the whole Robeco network in its new composition was created in this pilot project. Crucial parts of the new network were tested on the formulated requirements. Some points of attention for the implementation were also obtained from the pilot project.

Implement
The renewal of the Robeco network was implemented like the formulated schedule in the document 'The renewal of the Robeco network'. At first the new network was implemented totally independent of the existing network. The switch over to the new network was divided into several phases and steps.

The implementation had to be achieved without disturbing the primary processes of the Robeco Group, therefore, the implementation activities had to be performed in the evenings, at nights and at sundays. This meant that the present network was gradually replaced into the new network.

Acceptance
The users of the Robeco network have not noticed the renewal of the network in functionality or performance of the network services. They only noticed the operations on the corridors.

The formal acceptance was made by the head and the staff of the automation department of the Robeco Group.

Evaluate
The renewal of the Robeco network was reviewed when the change was implemented completely.

The renewal of the Robeco network was seen as a successful change due to a far reaching research before implementing the change, whereafter the change was tested elaborately.
Entities in the CM process
The following entities were recognized in the CM process (chapter 5); influence, request for change, change, Change Management, change manager, kind of maintenance, resources, and planning.

Influence
The data network of the Robeco Group had to be renewed due to:

★ A decrease of the performance of the data network.
★ The technical characteristics of the data network leaded to superfluous and inefficient data transport.
★ The NM was shredded and the management tools did not offer enough functionality.
★ The network was sensitive to disturbances: when a local disturbance occurred, it could influence the functioning of the whole network.
These reasons are based mainly on technical and economical influences.

Request for change
A request for change was submitted based on the influence that triggered the system engineer of the Technical Support department, who formulated the request for change concerning the renewal of the Robeco network.

Change
The change was not identified by a unique identification number. The change can be described by: the replacement of the present network by a network that is faster, more efficient, more reliable, and less sensitive. Besides these quality aspects, also the functionality concerning NM had to increase to integrate the management of all network components. These improvements were realized by replacing the 4 Mbyte links by faster 16 Mbyte links and replacing network components that were not able to support the transport protocol Frame Relay.

Change Management
The change was handled by the CM process. The formulated CM procedure present at the Robeco Group did not apply in case of the renewal of the Robeco network, therefore, a specific plan of approach, in the form of the document 'The renewal of the Robeco network', was formulated by the change manager.

Change Manager
The system engineer of the Technical Support department was responsible for the function of change manager. The system engineer supported and supervised the handling of the change, and therefore, participated in all activities of the Change Management procedure.

Kind of maintenance
The change is categorized as an M2 change because of the following reasons:
★ The change was performed as perfective maintenance: an improving performance using new devices.
New components with other characteristics were introduced. The requirements and preconditions of the users were not changed.

The change had consequences for the exploitation of the network: the NM was changed. The utilization of the network was not changed: the same network services were offered by the new network.

The decision for the renewal of the Robeco network was made on tactical level: the application of new devices in the network.

Resources
The resources required for the implementation of the change had to be distinguished. These resources included: the network components required, the employment of the NM-staff on sundays and at night to minimize the impact on the present network services, and the investments for new hardware and software.

Planning
The change had to be implemented in a predefined period of time, therefore a planning was made for the activities that had to be performed in order to design and implement the change.

Position of the renewal of the data network in the NM-model
This change concerning the renewal of the data network of the Robeco Group primarily concerned layers 1 and 2 of the NM-model. Only components of a new range of products were introduced without changing the network services, the requirements, the preconditions, or the strategy concerning NM (layers 3 to 5). Not only the managed systems of layer 1 and 2 of the NM-model were changed, but also the control bodies of those layers were changed.

7.7.2 The integration of the data and voice network
The integration of the data and voice network was researched to create network services that were based on both the data and voice network. The NM of these networks should therefore also be integrated. The preparations for the integration of the data and voice network are described by the CM process, the entities concerned, and the position of the change in the NM-model.

The Change Management process
The Change Management process described in chapter 5 was applied to this change. The activities recognized in the CM process were followed in case of the integration of the data and voice network, however, the integration was not yet implemented. The possibilities and impact of the integration of the data and voice networks were researched at the time of this case study.

Filter and record RFC
The integration of the data and voice network was researched, especially in what way it could be realized. The integration will take place in little steps. Each of these steps will be handled as a separate change with its own request for change (RFC).
Rejection
In near future some integrated network services based on the data and voice network had to be introduced to serve customers of the Robeco Group with the latest technologies, therefore, the change was not rejected in this stage.

Inform of rejection
This activity did not apply in case of the integration of the data and voice network at the Robeco Group.

Assess
The urgency, impact and priority of the integration of the data and voice network were researched and formulated in a report by the change manager.

The impact of an integration was high because of a change to the networks present, which were of strategic importance for realization of the primary processes of the Robeco Group.

Rejection
This activity did not apply in case of the integration of the data and voice network.

Plan and develop
The integration of the data and voice network had to be scheduled in small parts to minimize nuisance and the resources needed to build the change had to be determined.

Working
The integrated network service has to be tested elaborately for possible errors before it is taken into production.

Implement
The implementation of the integration of the data and voice network was only researched and therefore had not yet been implemented.

Acceptance
The integrated network has to be accepted by network users, when implemented.

Evaluate
The integration of the data and voice network has to be reviewed when the change is implemented completely.

Entities in the CM process
The following entities were recognized in the CM process: influence, request for change, change, Change Management, change manager, kind of maintenance, resources, and planning.

Influence
A technological influence causes changes to the network of the Robeco Group. New advanced techniques make it possible to create new network services that are a mixture of the data and voice network (see also figure 1.1 and 1.2).
Request for change
A request for change was not yet submitted. Research into the possibility of
integrating the data and voice network was based on the influence that triggered the
system engineer of the Technical Support department.

Change
A change was not identified by a unique identification number. The change can be
described by: the integration of the data and voice networks at the Robeco Group.
New network services were introduced by this integration. The NM was also changed
when the two networks were integrated.

Change Management
The integration was handled by the CM process. The formulated CM procedure
present at the Robeco Group did not apply in case of the integration of the data and
voice network, therefore, a specific plan of approach had to be formulated by the
change manager.

Change Manager
The system engineer of the Technical Support department was responsible for the
function of change manager. The system engineer supported and supervised the
integration of the data and voice network, therefore, they must participate in all
activities of the CM process.

Kind of maintenance
The change is categorized as an M2 change because of the following reasons:
- The change was performed as adaptive and additive maintenance: adaptations due
to alterations (changing environment), and additions due to more demanding or
extra requirements of users.
- New components with other characteristics were introduced. The requirements
and preconditions of the users were also changed with regard to network services
that are a mixture of network services are based on the data and voice network.
- The integration had consequences for the exploitation of the network: the NM
was changed. The utilization of the network was also changed: new network
services were offered by the integrated network.
- The decision for the integration of the data and voice networks was made on a
tactical level.

Resources
The resources required for the implementation of the change had to be distinguished.
These resources included: the network components required, the employment of the
NM-staff on sundays and at night to minimize the impact on the present network
services, and the investments for new hardware and software.

Planning
The change had to be implemented in a predefined period of time, therefore plans
were drawn up for the activities that had to be performed to design and implement the
change.
Position of the change in the NM-model
The integration of the data and voice network concerned layers 1, 2, 3 and 4 of the NM-model. Components of a new range of products were introduced, the network services were changed, and also the requirements and preconditions were altered. The strategy concerning NM at layer 5 is not changed by handling this change.

Not only the managed systems of layers 1 up to 4 of the NM-model were changed, but also the control bodies of those layers were changed.

7.8 Findings of the validation

The focus of this chapter was on the validation of the NM-model concerning the handling of changes in particular the CM process in relation to the NM-model. The following research question was the central issue in this chapter:

Research question third part: focus on the testing of the models developed:
Are the instruments developed applicable in general to Network Management in other situations outside the research environment?

The findings of the validation are described in this section. The application of the NM-taxonomy is described in section 7.8.1. The validation of the NM-model is described in section 7.8.2.

7.8.1 Application of the NM-taxonomy

The NM-taxonomy is applied to describe the organizations Getronics and the Robeco Group.

Getronics
The NM-taxonomy consists of three parts: the Real System (RS), the Network System (NWS), and Network Management (NM). Each of these three parts is considered on the basis of the entities as defined in chapter 3.

In the RS of Getronics only three entities were mentioned, namely the goal/structure, the organization structure and the staff of GemNet; the other four entities were not used (subsection 7.2.1).

In the NWS of Getronics the entities goal, network service, network, users, requirements, and preconditions were distinguished. The procedures for utilization were not present. These had to be created to support the users with the utilization of the network. The characteristics of the network and the network services were not documented (subsection 7.2.2).

In the NM of Getronics the entities goal, staff, process/task, procedure, and tool were distinguished. The procedure for handling changes was not present when this research was performed. A suitable Change Management procedure which focused on the impact of a change was composed for the specific Getronics situation. The functionality of the management tools present were used partly, when recognizing the layers of the NM-model (subsection 7.2.3).

Robeco
In the RS of the Robeco Group only three entities were mentioned, namely the
goal/strategy, the organization structure, and the staff of the Robeco Group; the other four entities were not described (subsection 7.5.3).

In the NWS of the Robeco Group the entities goal, network services, and network were distinguished. The procedures for utilization were not present. These had to be created to support the users with the utilization of the network. The characteristics of the network, the requirements and preconditions were not documented at the Robeco Group (subsection 7.5.3).

In the NM at the Robeco Group the entities goal, process/task, staff, procedure were distinguished (subsection 7.5.3).

### 7.8.2 Validation of the NM-model

The validation of the NM-model is performed to check the usefulness (practicability), correctness, and completeness of the NM-model. These validation factors are described in the remainder of this section. The validation is performed in two different real life situations at the organizations Getronics and the Robeco Group.

#### Getronics

The NM-model was found to be applicable for categorizing changes (subsection 7.4.1). The CM process developed was described using the NM-model to categorize changes based on the five layers. Only changes on layer 1 and 2 were considered at Getronics, other changes were handled in another way, without using a procedure.

The control measures were based on the procedure description in relation to the NM-model, the change categories, and the entities that were applied in the CM process, as formulated in chapter 5.

#### Usefulness

The complexity of NM is reduced using the NM-taxonomy, and the NM-model because of the division of NM into smaller parts that are more detailed.

The division of changes into categories increases the insight into the changes that occur in the network and the network services. A description of a Change Management procedure and all entities that play roles in the CM process helps managers to oversee the huge amount of changes that have to be managed and reckoned with during the NM of an evolving heterogeneous network.

#### Correctness

In the NM-model and the NM-taxonomy no incorrect parts were found, only deviations were found in the process description and the entities that are applied. Only little distinctions had to be made to the Change Management procedure to apply this procedure in the Getronics situation. For example the division that was applied within Getronics had to be interwoven with the procedure description designed.

#### Completeness

All aspects of the handling of changes could be positioned within the NM-model.

The process description appears to be complete and because no lacunae were found, however, some activities must be described in further detail on basis of finding of the application of the process description.
Robeco
The NM-model was found to be applicable for the handling of changes at the Robeco Group.
The practicability of the NM-model at the Robeco Group was shown in section 7.5.
The control measures were based on the procedure description in relation to the NM-model, the change categories, and the entities that were applied in the CM process, as formulated in chapter 5.

Usefulness
The complexity of NM is reduced using the NM-taxonomy, and the NM-model because of the division of NM into smaller parts that are more detailed.
The division of changes into categories increases the insight into the changes that occur in the network and the network services at the Robeco Group. A description of a Change Management procedure and all entities that play roles in the CM process helps managers to oversee the huge amount of changes that have to be managed and reckoned with during the NM of an evolving heterogeneous network.

Correctness
In the NM-model and the NM-taxonomy no incorrect parts were found, deviations were only found in the process description and the entities that are applied. Small distinctions had to be made to the Change Management procedure to apply this procedure in the Getronics situation. For example the division that was applied within Getronics had to be interwoven with the procedure description designed.

Completeness
All aspects of the handling of changes could be positioned within the NM-model.
The process description appears to be complete and because no lacunae were found, however, some activities must be described in further detail on the basis of findings of the application of the process description.
8 Epilogue

Many present day organizations rely heavily on communication networks to realize the primary objectives of the organization, meaning that networks are crucial to the continuation of organizations (see chapter 1). It is therefore essential that these networks are managed properly according to well defined requirements and preconditions.

Communication networks are characterized by evolution and heterogeneity. The evolution of a network is caused by changing business objectives resulting in other preconditions, by users that change their requirements, and by suppliers that change the characteristics of network components. The heterogeneity of a network is caused by the diversity of network components, which have different characteristics.

The objective of Network Management is to cope with the changing requirements and preconditions imposed by utilization and the changing characteristics of the network components.

The issue of Network Management (management, control, and maintenance) of evolving heterogeneous networks is addressed in this thesis. The objectives of this research project were twofold (section 1.5.1):

★ To analyze and describe evolving heterogeneous networks and their Network Management (NM).
★ To develop models that support NM in coping with the evolution of a heterogeneous network.

The research design (8.1), the research findings (8.2) and directions for further research (8.3) are given in this final chapter.

8.1 Research design

The research was divided into five phases to meet the objectives of the research project (see also figure 1.8):
★ Research questions (8.1.1).
★ Literature study (8.1.2).
★ Prescriptive models (8.1.3).
★ Descriptive case studies (8.1.4).
★ Test case studies (8.1.5).

The design and execution of these five phases are recapitulated in this section.
8.1.1 Research questions

The first phase in this research concerned the formulation of the research questions. The following general research question was formulated based on the objectives of this research:

*General research question:*

*How can management be supported with regard to the organization of Network Management (NM) of evolving heterogeneous networks and network services based upon these networks?*

The research was divided into two parts, each of which had a specific point of attention with its own specific research question. These research questions were derived from the general research question.

The processes Service Level Management (SLM) and Change Management (CM) were considered due to the fact that changes of the network and the network services, that cause evolution, are mainly handled by these two processes.

**Outsourcing and Service Level Management**

The focus of the first part of the research was on the evolution and heterogeneity originating from the outsourcing of a network and its NM. Outsourcing of a network and its NM leads to several changes of a different nature that have to be handled by the NM organization. The heterogeneity of the network system can be increased by these changes: a diversity of network components, network services, and network users can result from an outsourcing of a network and its NM.

The objective of this part of the research was to develop a model to support the decision making concerning changes caused by outsourcing of a network and its NM. This model had to deal with the Service Level Management process to support the contractual aspects of outsourcing. The emphasis was placed on the (re)arrangement of the NM organization.

The research question of the first part of the research runs as follows:

*Specific research question 1:*

*How can management be supported with regard to changes in the network and network services caused by outsourcing?*

**Change Management**

The focus of the second part of the research was on the evolution and heterogeneity caused by particular changes.

The objective of this part was to design a model to support the handling of these changes, which involves the Change Management process. Here the emphasis was in particular on the supporting of the decision making concerning these changes. To implement or not to implement? That is the question! Information must be obtained to assist management making well considered decisions. The consequences of a change can be assessed based on the information obtained.

The research question of the second part of the research runs as follows:
Specific research question 2:
How can management be supported when handling changes in the network and network services caused by external influences?

The models that were developed to answer these two research questions had to be validated in practice against situations; a third specific research question was therefore formulated:

Specific research question 3:
Are the instruments developed applicable in general to Network Management in other situations outside the research environment?

These three research questions were the basis for the next phases of the research approach.

8.1.2 Literature study

The second phase in this research was a literature study. The literature was considered to find existing directives concerning the NM of evolving heterogeneous networks. These directives had to be reviewed to find deficiencies concerning the NM of evolving heterogeneous networks in relation to the formulated research questions. This research was defined to solve the deficiencies found.

Three keywords for the literature study were: evolution, heterogeneity and Network Management.

Evolution
Literature was reviewed to answer the following questions:
* What is evolution according to literature?
* What is causing evolution according to literature?
* What directives are described in literature to cope with evolution?

Heterogeneity
Literature was also reviewed to answer the following questions:
* What is heterogeneity according to literature?
* What directives are described in literature to cope with heterogeneity?

Network Management
Literature was also reviewed to answer the following questions:
* What is NM according to literature?
* What directives are described in literature to assist management performing NM?

Findings of the literature study will be presented in section 8.2.1. The findings of the literature study were used to focus the research on the prescriptive models required for supporting outsourcing, service level management and change management.

8.1.3 Prescriptive models

The third phase in this research concerned the formulation of prescriptive models to
deal with the deficiencies of the specific models found in literature. The main deficiency in the models was the lack of support of the handling of evolution of heterogeneous networks, however, prescriptive models are essential to support (senior) managers with their decision making concerning changes of the network and the network services. The increasing strategic importance of networks, the expanding costs, and the increasing complexity of networks caused by heterogeneity and evolution mean that the (senior) management of companies can no longer determine the necessities for NM without suitable models and directives.

A first draft of two general models, named NM-taxonomy and NM-model, were developed to cope with organizational problems concerning the heterogeneity and evolution of networks (see section 8.2). The first drafts of these models were considered in detail in two descriptive case studies.

8.1.4 Descriptive case studies

The fourth phase in this research concerned two descriptive case studies. The NM-taxonomy and the NM-model were applied in two descriptive case studies in order to consider these models in detail with regard to the evolution of heterogeneous networks based on findings obtained from practice. The outsourcing of the VROM network and the handling of changes at RCC were considered in the two case studies chosen for their relation to the two specific research questions.

Outsourcing and Service Level Management
In the first descriptive case study the outsourcing of the VROM network was considered. The outsourcing of the VROM network led to several changes of different kinds. These changes were of a technical and organizational nature: the integration of the VROM network and the RCC network resulted in a network with a larger heterogeneity; and the organization of NM at RCC also needed to be changed radically to be able to perform adequately the NM of the VROM network. The objective of this case study was to expand the NM-taxonomy and the NM-model with regard to the outsourcing of a network and its NM. The emphasis was placed on the (re)arrangement of NM organization in particular on the Service Level Management (SLM) process.

Change Management
In the second descriptive case study the handling of network changes at RCC caused by external influences was considered. Evolution was handled by realizing changes to the network and the network services. The objective of this case study was to consider the NM-taxonomy and the NM-model in detail with regard to the handling of the changes in general. The emphasis was placed on supporting the decision making concerning the Change Management (CM) process.

8.1.5 Test case studies

The fifth phase in this research concerned three test case studies that were performed to check the expanded NM-taxonomy and the expanded NM-model on usefulness, correctness, and completeness.

The NM-taxonomy and the NM-model were tested in practice outside the research
environment in three case studies. These three case studies had to lead to an adjustment and refinement of the NM-taxonomy and the NM-model according to experiences gained from the application of the NM-taxonomy and the NM-model in practice.

**Outsourcing and Service Level Management**

The focus of the first case study was on the outsourcing of the creation of the GemNet network (chapter 6). The GemNet organization decided to outsource its network, which had to be built from scratch, and its NM. The focus of this case study was therefore mainly on the validation of NM-model concerning the SLM process.

**Change Management**

The focus of the second case study was on the handling of changes at the Getronics organization especially on the validation of the CM process description in relation to the NM-model (chapter 7).

The focus of the third case study was on the handling of changes at the Robeco Group, especially on the validation of the NM-model with regard to the CM process, therefore, two changes that occurred at the Robeco Group were considered (chapter 7). These changes concerned the renewal of the data network (section 7.7.1), and the integration of the data and voice network (section 7.7.2).

### 8.1.6 Research findings and further research

Finally the research findings were formulated concerning the two models developed. Remarks concerning further research were also made.

### 8.2 Research findings

The objective of this research project was to develop models that support NM in coping with the evolution of a heterogeneous network, therefore two general models, NM-taxonomy and NM-model, were developed.

Before describing the NM-taxonomy and the NM-model and their findings of application, first findings from the literature study are described (8.2.1).

The NM-taxonomy is described by its structure (8.2.2). Based on two descriptive case studies the NM-taxonomy is expanded with regard to two processes (8.2.3). The applicability of the NM-taxonomy is described according to the test case studies (8.2.4).

The NM-model is described by its structure (8.2.5). Based on the descriptive case studies the NM-model is expanded with regard to two processes (8.2.6): the Service Level Management process and the Change Management process. The applicability of the NM-model is described according to the test case studies (8.2.7).

Finally the research question is considered once more: how management is supported by the NM-taxonomy and the NM-model (8.2.8)?

### 8.2.1 Findings from the literature study

The scope of the literature study was formulated in section 8.1.2: literature was considered concerning evolution, heterogeneity, and NM. The findings of the
literature study concerning these three aspects were formulated in this section. It appeared that literature showed some deficiencies in relation to these aspects.

**Evolution according to literature**
Evolution was defined in the literature (chapter 1) as the gradual transition, via countless small changes, to increasingly differentiated and complex structures. In the context of this research these increasingly differentiated and complex structures should lead to an adjustment of the network for the services provided by the network to improve:

- Fulfilment of the requirements and preconditions demanded by users.
- Price in proportion to performance.
- Management, control and maintenance.
- Competitiveness.

**Causes of evolution according to literature**
Evolution was considered to be caused by driving forces and the contingency factors (chapter 2, section 2.3). It was found from literature that the driving forces result in changing the network and/or the network services, e.g. the technology concerning networks and network services is changing rapidly. Not only is the functionality changing drastically, resulting in new network services, but also the performance of network components and the network in total is being improved to be able to offer new network services. The contingency factors influence an organization and the NM in that organization by changing the requirements and preconditions to the network and the network services.

**Directives to cope with evolution in literature**
Directives to cope with evolution of networks were not found in literature.

**Research finding 1 Deficiency:** How to deal with the driving forces and contingency factors to cope with evolution were not found in the literature.

**Heterogeneity according to literature**
Heterogeneity pointed to the diversity of components. Heterogeneity was divided into four kinds according to the kind of component as defined in literature (chapter 2, section 2.2):

- **Multi vendor heterogeneity** referring to the network components that are supplied by different vendors.
- **Multi fabric heterogeneity** referring to the different kind of links in the network.
- **Multi protocol heterogeneity** referring to the diversity of prescriptions that is used to transmit data in a predefined format.
- **Multi functionality heterogeneity** referring to the network services that offer different functionality.

**Directives to cope with heterogeneity in literature**
The diversity of network components concerning the vendor and the diversity of protocols used was only considered in the literature. The emphasis of this research was on organizational problems caused by multi vendor and multi functionality heterogeneity. The heterogeneity concerning multi protocol and multi fabric was
assumed to be a technical problem, with technical solutions, therefore these kinds of heterogeneity were not considered in this research.

**Research finding 2** Deficiency: *Organizational problems concerning multi vendor and multi functionality heterogeneity were not found in the literature. Only technical problems concerning heterogeneity were considered and dealt with in the literature.*

**NM according to literature**
Several definitions of NM were found in literature. In this research NM is defined analogously to the management of information systems as defined in [Looijen96] as:

*The management, control and maintenance of implemented networks in accordance with the requirements and preconditions imposed by utilization and the characteristics of the network components.*

**Directives to assist management to perform NM in literature**
Five models presented in the literature were considered in case of this research: OSI Network Management model, TMN, OMNIPoint, ITIL, T-FOREce, and DUnet Management Model. These models were developed to support the management, control and maintenance of IT infrastructure components. These models were compared to each other using five key success factors: NM architecture, NM functions/tasks, NM instrumentation, organizational components, and organizational approach. The deficiencies of the models were found by making this comparison.

**Research finding 3** Deficiency: *The five models were found to be inadequate to model heterogeneous evolving networks due to the following deficiencies (chapter 2, section 2.4):*

- None of the models deal with the evolution of networks.
- The models only describe NM on an abstract level; the actual realization of the NM in practice is not considered.
- The models focus primarily on technical aspects of NM.
- Strategic and tactical NM are barely defined.

**8.2.2 Outline of the NM-taxonomy**

The NM-taxonomy was developed to describe a particular NM organization and its environment.

The NM-taxonomy was based on the management paradigm ([Looijen95]) in which three systems are distinguished (chapter 3, section 3.2): the Real System, the Network System and the Network Management System. Each system is considered in more detail by specifying the entities and their relationships that can be recognized in those systems.

**The Real System**
The Real System (RS) concerns the activities of a company to achieve the core competencies of that company.

The following entities were considered in the RS (figure 3.2): strategy and goals, organization structure, staff, systems, management style, skills of the company, and
the culture of the company (section 3.2.3). The mutual relationships of these entities were not considered in this research.

Only the entities strategy/goal, organization structure, staff, and system were described in all five case studies to give an impression of the real system of the companies. The entities style, skill and culture were not considered during this research due to the nature of those entities, however, when preconditions have to be formulated these entities also have to be taken into account. In this research it was not considered how these relationships manifested, only the dependencies were recognized.

The Network System
The goal of the Network System (NWS) is to control, to improve and to explore the Real System demarcated to communication matters.

The following entities were considered in the NWS: network, network components, network service, user, procedure for utilization, requirement, characteristic, and precondition (section 3.2.2).

These entities were related to each other (figure 3.2):

- A network has specific characteristics.
- A network consists of network components.
- A network component has specific characteristics.
- A network service is based on a network.
- A network service has specific characteristics.
- A user uses the network.
- A user uses the network service.
- A user works via procedures to consult the network and the network services.
- A user formulates requirements concerning the network and the network services.
- Preconditions are derived from the goals and strategy of the RS.
- The requirements that are formulated by users of the network services, the characteristics of the network and network services, and the preconditions that are formulated by the management formed the basis for the NM goal that is an entity in the Network Management System.

The Network Management System
The Network Management System (NMS) deals with the management, control and maintenance of implemented networks in accordance with the requirements and preconditions imposed by utilization and the characteristics of the network components.

The following entities were considered in the NMS: NM goal, NM tasks, NM processes, NM procedures, NM staff, and NM tools (section 3.2.1).

These entities were related to each other (figure 3.2):

- NM tasks are derived from the NM goal.
- NM tasks consist of NM processes.
- NM processes are described by NM procedures.
- The NM staff works via NM procedures.
- The NM staff uses NM tools.
External influences
Four kinds of external influences were considered (section 3.2.4): managerial, contractual, economic and technical influences. These external influences caused all kind of disturbances, that were distinguished at all five layers in the NM-model (section 8.2.5).

8.2.3 Expansion of the NM-taxonomy

The NM-taxonomy is expanded with the Service Level Management (SLM) process and the Change Management (CM) process. These processes were only mentioned in chapter 3 (section 3.5), therefore, these processes had to be considered in relation to the NM-taxonomy to cope with changes that cause evolution of the network and the network services.

The NM-taxonomy was considered in detail concerning the SLM process and CM process based on experiences gained from the two descriptive case studies: the outsourcing of the VROM network (see chapter 4) and the handling of changes at RCC (see chapter 5).

The NM-taxonomy in detail concerning Service Level Management
The NMS of the NM-taxonomy was expanded with entities that were of importance for the SLM process based on the descriptive case study concerning the outsourcing of the VROM network (chapter 4). The following entities were recognized in the NMS, besides the entities mentioned in 8.2.2, when considering the SLM process: service level manager, Service Level Management, service level report, kind of requirement, Service Agreement, Service Level Agreement, Financial Aspects, Arrangements and Procedures. These entities are a specialization of the entities recognized in the NMS of the NM-taxonomy.

These entities were related to each other:
★ The service level manager is a member of the NM-staff.
★ The service level manager coordinates the SLM process.
★ The SLM process is an NM process.
★ The four entities Service Agreement, Service Level Agreement, Financial Aspects, Arrangements and Procedures are specific contracts.
★ The NM goal formulated in the contract is based on the SLM process.
★ The kind of requirement is identifying a contract.
★ Requirements concerning service level reports are formulated in the Service Agreement contract.
★ Service level reports can be generated by a NM tool.
★ NM procedures are described in the Arrangements and Procedures contract.

The NM-taxonomy in detail concerning Change Management
The NMS of the NM-taxonomy was expanded with entities that were of importance for the CM process based on the descriptive case study at RCC (chapter 5). The following entities were recognized in the NMS, besides the entities mentioned in 8.2.2, when considering the CM process: Change Management, change manager, influence, request for change, resource, planning, kind of maintenance, change, M1 change, M2 change.
These entities were related to each other:

- The change manager is a member of the NM-staff.
- The change manager coordinates the CM process.
- The CM process is an NM process.
- The CM process handles changes.
- A change is divided into two categories: M1 and M2 changes, based on the impact of the change.
- The change category is depending on the kind of maintenance that realizes the change.
- A change is requested by a Request For Change.
- A Request For Change is triggered by a specific influence.
- Resources are required to implement the change.
- A change has a specific planning.

8.2.4 Applicability of the expanded NM-taxonomy

The two descriptive case studies led to an expansion of the NM-taxonomy with entities and their relationships concerning Service Level Management and Change Management. The applicability of the expanded NM-taxonomy is described in this section based on three test case studies: the outsourcing of the creation of the GemNet network, the handling of changes at Getronics and the handling of changes at the Robeco Group. In each case study the entities as recognized in the expanded NM-taxonomy were used to describe the situation present at the moment of this research.

**GemNet**

In the GemNet case shortcomings were found in the present situation using the expanded NM-taxonomy, namely the formulation of contracts and the periodic reporting were the only SLM activities performed at RCC, other activities were not distinguished in the *NM procedures*. The function *Service Level Manager* was not recognized at RCC. The *NM tools* present were not sufficient to support the activities of the *NM staff* that were formulated in the *NM procedures*.

**Getronics**

In the Getronics case shortcomings were found in the present situation using the expanded NM-taxonomy, namely the *procedures* for utilization were not present in the network system (NWS) at Getronics. These procedures had to be created to support the *users* with the utilization of the *network*. The *characteristics* of the *network* and the *network services* were not documented (sections 7.2.2 and 7.5.3). An *NM procedure* for handling changes was not present when this research was performed in the NMS at Getronics.

**Research finding 4** Shortcomings in the present situation of SLM and CM could be detected when applying the expanded NM-taxonomy.

**Robeco**

In the Robeco case all entities distinguished in the expanded NM-taxonomy were recognized (chapter 7) when the Change Management process was considered on the basis of two changes that were considered.
Research finding 5 The case studies did not provide entities that were not already in the NM-taxonomy when considering the processes Service Level Management and Change Management, nor did the case studies provide refutations of entities defined in the NM-taxonomy.

8.2.5 Outline of the NM-model

The NM-model was developed to realize an adequate and appropriate NM. The complexity with regard to the management and control of the evolution and heterogeneity of the NWS was unravelled by dividing the Network System (NWS) into five coherent parts, based on the entities recognized in the NM-taxonomy. This subdivision led to a better control of activities that had to be performed.

The following parts of the NWS were considered (chapter 3, section 3.3):

★ A product line. A product line consists of network components that are produced by one supplier; so a product line is not heterogeneous concerning multi vendor. The network components of a product line have similar characteristics. The coordination of a product line is considered at layer 1. This layer concerns the entities network component and its characteristics as distinguished in the NWS of the NM-taxonomy.

★ A heterogeneous network. Several product lines form a heterogeneous network (concerning multi vendor). This network has its own characteristics. The coordination of a heterogeneous network is considered at layer 2. This layer concerns the entities network and its characteristics as distinguished in the NWS of the NM-taxonomy.

★ A network service. A service that is based upon the network, e.g. electronic mail and video on demand, has to be managed, controlled and maintained. Each network service has its own specific characteristics. The coordination of a network service is considered at layer 3. This layer concerns the entities network service and its characteristics as distinguished in the NWS of the NM-taxonomy.

★ The heterogeneous network and the network services. The heterogeneous network and the network services must be tuned to each other. The procedures for utilization and the requirements concerning the services that are formulated by users in contracts must be considered also. The coordination of the heterogeneous network and the network services is considered at layer 4. This layer concerns the entities user, requirements (that have to be formulated in contracts) and procedures for utilization as distinguished in the NWS of the NM-taxonomy.

★ The policy concerning NM. The network services should contribute to the realization of business processes of a company, which are formulated in the goals of a company. These goals are transformed into preconditions for the NWS to realize this contribution. These preconditions influence the goal of NM and ask for a certain policy. The coordination of the policy concerning NM is considered at layer 5. This layer concerns the entity precondition as distinguished in the NWS of the NM-taxonomy.

The NM-model was built using operation paradigms that were interwoven using the
recursion principle. Each layer of the NM-model was modelled by an operation paradigm consisting of a controlled system, a control body, disturbances, observations, and control measures (section 3.3.1).

8.2.6 Expansion of the NM-model

The NM-model is expanded with the Service Level Management (SLM) process and the Change Management (CM) process. These processes were only mentioned in chapter 3 (section 3.5), therefore, these processes had to be considered in relation to the NM-model to cope with changes that cause evolution of the network and the network services.

The NM-model was considered in detail concerning the SLM process and CM process based on experiences gained from the two descriptive case studies: the outsourcing of the VROM network (see chapter 4) and the handling of changes at RCC (see chapter 5).

The NM-model in detail concerning Service Level Management

The outsourcing of the VROM network showed the impact of several disturbances caused by external influences. Two of these influences were a managerial influence and a contractual influence.

A managerial influence caused the initiation of the outsourcing of the VROM network. The management of the VROM department decided to outsource its network in order to concentrate its attention on its core business.

The contractual influence was related to the outsourcing of the VROM network, namely contracts had to be formulated and guarded. The formulation and the guarding are activities in the SLM process.

Outsourcing had to be divided into phases and steps to avoid nuisance caused by the various disturbances that occurred as consequence of the external influences. Outsourcing was therefore subdivided into four phases, which were further subdivided into steps.

The steps were considered to be control measures at all layers of the NM-model.

Concluding the expansion of the NM-model concerning Service Level Management and outsourcing: the NM-model was further detailed and expanded concerning the SLM process, based on experiences gained from the outsourcing of the VROM network, with:

- A subdivision of an outsourcing into phases to guide an outsourcing step by step. These steps were related to the control measures in the NM-model.
- A process description of the SLM process. The activities distinguished in the process description were part of the steps considered in the phases recognized.

The NM-model in detail concerning Change Management

The RCC case showed the importance of the determination of the impact of changes. Therefore the impact had to be analyzed for each change. At each layer of the NM-model changes were distinguished that had a impact on specific components of the NWS. Changes were also divided into two categories of changes: M1 and M2.
changes. M1 changes have effect on the Network System (Controlled System) and M2 changes also have effect on the Network Management System (Controlled Body).

Concluding the expansion of the NM-model concerning Change Management: the NM-model was further detailed and expanded concerning the CM process, based on experiences gained from the handling of changes at RCC, with:

- A subdivision of changes into five kind of changes based on the five layers of the NM-model and a subdivision of changes into two categories: M1 and M2 changes.
- A process description of the CM process to handle of changes. The activities recognized in the process description are control measures at each layer of the NM-model.

8.2.7 Applicability of the expanded NM-model

The applicability of the expanded NM-model is described in this section based on three test case studies executed at the following organizations: GemNet, Getronics and Robeco.

GemNet
Changes were initiated on all five layers when the creation of the GemNet network was outsourced. In the GemNet case the steps defined to support the handling of changes caused by outsourcing were followed at each layer of the NM-model. Some steps were not considered in case of the outsourcing of the creation of the GemNet network, which resulted in imperfections (chapter 6, section 6.3).

Research finding 6 Imperfections that occurred with the outsourcing of the creation of the GemNet network and its NM could have been prevented if all the steps of the phases for outsourcing had been applied.

The agreements between the service provider, RCC, and the customer, the GemNet organization were important for the outsourcing of the creation of the GemNet network, therefore, the Service Level Management process was considered in detail at layer 4 of the NM-model (section 6.3.2). The activities considered in the SLM process, that were a part of the steps defined, were all performed in the case of GemNet.

Research finding 7 The subdivision into phases was shown to be applicable to the outsourcing of an existing network (VROM case study) and also to the outsourcing of a network that has to be built or expanded (GemNet case study).

Getronics
In the Getronics case the subdivision of changes was used to make a distinction between changes based on their impact to NM and the requirements that were formulated in contracts with customers of Getronics. This distinction was shown to be useful when decisions had to be made whether or not to implement a change (section 7.4.1).

Information required for the decision making concerning changes was based on the
five layers of the NM-model. At each layer information had to be obtained to support the decision making concerning changes.

Robeco

In the Robeco case study the activities of the Change Management process were used to follow two changes (chapter 7, section 7.1): the renewal of the data network, and the integration of the data and voice network. All activities were recognized when handling these two changes.

Research finding 8 The three test case studies did not provide elements that were not already in the NM-model when considering the Service Level Management process in the GemNet case and the Change Management process in the Robeco case and Getronics case, nor did the three case studies provide refutations of elements defined in the NM-model.

8.2.8 Research answers

The research questions were formulated in section 1.5.2 and repeated in section 8.1.1. The general research question tackled the problem of how managers can be supported with regard to the organization of Network Management (NM) of evolving heterogeneous networks and network services based upon these networks.

This research has shown that this problem can be solved when managers use the NM-taxonomy and the NM-model, outlined in this thesis.

NM-taxonomy

The NM-taxonomy can be used by management to describe a particular NM organization and its environment in a standard manner. Using the NM-taxonomy management should be able to:

- Recognize a Real System (RS), a Network System (NWS), and an Network Management System (NMS) and their position and dependencies.
- Recognize external influences that cause evolution.
- Compare different situations based on the entities present.
- Check if there are shortcomings in the present situation by going through the entities, which are then used as a checklist.

_and specific in relation to Service Level Management:

- Compare different situations concerning Service Level Management based on the entities recognized.
- Check if there are shortcomings in the situation present concerning Service Level Management by going through the added entities, which can be used as a checklist.

_and specific in relation to Change Management:

- Compare different situations concerning Change Management based on the entities recognized.
- Check if there are shortcomings of the situation present concerning Change Management by going through the added entities, which can be used as a checklist.
NM-model

The NM-model can be used by management to distinguish the dynamics of the network and its NM caused by external influences. Using the NM-model management should be able to:

★ Consider evolution of heterogeneous networks by recognizing disturbances and control measures on all five layers.
★ Consider the actual realization of the NM in practice on a concrete level in stead of an abstract level.
★ Consider organizational aspects of NM by giving directives to organize NM in five parts (based on the five layers of the NM-model). These five parts also handled strategic and tactical aspects of NM.
★ Obtain information about the network and its services and their management, control and maintenance.

and specific in relation to Service Level Management:

★ Provide control measures at all layers of the NM-model in the form of phases and a subdivision into steps for the handling of an outsourcing of a network and its NM.
★ Consider organizational aspects of Service Level Management by giving directives to organize the Service Level Management process.
★ Provide control measures to perform Service Level Management.

and specific in relation to Change Management:

★ Distinguish several kind of changes based on their impact on the objects of Network System that change.
★ Distinguish two categories of changes based on the impact on the exploitation or utilization of the network and its services.
★ Consider organizational aspects of Change Management by giving directives to organize the Change Management process.
★ Provide control measures to perform Change Management at all five layers of the NM-model.

8.3 Future research

Possibilities to improve the NM-taxonomy and the NM-model are discussed respectively in sections 8.3.1 and 8.3.2. The fine tuning of the NM-model application is discussed in section 8.3.3. Ways to extend the NM-model are discussed in two sections. In section 8.3.4 the NM-model is related to the state model. In section 8.3.5 the focus is on other aspects of networks and network services.

8.3.1 Improvement and completion of the NM-taxonomy

The NM part of the NM-taxonomy was only detailed in this research according to two processes: the Service Level Management (SLM) process (chapter 4) and the Change Management (CM) process (chapter 5). In chapter 3 was stated that ten processes were of importance when performing NM, therefore the other eight processes viz. Network Service Management, Cost Management, Capacity Management, Contingency Planning, Availability Management, Help Desk, Problem Management, and Configuration Management, should also be included in the NM-taxonomy.
Evolution of heterogeneous networks is caused by external influences. These influences also have effects on the organization of NM, according to the management paradigm (figure 1.6). These external influences can also have impact on the NM-taxonomy which describes the organization of NM. The NM-taxonomy should be reconsidered in each application in future.

8.3.2 Improving and completion of the NM-model

The NM-model was only detailed in this research according to two processes: the Service Level Management (SLM) process (chapter 4) and the Change Management (CM) process (chapter 5). In chapter 3 was stated that ten processes were of importance when performing NM, therefore the other eight processes viz. Network Service Management, Cost Management, Capacity Management, Contingency Planning, Availability Management, Help Desk, Problem Management, and Configuration Management, should be described in detail to organize NM in total according to the philosophy of the NM-model.

The need for this completion is increased due to the dependency of the SLM process on information that has to be derived from the processes Cost Management, Capacity Management, Contingency Planning, and Availability Management (figure 3.12). It is essential for the actual implementation of the SLM process that these processes are also defined and implemented to justify the existence of the SLM process.

The processes at a specific layer have to be tuned to processes on other layers. This tuning can be realized by defining performance indicators concerning the quality, costs and functionality of the Controlled System in a specific layer. These performance indicators give information to higher layers. [Wijs95] defined performance indicators for each process. These performance indicators can be used for the coordination of a specific layer. They can also be used to compose generic performance indicators of a layer as a whole to pass on information to a higher layer of the NM-model.

Evolution is caused by external influences. These influences also have effects on the organization of NM, according to the management paradigm (figure 1.6). These external influence can also have impact on the NM-model which describes the organization of NM. The NM-model should be reconsidered in each application in future.

8.3.3 Fine tuning of the NM-model application

The actual performance and co-operation of the NM processes, that are part of the five layers of the NM-model, can be modelled using simulation techniques such as were used by [Wijs95] and [Jong96]. Experiences of simulations of NM processes at all layers of the NM-model should be used to fine tune the NM-model and its application. The control measures can be changed according to the findings of the simulation.

8.3.4 Beyond the state Maintenance

The NM-model was developed to cope with the evolution of heterogeneous networks, therefore the focus in this research was on the state Maintenance (M) (section 1.4.2).
The other states of the state model are also of importance when NM is considered in total. The NM-model can also be used to organize the state Exploitation (E) when defining control measures at all five layers. The control measures should react on the observations and disturbances that occur. Future research should define all control measures.

The NM-model gives no guidance to organize the state Utilization (U), only the interactions between the service supplier and the customer are defined on broad outlines. The interactions consist of the defining of Service Level Agreements, the service level reports, new or changed requirements or preconditions, problem, and questions. To organize these interactions the customer also has to perform management tasks which are part of Functional Management ([Looijen95]). These management tasks should also be defined in future research.

Another important issue, which is only mentioned in this thesis, is the determination of the objectives and strategy concerning NM, which concerns layer 5 of the NM-model (section 3.3.7). The objectives and strategy concerning NM is determined in the state Information Planning and Policy (IPP). The determination of the objectives and strategy concerning NM can be object of research for another dissertation.

8.3.5 Focus on other aspects concerning networks and network services

The aspects heterogeneity and evolution were considered in this thesis in relation to modelling the organization of NM. Other points of departure could also be the subject of future research that can be related to the NM-model.

- Security of networks ([Spruit96]) especially organizational aspects like procedures for authorization; technical aspects like encryption and firewalls have already been described.
- Costs of ownership of networks regarding the NM organization.
- Performance indicators in relation to the simulation of NM ([Jong96]).
- Network services that introduce a new functionality, like the World Wide Web (WWW) at Internet and electronic mail services ([Hendriks]).
- Aspects that concern the management of international networks ([Broek]).
- Technical implementations of services, e.g. the Client/Server-concept.

8.3.6 Generalize the NM-model

The NM-model described in chapter 3 should be tested for its ability to model the management, control and maintenance of infrastructures or information systems (IS) in general. The basics of the NM-model will also probably apply with some adaptations, if the Network System (NWS) is replaced by an IS.
Bibliografy


[Eveleens95a] Eveleens, Cees, Integratie van communicatievoorzieningen, onderzoekstaak, 12 juni 95 (in Dutch).


[Pink94] Pink Elephant education development bv, ITIL Essentials, Voorburg, 1994


Summary in Dutch

Modellering van wijzigingsbeheer van evoluerende heterogene netwerken

Veel organisaties vertrouwen tegenwoordig op communicatienetwerken voor de realisatie van hun bedrijfsdoelstellingen; hetgeen betekent dat deze netwerken van cruciaal belang zijn voor de continuïteit van deze organisaties. Het is daarom essentieel dat deze netwerken worden beheerd op basis van goed gedefinieerde eisen en randvoorwaarden.

De communicatienetwerken worden gekenmerkt door evolutie en heterogeniteit. De evolutie wordt veroorzaakt door gebruikers die hun eisen aan de netwerkdienstverlening veranderen, door gewijzigde bedrijfsdoelstellingen die resulteren in andere randvoorwaarden en door leveranciers die de karakteristieken van netwerkcomponenten wijzigen. De heterogeniteit van een netwerk wordt veroorzaakt door een diversiteit aan netwerkcomponenten met verschillende karakteristieken.

Het doel van netwerkbeheer is dan ook om de complexiteit die met name gekenmerkt wordt door heterogeniteit en dynamiek, veroorzaakt door de evolutie, beheerbaar te houden. Het beheer van evoluerende heterogene netwerken is het onderwerp van dit onderzoek.

De doelstellingen van het onderzoek zijn tweeledig, namelijk om:

* evoluerende heterogene netwerken en het beheer daarvan te analyseren en te beschrijven;
* modellen te ontwikkelen die het management ondersteunen bij het beheer van evoluerende heterogene netwerken.

De onderzoeksopzet en de onderzoeksbevindingen worden in deze samenvatting beschreven.

Onderzoeksopzet

Het onderzoek is onderverdeeld in vijf fasen om het doel van het onderzoek te bereiken:

1) formuleren van onderzoeksvragen;
2) uitvoeren van een literatuurstudie;
3) ontwikkelen van voorschrijvende modellen;
4) uitvoeren van beschrijvende case studies;
5) uitvoeren van toetsende case studies.

Ad 1) **Formuleren van onderzoeksvragen**

De eerste fase in het onderzoek betreft de formulering van de onderzoeksvragen. De volgende algemene onderzoeksvraag is gebaseerd op de doelstelling van dit onderzoek:

**Algemene onderzoeksvraag:**
_Hoe kan management ondersteund worden bij de organisatie van netwerkbeheer van evoluerende heterogene netwerken en de daarop gebaseerde netwerkdiensten?_

Het onderzoek is verdeeld in drie delen, die elk hun eigen specifieke aandachtsgebied hebben en tevens ingaan op een specifieke onderzoeksvraag. Deze onderzoeksvragen zijn afgeleid van de algemene onderzoeksvraag.

In deze onderzoeksvragen komen twee processen aan de orde; het betreft de processen Service Level Management (SLM) en Change Management (CM). Deze twee processen zijn beschouwd vanwege het feit dat wijzigingen van het netwerk en de daarop gebaseerde dienstverlening, die evolutie veroorzaken, voornamelijk afgehandeld worden door middel van deze twee processen.

**Service Level Management**
Het eerste deel van het onderzoek gaat in op de evolutie en heterogeniteit die ontstaan is door het uitbesteden van een netwerk en het beheer daarvan. Dit leidt tot een verscheidenheid aan wijzigingen van verschillende aard die alle moeten worden afgehandeld door de beheerorganisatie. De heterogeniteit van het netwerksysteem kan vergroot worden bij deze wijzigingen: een diversiteit aan netwerkcomponenten, netwerkdiensten en netwerkgebruikers als gevolg van uitbesteding van een netwerk en het beheer daarvan.

De onderzoeksvraag van het eerste deel van het onderzoek is als volgt geformuleerd:

**Specifieke onderzoeksvraag 1:**
_Hoe kan management ondersteund worden bij de afhandeling van door uitbesteding veroorzaakte wijzigingen in het netwerk en de netwerkdiensten?_

Het doel van dit deel van het onderzoek is om een model te ontwikkelen voor de ondersteuning van het management bij het beheer van wijzigingen die veroorzaakt worden door uitbesteding van het netwerk. De nadruk ligt op de reorganisatie van het beheer. Het ontwikkelde model gaat voornamelijk in op het Service Level Management proces met betrekking tot de contractuele aspecten van uitbesteding.
Change Management
Het tweede deel van het onderzoek gaat in op de evolutie en heterogeniteit veroorzaakt door externe invloeden.
De onderzoeks vraag van het tweede deel van het onderzoek is als volgt geformuleerd:

Specifieke onderzoeks vraag 2:
_Hoe kan management ondersteund worden bij de afhandeling van wijzigingen in het netwerk en netwerkdiensten die veroorzaakt worden door externe invloeden?

Het doel van dit deel van het onderzoek is om een model te ontwikkelen dat de afhandeling van deze wijzigingen ondersteunt in relatie tot het Change Management proces. De nadruk in dit tweede deel ligt op het ondersteunen van het beslissingsproces betreffende deze wijzigingen. 'To implement or not to implement? That is the question!' Informatie moet verkregen worden om het management te ondersteunen bij het maken van weloverwogen beslissingen. De consequenties van een wijziging moeten bepaald kunnen worden op basis van die informatie.

Toetsing
Tot slot het derde deel van het onderzoek: de toetsing van de ontwikkelde modellen.
Het doel van dit deel van het onderzoek is om de ontwikkelde modellen in de praktijk te toetsen aan andere gevallen om daarmee de bruikbaarheid, correctheid en compleetheid van de modellen te verifiëren.

Specifieke onderzoeks vraag 3:
_Voldoen de ontwikkelde modellen ook in situaties buiten de onderzoeksomgeving?

De drie specifieke onderzoeksvragen vormen de basis voor de volgende fasen van het onderzoeksopzet.

Ad 2) Uitvoeren van een literatuurstudie
De tweede fase in het onderzoek betreft een literatuurstudie die gericht is op het verkennen van bestaande richtlijnen op het gebied van het beheer van evoluerende heterogene netwerken. Deze richtlijnen worden geanalyseerd om tekortkomingen te kunnen vaststellen betreffende het beheer van deze netwerken in relatie tot de geformuleerde onderzoeksvragen.
Drie sleutelwoorden voor de literatuurstudie waren: evolutie, heterogeniteit en netwerkbeheer. Literatuur is bestudeerd om de volgende vragen te beantwoorden:
★ Wat wordt verstaan onder _evolutie_ volgens de literatuur?
★ Wat veroorzaakt _evolutie_ volgens de literatuur?
★ Welke richtlijnen voor het beheren van _evolutie_ zijn beschreven in de literatuur?
★ Wat wordt verstaan onder _heterogeniteit_ volgens de literatuur?
★ Welke richtlijnen voor het beheren van _heterogeniteit_ zijn beschreven in de literatuur?

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* Wat wordt verstaan onder netwerkbeheer volgens de literatuur?
* Welke richtlijnen om het management te ondersteunen bij het uitvoeren van netwerkbeheer zijn beschreven in de literatuur?

De bevindingen van de literatuurstudie zijn gebruikt om het onderzoek toe te spitsen op voorschrijvende modellen die nodig zijn om service level management en change management te ondersteunen.

Ad 3) Ontwikkelen van voorschrijvende modellen

De derde fase in het onderzoek betreft de formulering van voorschrijvende modellen om de tekortkomingen van de gevonden modellen in de literatuur te ondervangen. De belangrijkste tekortkoming in de bestaande modellen is het gemis aan ondersteuning bij het afhandelen van evolutie binnen heterogene netwerken. Voorschrijvende modellen zijn echter essentieel en onmisbaar bij het nemen van beslissingen op managementniveau. Het toenemende strategische belang van netwerken, de toenemende kosten en complexiteit van netwerken die wordt veroorzaakt door heterogeniteit en evolutie hebben namelijk tot gevolg dat het management niet langer in staat is om, zonder geschikte modellen en richtlijnen, te bepalen wat vereist is voor netwerkbeheer.

Om bovenstaand vraagstuk op te lossen zijn in dit onderzoek twee modellen ontwikkeld. Een eerste opzet van twee algemene modellen, de NM-taxonomie en het NM-model, is ontwikkeld om organisatorische problemen als gevolg van heterogeniteit en evolutie van netwerken te kunnen ondervangen. Deze eerste opzet is nader beschouwd in twee beschrijvende case studies.

Ad 4) Uitvoeren van beschrijvende case studies

De vierde fase in het onderzoek betreft de uitvoering van twee beschrijvende case studies waarin de NM-taxonomie en het NM-model zijn toegepast. Het doel is om de eerste opzet van deze modellen in detail te beschouwen met betrekking tot de evolutie van heterogene netwerken gebaseerd op bevindingen in de praktijk. De uitbesteding van het VROM netwerk en de afhandeling van wijzigingen bij het RCC netwerk zijn beschouwd in de twee case studies. Deze case studies zijn geselecteerd vanwege hun relatie tot de eerste twee specifieke onderzoeksvragen.

Service Level Management

In de eerste beschrijvende case studie is de uitbesteding van het VROM netwerk beschouwd.

De uitbesteding van het VROM netwerk heeft geleid tot een grote verscheidenheid aan wijzigingen. Deze wijzigingen waren zowel van technische als van organisatorische aard. De integratie van het VROM netwerk en het RCC netwerk resulteerde in een netwerk met grotere heterogeniteit. Voorts diende eveneens de organisatie van netwerkbeheer bij RCC aanzienlijk gewijzigd te worden om het netwerkbeheer van het VROM netwerk adequaat te kunnen inrichten.

Het doel van de case studie was om de NM-taxonomie en het NM-model nader te bezien en uit te breiden met betrekking tot de uitbesteding van een netwerk en het
beheer daarvan. De nadruk lag op de reorganisatie van het netwerkbeheer en in het bijzonder op het Service Level Management (SLM) proces.

**Change Management**

In de tweede beschrijvende case studie bij RCC is de afhandeling van netwerkwijzigingen die veroorzaakt werden door externe invloeden beschouwd. Evolutie is beschouwd door het realiseren van wijzigingen aan het netwerk en de netwerkdiensten. Het doel van de case studie is om de NM-taxonomie en het NM-model in detail te beschouwen met betrekking tot de afhandeling van wijzigingen in het algemeen. De nadruk lag op het ondersteunen van de besluitvorming inzake het Change Management proces.

**Ad 5) Uitvoeren van toetsende case studies**

De vijfde fase in het onderzoek betreft de uitvoering van drie toetsende case studies die als doel hebben om de uitgebreide NM-taxonomie en het uitgebreide NM-model te controleren op bruikbaarheid, correctheid en compleetheid. Deze drie case studies moesten leiden tot een eventuele aanpassing en verfijning van de NM-taxonomie en het NM-model op basis van ervaringen die opgedaan waren bij de toepassing van de NM-taxonomie en het NM-model in de praktijk. Deze vijfde fase gaat in op de derde specifieke onderzoeksvraag.

**Service Level Management**

De eerste case studie betreft de uitbesteding van de ontwikkeling van het GemNet netwerk. De GemNet organisatie besliste om haar netwerk uit te besteden. Het ontwerp en het beheer van dit netwerk moesten nog in zijn geheel worden ontwikkeld. De focus van deze case studie is derhalve voornamelijk op de validatie van het NM-model betreffende het SLM proces; het maken van afspraken met een leverancier betreffende de kwaliteit, functionaliteit en kosten van het te ontwikkelen en te beheren netwerk.

**Change Management**

De tweede case studie betreft de afhandeling van wijzigingen bij Getronics waarbij de nadruk ligt op de validatie van de beschrijving van het Change Management proces in relatie tot het NM-model.

De derde case studie betreft de afhandeling van wijzigingen bij de Robeco Groep, die hoofdzakelijk ingaat op de validatie van het NM-model met betrekking tot het Change Management proces. In deze case studie zijn derhalve twee wijzigingen die zich voordeden bij de Robeco Groep beschouwd. De wijzigingen betroffen de herziening van het datanetwerk en de integratie van het data en voice netwerk.

**Onderzoeksbevindingen**

De doelstelling van het onderzoek is modellen te ontwikkelen die het beheer van evoluerende heterogene netwerken ondersteunen. Daartoe zijn twee algemene modellen, de NM-taxonomie en het NM-model, ontwikkeld.

Voorafgaand aan de beschrijvingen van de NM-taxonomie en het NM-model en de
bevindingen van de toepassingen van deze modellen zijn de bevindingen van de literatuurstudie beschreven. Daarna wordt de structuur van de NM-taxonomie en het NM-model uiteengezet, waarna beide structuren uitgebreid worden door twee processen die gebaseerd zijn op twee beschrijvende case studies. Het betreft de processen Service Level Management en Change Management. De toepasbaarheid van de NM-taxonomie en het NM-model zijn beschreven aan de hand van drie toetsende case studies. Tot slot is aangegeven hoe de NM-taxonomie en het NM-model gebruikt kunnen worden door het management als ondersteuning bij het nemen van beslissingen over het beheer van evoluerende heterogene netwerken.

Bevindingen uit de literatuurstudie

Literatuur is bestudeerd betreffende evolutie, heterogeniteit en netwerkbeheer. De bevindingen van de literatuurstudie betreffende deze drie aspecten zijn hieronder geformuleerd. Aan de hand van de literatuurstudie blijkt dat de literatuur niet volledig ingaat op aspecten die te maken hebben met evolutie, heterogeniteit en netwerkbeheer.

Evolutie

_Evolutie volgens de literatuur_

Evolutie is gedefinieerd in de literatuur als de transitie, via kleine veranderingen, tot een gedifferentieerde en complexe structuur. In de context van dit onderzoek dient de gedifferentieerde en complexe structuur te leiden tot een aanpassing van het netwerk om het volgende te verbeteren:

- vervulling van de eisen en randvoorwaarden zoals gesteld vanuit het gebruik;
- kwaliteit van netwerkdiensten;
- prijs in verhouding tot prestaties;
- concurrentiepositie.

_Oorzaken van evolutie volgens de literatuur_

Evolutie wordt veroorzaakt door 'driving forces' en contingentie factoren. De 'driving forces' resulteren in verandering van het netwerk en/of de netwerkdiensten. Een 'driving force' is bijvoorbeeld de zeer snel veranderende technologie betreffende de netwerken en netwerkdiensten. Niet alleen de functionaliteit verandert drastisch en resulteert in nieuwe netwerkdiensten, maar ook de prestaties van de netwerkcomponenten en het netwerk in zijn totaliteit worden continu verbeterd om nieuwe netwerkdiensten aan te kunnen bieden. Contingentie factoren beïnvloeden een organisatie en het beheer van het netwerk in die organisatie door verandering van eisen en randvoorwaarden die gesteld worden aan zowel het netwerk als de netwerkdiensten.

_Richtlijnen voor het beheren van evolutie volgens de literatuur_

Richtlijnen om te kunnen omgaan met evolutie van netwerken zijn niet gevonden in de literatuur.

_Onderzoeksbevinding 1 Tekortkoming: Hoe om te gaan met de 'driving forces' en contingentie factoren om evolutie te kunnen beheersen werden niet gevonden in de literatuur._
Heterogeniteit

**Heterogeniteit volgens de literatuur**
Heterogeniteit verwijst naar de diversiteit aan componenten. Er worden vier soorten onderscheiden, afhankelijk van de soort component:

- *multi vendor heterogeniteit* refererend aan de netwerk componenten die geleverd worden door verschillende leveranciers;
- *multi fabric heterogeniteit* refererend aan de verschillende soorten bekabeling in het netwerk;
- *multi protocol heterogeniteit* refererend aan de diversiteit van protocollen die gebruikt worden om data te verzenden in een vooraf gedefinieerd formaat;
- *multi functionality heterogeniteit* refererend aan de netwerkdiensten die verschillende functionaliteiten leveren.

**Richtlijnen voor het beheren van heterogeniteit volgens de literatuur**
Alleen de diversiteit aan netwerkcomponenten betreffende de leveranciers en de diversiteit aan protocollen zijn beschouwd in de literatuur en wel voornamelijk de technische problemen die zich daarbij voordoen. Heterogeniteit met betrekking tot multi protocol en multi fabric wordt verondersteld een technisch probleem te zijn met bijbehorende technische oplossingen; derhalve zijn deze soorten van heterogeniteit niet beschouwd in dit onderzoek. Organisatorische problemen die samengaan met multi vendor en multi functionaliteit heterogeniteit zijn niet belicht in de literatuur.

**Onderzoeksbevinding 2 Tekortkoming: Organisatorische problemen betreffende multi vendor en multi functionaliteit heterogeniteit zijn niet gevonden in de literatuur. Alleen technische problemen betreffende heterogeniteit worden beschouwd in de literatuur.**

**Netwerkbeheer**

**Netwerkbeheer volgens de literatuur**
Verscheidene definities van netwerkbeheer zijn aangetroffen in de literatuur. In dit onderzoek is netwerkbeheer gedefinieerd analoog aan het beheer van informatiesystemen zoals gedefinieerd in [Looijen96] als:

> Beheer van netwerken (netwerkbeheer) is de instandhouding van de netwerksysteemcomponenten apparatuur, programmataruut, gegevensverzamelingen en procedures en bijbehorende gegevensverwerkings- en informatieveoorzieningsprocessen overeenkomstig eisen en randvoorwaarden gesteld vanuit het gebruik en rekening houdend met de karakteristieken van de genoemde netwerksysteemcomponenten en de mensen die deel uitmaken van de netwerksystemen evenwijdig gebruik maken van deze systemen.

**Richtlijnen om het management te ondersteunen bij netwerkbeheer volgens de literatuur**
Vijf bestaande modellen voor ondersteuning van het beheer van IT infrastructuurcomponenten zijn beschouwd in dit onderzoek.
Het betreft: OSI Netwerk Management, Telecommunication Management Networks (TMN), OMNIPoint, IT Infrastructure Library (ITIL), het drievoudig model van beheer en het DUnet Management Model. Deze modellen zijn met elkaar vergeleken gebruikmakend van vijf succesfactoren: NM architectuur, NM functies/taken, NM instrumentaria, organisatorische componenten en organisatorische aanpak. De tekortkomingen van de modellen zijn door middel van deze vergelijking gevonden.

Onderzoeksbevinding 3 Tekortkoming: de vijf modellen waren inadequaat om het beheer van evoluerende heterogene netwerken te modelleren vanwege de volgende tekortkomingen:
- geen van de modellen ging in op het voortschrijdende karakter waar evoluerende netwerken door gekenmerkt worden;
- de modellen beschrijven netwerkbeheer alleen op een abstract niveau; de daadwerkelijke realisatie van netwerkbeheer in de praktijk wordt niet beschouwd;
- de modellen richten zich voornamelijk op de technische aspecten van netwerkbeheer, organisatorische aspecten waren sterk onderbelicht;
- strategisch en tactisch netwerkbeheer zijn nauwelijks gedefinieerd.

De NM-taxonomie in grote lijnen

De NM-taxonomie is gebaseerd op het beheerparadigma ([Looijen95]) waarin drie systemen onderscheiden worden: het reële systeem, het informatiesysteem en het beheersysteem. In geval van het onderzoek is er sprake van een netwerksysteem in plaats van een informatiesysteem. Elk van deze drie systemen is beschouwd in meer detail door het specificeren van entiteiten en hun onderlinge relaties. De NM-taxonomie heeft tot doel om een specifieke beheerorganisatie en de omgeving op eenduidige wijze te beschrijven.

Het reële systeem
Het reële systeem (RS) betreft de reële, primaire processen van een bedrijf, zoals bijvoorbeeld het transport van grondstoffen.


Het netwerksysteem
Het doel van het netwerksysteem (NWS) is het besturen, het verbeteren en het verkennen van het reële systeem afgebakend op communicatieaspecten.

De volgende entiteiten worden beschouwd in het NWS: netwerk, netwerk componenten, netwerkdienst, gebruiker, gebruiksprocedure, eis, randvoorwaarde en karakteristiek.

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Het beheersysteem
Het beheersysteem omvat het beheer van netwerken in overeenstemming met de eisen en randvoorwaarden die gesteld worden vanuit het gebruik en met de karakteristieken van de netwerkcomponenten.

De volgende entiteiten worden beschouwd in het beheersysteem: beheerdooel, beheertaak, beheerproces, beheerprocedure, beheerder en beheerhulpmiddel.

Externe invloeden
Vier soorten externe invloeden worden beschouwd: bestuurlijke, contractuele, economische en technische invloeden. Deze externe invloeden veroorzaken verstoringen die worden onderkend in het NM-model.

Uitbreiding van de NM-taxonomie

De NM-taxonomie is nader uitgewerkt met betrekking tot de processen Service Level Management (SLM) en Change Management (CM). Deze processen zijn beschouwd in verband met hun relatie tot wijzigingen die evolutie van netwerken en netwerkdiensten veroorzaken.

De uitwerking is gebaseerd op ervaringen die opgedaan zijn in de twee beschrijvende case studies: de uitbesteding van het VROM netwerk en de afhandeling van wijzigingen bij RCC.

De NM-taxonomie in detail betreffende Service Level Management
Het beheersysteem van de NM-taxonomie is uitgebreid met entiteiten die van belang zijn voor het SLM proces gebaseerd op de beschrijvende case studie ‘De uitbesteding van het VROM netwerk’. De volgende entiteiten worden beschouwd in het beheersysteem, naast de eerder genoemde entiteiten, wanneer het SLM proces wordt beschouwd: service level manager, service level management, service level rapportage, soort eis, service agreement, service level agreement, financiële aspecten, afspraken en procedures. Deze entiteiten zijn een specialisatie/verbijzondering van de entiteiten zoals onderkend in het beheersysteem van de NM-taxonomie.

De NM-taxonomie in detail betreffende Change Management
Het beheersysteem van de NM-taxonomie is uitgebreid met entiteiten die van belang zijn voor het CM proces, gebaseerd op de beschrijvende case studie ‘Wijzigingsafhandeling bij RCC Netwerk Services’. De volgende entiteiten worden onderscheiden in het netwerksysteem, naast de entiteiten die al eerder genoemd zijn: change management, change manager, invloed, wijzigingsverzoek, middel, planning, soort onderhoud, wijziging, W1 wijziging, W2 wijziging. Deze entiteiten zijn een specialisatie/verbijzondering van de entiteiten zoals onderkend in het beheersysteem van de NM-taxonomie.

Toepasbaarheid van de NM-taxonomie

De twee beschrijvende case studies hebben geleid tot een uitbreiding van de NM-taxonomie met entiteiten en hun onderlinge relaties betreffende de processen Service
Level Management en Change Management. De toepasbaarheid van de uitgebreide NM-taxonomie is beschreven in deze paragraaf en is gebaseerd op drie toetsende case studies: de uitbesteding van de ontwikkeling en beheer van het GemNet netwerk, de afhandeling van wijzigingen bij Getronics en de afhandeling van wijzigingen bij de Robeco Groep. In elke case studie zijn de entiteiten zoals onderkend in de uitgebreide NM-taxonomie gebruikt om te beschrijven hoe de situatie was op het moment dat het onderzoek uitgevoerd werd.

GemNet
In de GemNet case studie zijn tekortkomingen gevonden met behulp van de uitgebreide NM-taxonomie. De enige SLM activiteiten die bij RCC werden uitgevoerd waren de formulering van contracten en de periodieke rapportage; andere activiteiten werden niet onderkend in de beheerprocedures. De functie service level manager werd niet onderkend bij RCC. De aanwezige beheerhulpmiddelen boden niet voldoende ondersteuning om de beheeractiviteiten (zoals onderkend in de beheerprocedures) optimaal uit te kunnen voeren.

Getronics
In de Getronics case studie zijn tekortkomingen gevonden gebruikmakend van de uitgebreide NM-taxonomie. Gebruiksprescedures werden namelijk niet onderkend in het netwerksysteem bij Getronics. Deze procedures moesten gecreëerd worden om gebruikers te ondersteunen bij het gebruik van het netwerk. De karakteristieken van het netwerk en de netwerkdiesten waren niet gedocumenteerd. Een beheerprocedure voor het afhandelen van wijzigingen was dan ook niet aanwezig toen dit onderzoek werd uitgevoerd.

Onderzoeksbevinding 4 Tekortkomingen betreffende SLM en CM hadden met behulp van de uitgebreide NM-taxonomie ontdekt kunnen worden.

Robeco
In de Robeco case studie zijn alle entiteiten, die in de uitgebreide NM-taxonomie werden onderkend, teruggevonden toen het Change Management proces werd beschouwd op basis van twee wijzigingen.

Onderzoeksbevinding 5 De case studies hebben geen entiteiten opgeleverd bij het beschouwen van de processen Service Level Management en Change Management. Eveneens zijn er geen tegenspraken gevonden met betrekking tot de onderkende entiteiten in de NM-taxonomie.

Het NM-model in grote lijnen
Het NM-model heeft tot doel om een adequaat netwerkbeheer te realiseren. De complexiteit met betrekking tot het beheer van de evolutie en heterogeniteit van het netwerksysteem is uiteenengerafeld door het netwerksysteem (NWS) in vijf samenhangende delen op te splitsen. Deze splitting is gebaseerd op de entiteiten zoals die onderkend zijn in de NM-taxonomie. Dit leidt tot betere controle over activiteiten die uitgevoerd dienen te worden om het netwerk adequaat te beheren.
De volgende delen van het netwerksysteem worden beschouwd:

- Een apparatuurlijn. Een apparatuurlijn bevat netwerkcomponenten die afkomstig zijn van 1 leverancier; dus een apparatuurlijn is niet heterogeen betreffend multi vendor. De coördinatie van een apparatuurlijn is beschouwd op laag 1 van het NM-model.
  Deze laag betreft de entiteiten netwerkcomponent en karakteristiek zoals onderkend in het netwerksysteem van de NM-taxonomie.

  De coördinatie van een heterogeen netwerk is beschouwd op laag 2 van het NM-model.
  Deze laag betreft de entiteiten netwerk en karakteristiek zoals onderkend in het netwerksysteem van de NM-taxonomie.

  De coördinatie van een netwerkdienst is beschouwd op laag 3 van het NM-model.
  Deze laag betreft de entiteiten netwerkdienst en karakteristiek zoals onderkend in het netwerksysteem van de NM-taxonomie.

- Een heterogeen netwerk en de netwerkdiensten. Het heterogene netwerk en de netwerkdiensten moeten op elkaar afgestemd worden. De gebruikspriorities en de eisen betreffende de diensten die geformuleerd zijn door de gebruikers in contracten, dienen ook beschouwd te worden. De coördinatie van het heterogene netwerk en de netwerkdiensten is beschouwd op laag 4 van het NM-model.
  Deze laag betreft de entiteiten gebruiker, eis (zoals geformuleerd in contracten) en gebruiksprioriteit zoals onderkend in het netwerksysteem van de NM-taxonomie.

- Een beleid betreffende netwerkbeheer. De netwerkdiensten moeten bijdragen aan de realisatie van de bedrijfsprocessen die geformuleerd zijn in de doelstelling van een bedrijf. Deze doelstelling is het uitgangspunt van eventuele randvoorwaarden voor het netwerksysteem. Deze randvoorwaarden beïnvloeden het doel van netwerkbeheer en vragen om een specifiek beleid. De coördinatie van het beleid met betrekking tot netwerkbeheer is beschouwd op laag 5 van het NM-model.
  Deze laag betreft de entiteit randvoorwaarde zoals onderkend in het netwerksysteem van de NM-taxonomie.

Het NM-model is opgebouwd door gebruik te maken van besturingsparadigma’s die met elkaar verweven zijn door middel van het recursieprincipe. Elke laag van het NM-model is gemodelleerd door een besturingsparadigma die bestaat uit een bestuurd systeem en een besturend orgaan, verstoringen, observatie en stuurmaatregelen.

Uitbreiding van het NM-model

Het NM-model is nader uitgewerkt met betrekking tot de processen Service Level Management (SLM) en Change Management (CM). Deze processen zijn beschouwd in verband met hun relatie tot wijzigingen die de evolutie van het netwerk met zich meebrengt.
De uitwerking van het NM-model is gebaseerd op ervaringen die zijn opgedaan uit de twee beschrijvende case studies: de uitbesteding van het VROM netwerk en de afhandeling van wijzigingen bij RCC.

Het NM-model in detail betreffende Service Level Management
De uitbesteding van het VROM netwerk toonde de gevolgen van diverse verstoringen die veroorzaakt werden door twee externe invloeden: een bestuurlijke en een contractuele invloed.

Een bestuurlijke invloed heeft de initiatie van de uitbesteding van het VROM netwerk veroorzaakt. Het ministerie van VROM besloot het netwerk uit te besteden om zich zodoende te kunnen concentreren op kerntaken.

De contractuele invloed was gerelateerd aan de uitbesteding van het VROM netwerk, namelijk contracten inzake de dienstverlening moesten geformuleerd en bewaakt worden. De formulering en de bewaking zijn activiteiten in het SLM proces.

De uitbesteding moest in fasen en stappen opgedeeld worden om hinder van verscheidene verstoringen die zich voordeden als consequentie van externe invloeden te vermijden. De uitbesteding is derhalve opgedeeld in vier fasen, die weer verder onderverdeeld zijn in stappen.

De stappen zijn gerelateerd aan specifieke lagen van het NM-model; ze zijn als het ware stuurmaatregelen op de vijf lagen van het NM-model.

Concluderend: het NM-model is verder gedetailleerd en uitgebreid met:

- een onderverdeling van een uitbesteding in fasen om een uitbesteding stap voor stap te begeleiden. De stappen zijn gerelateerd aan de stuurmaatregelen in het NM-model;
- een procesbeschrijving van het SLM proces. De activiteiten in de procesbeschrijving maken deel uit van de stappen in de vier fasen die onderkend worden bij een uitbestedingstraject.

Het NM-model in detail betreffende Change Management
De case studie 'Wijzigingsafhandeling bij RCC Netwerk Services' toonde het belang van het bepalen van de gevolgen van wijzigingen. In feite zouden de gevolgen van elke wijziging bepaald moeten worden. Wijzigingen op iedere laag van het NM-model worden gekenmerkt door gevolgen voor specifieke componenten van het netwerksysteem.


Concluderend: het NM-model is verder gedetailleerd en uitgebreid met:

- een onderverdeling van wijzigingen in vijf type wijzigingen die gebaseerd zijn op de vijf lagen van het NM-model en een opdeling van wijzigingen in de twee categorieën: W1- en W2-wijzigingen;
- een procesbeschrijving van het Change Management proces om wijzigingen af te handelen. De activiteiten die deel uitmaken van de procesbeschrijving zijn stuurmaatregelen op elke laag van het NM-model.
Toepasbaarheid van het uitgebreide NM-model

De toepassing van het uitgebreide NM-model is beschreven op basis van drie toetsende case studies die uitgevoerd zijn bij de volgende organisaties: GemNet, Getronics en Robeco.

**GemNet**

Wijzigingen zijn geëmitieerd op de vijf lagen van het NM-model bij de uitbesteding van het GemNet netwerk. In de GemNet case studie zijn de stappen gevolgd op alle lagen om de afhandeling van wijzigingen die veroorzaakt zijn door uitbesteding te ondersteunen. Enkele stappen zijn niet beschouwd in het geval van de uitbesteding van de ontwikkeling van het GemNet netwerk, dit resulteerde in tekortkomingen.

**Onderzoeksbevinding 6** Tekortkomingen die zich voordeden bij de uitbesteding van de realisatie van het GemNet netwerk en het bijbehorende netwerkbeheer, hadden voorkomen kunnen worden indien alle stappen waren toegepast.

De overeenkomsten tussen de dienstverlener, RCC, en de klant, de GemNet organisatie, waren belangrijk voor de uitbesteding van de ontwikkeling van het GemNet netwerk, vandaar dat het Service Level Management proces in detail is beschouwd op laag 4 van het NM-model. De activiteiten die onderscheiden zijn in het SLM proces, die deel uitmaakten van de gedefinieerde stappen, zijn volledig uitgevoerd bij GemNet.

**Onderzoeksbevinding 7** De onderverdeling in fasen is toepasbaar gebleken bij de uitbesteding van een bestaand netwerk (VROM case studie) en eveneens bij de uitbesteding van een netwerk dat nog ontwikkeld moet worden (GemNet case studie).

**Getronics**

In the Getronics case is de onderverdeling van wijzigingen gebruikt om onderscheid te maken tussen wijzigingen gebaseerd op hun gevolgen voor het netwerkbeheer. Dit onderscheid blijkt bruikbaar te zijn wanneer beslissingen genomen moeten worden voor het al dan niet doorvoeren van een wijziging.

De informatie benodigd voor het nemen van een beslissing is gebaseerd op de vijf lagen van het NM-model. Op elke laag dient informatie te worden verzameld om het beslissingsproces inzake wijzigingen te ondersteunen.

**Robeco**

In the Robeco case studie zijn de activiteiten van het Change Management proces gebruikt om twee wijzigingen te analyseren: de herinrichting van het data netwerk, en de integratie van het data en voice netwerk. Alle activiteiten werden onderkend bij de afhandeling van deze twee wijzigingen.

**Onderzoeksbevinding 8** De drie toetsende case studies leveren geen aanleiding om het NM-model uit te breiden of aan te passen.
Gebruik van de NM-taxonomie en het NM-model

De algemene onderzoeksvraag omvat het vraagstuk hoe het management ondersteund kan worden bij de organisatie van netwerkbeheer van evoluerende heterogene netwerken. Het onderzoek heeft aangetoond dat dit vraagstuk opgelost kan worden indien management gebruik maakt van de NM-taxonomie en het NM-model, zoals hiervoor beschreven.

In het navolgende wordt weergegeven hoe management gebruik kan maken van de NM-taxonomie en het NM-model.

NM-taxonomie
Het management kan de NM-taxonomie gebruiken om een specifieke beheerorganisatie en zijn omgeving op uniforme wijze te beschrijven. Gebruikmakend van de NM-taxonomie is het mogelijk om:

- een reëel systeem, een netwerksysteem en een beheersysteem en hun onderlinge relaties en afhankelijkheden te onderscheiden;
- externe invloeden die evolutie veroorzaken te onderscheiden;
- verschillende situaties te vergelijken aan de hand van de onderkende entiteiten;
- te controleren of er tekortkomingen zijn in de huidige situatie.

De NM-taxonomie kan eveneens gebruikt worden specifiek in relatie tot Service Level Management om:

- verschillende situaties betreffende Service Level Management te vergelijken die gebaseerd zijn op de onderkende entiteiten;
- te controleren of er tekortkomingen zijn in de huidige situatie betreffende Service Level management.

De NM-taxonomie kan eveneens specifiek in relatie tot Change Management gebruikt worden om:

- verschillende situaties betreffende Change Management te vergelijken die gebaseerd zijn op de onderkende entiteiten;
- te controleren of er tekortkomingen zijn in de huidige situatie betreffende Change Management.

NM-model
Het NM-model kan door het management gebruikt worden om de dynamiek, waarmee het beheer wordt geconfronteerd vanwege externe invloeden op het netwerk, te onderscheiden. Gebruikmakend van het NM-model is het mogelijk om:

- evolutie van heterogene netwerken te beschouwen door verstoringen en stuurmaatregelen op de vijf lagen te onderkennen;
- de daadwerkelijke realisatie van netwerkbeheer in de praktijk te beschouwen op een concreet niveau in plaats van op een abstract niveau;
- organisatorische aspecten van netwerkbeheer te beschouwen door het geven van richtlijnen om netwerkbeheer te organiseren in vijf delen (gebaseerd op de vijf lagen van het NM-model). Deze vijf delen behandelen ook strategische en tactische aspecten van netwerkbeheer;
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* informatie over het netwerk en de daarop gebaseerde dienstverlening tezamen met het beheer daarvan te verkrijgen.

Het NM-model kan eveneens specifiek in relatie tot Service Level Management gebruikt worden om:
* stuurmaatregelen op alle lagen van het NM-model te verschaffen in de vorm van fasen en een onderverdeling daarvan in stappen, om de wijzigingen die een uitbesteding van een netwerk met het bijbehorende beheer te ondersteunen;
* organisatorische aspecten van Service Level Management te beschouwen door het geven van richtlijnen voor het organiseren van het Service Level Management proces;
* stuurmaatregelen voor de uitvoering van Service Level Management te verschaffen.

Het NM-model kan eveneens gebruikt worden specifiek in relatie tot Change Management om:
* verschillende typen wijzigingen te onderscheiden die gebaseerd zijn op de gevolgen voor de veranderende objecten van het netwerksysteem;
* twee categorieën wijzigingen te onderscheiden die gebaseerd zijn op de gevolgen van die wijzigingen voor de exploitatie of voor het gebruik van het netwerk en de daarop gebaseerde diensten;
* organisatorische aspecten van Change Management te beschouwen door het geven van richtlijnen om het Change Management proces te organiseren;
* stuurmaatregelregelingen voor de uitvoering van Change Management te verschaffen op de vijf lagen van het NM-model.

Hieruit blijkt dat beide modellen een ondersteunende rol hebben in het kader van het beheer van evoluerende heterogene netwerken.
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He began his research project for this dissertation in September 1992, as part of a research project that was a cooperation between RCC Informationservices B.V. and Delft University of Technology. He performed much of his research at RCC in Apeldoorn from 1993 until 1996. During the research various presentations were given for both practioners and researchers. He has participated in several courses on information systems management, and he has coached several students working for their Master’s degree on information systems management.

At present he is working as a consultant within Interprom B.V., which is a company that focuses on (the implementation of) the management, control and maintenance of multi vendor, open IT infrastructures.
Acknowledgements

Many people have contributed to the research project described in this dissertation. First of all I would like to thank Maarten Looijen for his ever critical but constructive support during the research project. We very frequently discussed the results of the research, despite the fact I was based in the east of the Netherlands for most of the research period.

Many thanks to my colleagues from the department of Information Systems, Marcel Spruit, Wouter de Jong, and Bert Geers, who provided a willing ear whenever I needed one. Especially my fellow Ph.D. students Rob Mersel, Cees de Wijs, and Floris van den Broek, with whom I spend many nights in Delft discussing the research programme of the Management, Control and Maintenance of Information Systems.

I would also like to thank the management of RCC for the facilities they offered me during the research. Especially the members of the steering committee: Kees Verhoeven, George Smits, Steven Huigens, and Ludy Pasman, who were always ready to enter into critical discussions concerning the case studies performed at the RCC organization.

"My isolated position" as I have called it, was minimized by colleagues at RCC (Network Services). Especially Wendy van Campen, Manon Eenink, and Ron Verburg I want to thank for their support and inspiration they gave me.

"No man is an island, entire of it self" (Donne, Meditation XVII)

Besides RCC a number of Dutch organizations agreed to cooperate in the case studies. I would like to thank the persons who created the necessary commitment within the case study organizations: Jan Vermeulen, and Jan Willem Kalkman (NSO), Fred de Goede (Getronics), Peter Dammers and, Willem Mooijekind (Robeco Group).

Several students from the department of Information Systems contributed to this research project in the organisations mentioned above. They provided me with empirical data and refreshing ideas. I would like to mention Frank van de Aart, William de Vries, Ard Jan Hartman, and Cees Eveleens.

I would like to thank the management of InterProm, Godfried Beek, Marco Lesmeister, Pieter Hoenderken, and Mart Rovers, who gave me the opportunity to finish this dissertation.
Acknowledgements

Special thanks to Bram Roke, Erik Kohl, Rob Mersel, and Danny Appelboom who have supported me during the writing process with elaborate comments and profound discussions.

I would like to thank Miranda Aldham-Breary in particular for her endeavours to make this thesis more readable. Without her help this thesis would have been written in a language that only looked like English. Now even Japanese readers should be able to understand the dissertation.

Last but not least, I would like to thank my parents, family, and friends for their everlasting support, and for the required distraction from the research. I would never have reached the finish without their support.

Louis van Hemmen
Klarenbeek, March 1997