The Development of a Reference Architecture for Local Government

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Abstract

Traditionally, government agencies are organized vertically around departments. Many local government agencies are looking for ways to develop an integrated architecture. Many architectural methods are available, however, they remain often abstract, provide limited support for the translation of the concepts to a concrete situation, and have limited visualization support to create a shared understanding.

In the research presented in this paper we describe the development of a reference enterprise architecture for a municipality using action research. Our development approach is based on modeling the interdependencies among, and within organization, business process, and application layer. We used discrete-event simulation, and animation to provide insight in the existing situation, and develop and create a shared understanding of the reference architecture.

1. Introduction

Traditionally, government agencies are organized vertically around departments. Cross-organizational processes can only be created by integrated information systems delivering timely and right information, and supporting cross-departmental processes. Systems are often development within departments without having in mind the big picture capturing the enterprise architecture of the whole organization. The existence of isolated, overlapping in function and content, highly fragmented, and unrelated computerized applications within the same public organization has resulted in a major interoperability problem and has led to 'isolated islands of technology' while information systems were viewed as being internal to the public organizations [26].

E-government architectures should not be merely about service delivery, but also about integrating and sharing resources and using common systems [17]. Opportunities for joint-development, pooling of resources and coordination of efforts are often neglected due to the lack of overview. The need for improved coordination calls for an enterprise architecture.

Good system design and architecture is necessary, but not sufficient for successful implementation. Transformation requires that there exist strong communication, coordination, and cooperation between ICT and business personnel [21]. The importance of communication in achieving project success has been well documented in technology adoption literature [3]. Lack of communication has been linked to numerous project failures [27]. Communication becomes the means through with information about the structure, the benefits and possible pitfalls of the technology flows to organizational members. The outcomes of communication should influence the behavior of adoption positively, but also enable discussions to improve the system requirements. Effective communication should lead to trust in the systems, improvement of system requirements and ultimately to a better acceptance of the technology.

Currently, pleas have been made for an architectural approach [13]. Although there a number of enterprise architectures available (e.g. [6],[9],[24],[26],[30]), public managers find it difficult to translate the architecture to their specific situation, use these architectures to guide their decision-making and use these architectures as guidance for development from the existing situation. One of the reasons is that concepts are only vaguely

defined, too abstract or too technical defined [18], [26]. As such public organizations are looking for ways to get insight into their current situation and to develop a reference architecture that can be used for managing the road to the future. In the research presented in this paper a reference enterprise architecture for local government is developed using action research.

2. Research approach

Public managers have the feeling that they are not able to govern their architecture. As such a reference architecture depicting the hypothetical future architecture and the existing architecture should be analyzed. We chose discrete-event simulation as an architecture modeling and communication vehicle, as it allows us to understand the essence of business systems, to identify opportunities for change, and to evaluate the effect of proposed changes on key performance indicators [18], [31],[32].

The research approach taken was action research. Action research or applied case study research is focused on 'how to' questions [4]. Instead of taking the observer point of view, as with case studies, the researcher is a participant. The researcher observes as is the case with case studies, but also gets involved in theory application and testing improvements. The following steps were taken.

1. Practitioners and researchers defined the research questions together;
2. The researchers structure the field based on theoretical and practical knowledge and using interviews;
3. The researcher provides insight into the situations from various points of views;
4. During group sessions the reference architecture is developed, validated and suggestions are incorporated to refine the results;

The main steps include the analysis of the existing situation and the developing of a reference architecture that can be used as managing the road to the future situation.

3. Architecture

In order to manage all changes, ensure interoperability, public agencies want to develop enterprise architectures, as its purpose to effectively align the strategies of enterprises with their business processes and the coordination of their resources [26], [36]. Enterprise architecture defined and interrelated data, hardware, software, and communications resources, as well as the supporting organization required to maintain the overall physical structure requires by the architecture [29]. Some top-down architecture initiatives have been founded for the public sector such as the Federal Enterprise Architecture Program Management Office in the USA [9] and the e-Envoy Office Framework including the Government Common Information Model (GCIM) which is a generic data model representing the basic entities and relationships during the phase of public service provision in the UK [24] and the Electronic Architecture in The Netherlands [6]. Peristera and Tarabanis [26] provides an overview of enterprise architecture methods for the public sector based on what they tried to model on one axis (process and data, process and data aspects) and the scope of the models on another axis (meta frameworks/methodology, generic models, specific industry applications). Schekkerman [30] provides an overview of and describes the differences and commonalties of enterprise architecture frameworks.

The enterprise framework formula, in general terms, specifies how information technology is related to the overall business processes and outcomes of organizations, describing relationships among technical, organizational, and institutional components of the enterprise [5],[8],[11],[23],[29]. While these general frameworks are a useful starting point, very little is known about how they can best be adapted and used. Enterprise frameworks and overall information architecture concepts are of necessity quite general, so as to be relevant to a wide range organizational situations. However, to be used effectively, they must be adapted to specific circumstances and needs. How this adaptation can best occur has not been extensively studied, nor have results of such adaptations been widely investigated.

Architecture aims at creating some kind of structure in a chaotic environment using systematic approaches. One way of looking at architecture is that it poses constraints on changes and development projects. Architecture can be viewed at various levels, including hardware, network, system, application, business process and enterprise level [1]. The relationships within and among architectural levels should also be taken considered for a complete architectural picture. A common pitfall or architecture is that the level of abstraction is too high [26]. The translation of practical situation needs interpretation that might lead to a result different from the original intention of the architect.

Enterprise architectures should be understandable by all stakeholders in order to make it work. The creation of a shared vision, communication among

stakeholders and evaluation of the impact seem to be crucial aspects. One way of managing the complexities involved and to create a shared understanding is by means of modeling. Enterprise architectures can be viewed as discrete-event system operating at various architecture levels that are dependent on each other.

4. Modeling and visualizing approach

The approach taken in this study is focused on involving people using visualizations of the reference architecture using models. The modeling should ensure that the architecture is not too abstract. The visualization should ensure that the heterogeneous type of people involved have a similar, shared understanding of the reference architecture.

Presenting a strong business case is necessary for gaining management support [18]. A business case should provide insight into the benefits, but also into the drawbacks and implementation pitfalls. The real importance lies in controlling expectations, and focus on the real architectural issues that are of relevance.

Modeling can play an essential part in communication of the implications and benefits to stakeholders. Various stakeholders for communication can be distinguished, the decision-makers such as mayor, aldermen, and information managers, and the process owners, such as administrative staff, and technology experts. Communication to these two type of groups should be focused on providing insight into the current as well 'to be' situation of the reference architecture in order to support decision-making. The requirements on modeling can be summarized as follows.

- It must show a high degree of qualitative as well as quantitative correspondence with the problem situation as perceived in reality;
- It should be possible to experiment with models in order to obtain numerical results of the model of the existing situation, as well as of the models of 'to be' situations including the reference architecture;
- Various architecture levels such as business, organizational process, application and technical infrastructure should be modeled;
- Should support stakeholders to draw conclusions about the benefits and disadvantages based on the insight gained by means of visualizing the existing situation and the 'to be' situation with a reference architecture;
- Interactions and dynamic behavior among and within various levels of architecture should be visualized. Especially the interactions among components and the relationship with the business processes should be visualized;
- It should incorporate the time-ordered dynamics of the architecture levels under consideration.

The importance of communication in achieving project success has been well documented in technology adoption literature [3]. Lack of communication has been linked to numerous project failures [27]. Communication becomes the means through with information about the benefits and possible pitfalls of the technology flows to organizational member. The outcomes of the communication should influence the behavior of adoption positively, but also enable discussions to improve the system requirements. Thus effective communication should lead to trust in the systems, improvement of system requirement and ultimately to a better acceptance of the technology.

One of the greatest pitfalls why efforts fail is that of architects model all what you see [2]. An important issue when modeling architectures is the choice of the appropriate *level of abstraction*. A model at a too high abstraction level only describes could be too vague, while a model at a low abstraction level, including all details, might not only lead to long data collection time, but also to confusion instead of understanding.

A similar discussion can be found in modeling literature, the choice of phenomena to include and to omit in a model [14]. Modeling should capture the requirements discussed above, but avoid presenting so much detail that it requires too much effort and scarce time of decision-makers to understand the models. This aspect is complicated, as we had to deal with multiple stakeholders having various backgrounds and levels of knowledge. Consequently they might need different level of detail.

Discrete-event simulation constitutes one of the most widely used applications of operations research, as it allows us to understand the essence of business systems, to identify opportunities for change, and to evaluate the effect of proposed changes on key performance indicators [18]. Discrete-event simulation means that the time aspects of a sequence of discrete-events are modeled [25]. Essential is that simulation can be used to understand the behavior of a concrete system, to evaluate various strategies for the operation of the system, and to study the impact of scenarios representing a particular path to a hypothetic future situation [32]. The philosophy behind simulation is to develop a dynamic model of the problem situation, experiment with this model, and experiment with alternatives for the problem situation [31]. Simulation can be used to assess

process design options. One of the advantages of simulation is that what-if analysis can be committed without changing reality at lower costs.

Visualization is often a standard feature of a simulation language [34]. Pegden, et al. [25] describe *animation* as a dynamic display of graphical objects that change position, shape or color on a static background. Animation of time-ordered sequences of tasks can take place against a static background, which provides the layout of an organization. Simulation can be used as a communication instrument to stakeholders, and thus satisfied the requirements for our study.

There are a large number of simulation packages available [33]. Arena was selected as simulation package, as it matches the requirements described above and was readily available.

5. Case: Municipality Delft

The Dutch municipalities are free to design their information architecture and to choose appropriate software vendors. Often there is no central management with a municipality and departments can buy their own applications for each process. As a result, municipalities have a highly fragmented ICT-architecture, consisting of legacy systems for each product they offer.

Municipality Delft is a medium-sized municipality with 3000 employees consisting of various departments. This municipality is well known for it innovative capabilities. Architecture is perceived as having an inherently technical nature. Architects are only found within the ICT departments. This prevents the use of architecture as a strategic planning instruments and building of relationship between business and ICT. This is the second land mine of the top 10 land mines of architecture of Rehkopf and Wybolt [26].

An explosion in information system has created a myriad of poorly integrated systems with overlapping functionality. The managers did no or limited insight into the current architecture, were worried about the increasing of cost and wanted to know which decisions has to be taken to create an architecture enabling integration with other agencies and reuse of functionality. Specifically, the managers were complaining about the lack of insight into the application architecture and that they are not able to make decisions to prioritize development. They merely assign budgets to development projects, but do hardly know what kind of results can be expected. As such they want to improve their understanding of the application architecture.

The *aims* of the architecture development process is to create a shared understanding of the situation where the municipality is right now and to create a vision that is shared by and agreed on managers, technical experts and administrative staff. The involvement of staff of various departments to ensure that their view was included and commitment was created, was found to be of crucial importance for the initiating of this project. The vision should be usable an enterprise reference model for managing the development of information technology projects.

It is impossible to involve all persons from all departments in the development process. Therefore it was chosen to initially focus on the departments involved in the hotel and catering industry, because many internal and external departments are involved, this processes are complex and this could be considered as representative for the whole municipalities. In the subsections hereafter we shortly describe the situation of the municipality.

5.1. Organization architecture

The current organization structure is shown in Figure 1. At the top the customers (hotel, restaurants and bars) are shown. They deal with a so-called service center, which aims at answering exceptional request, or with departments providing product or permits needed (like a liquor permit).

Figure 1: Organization structure

A critical factor for customer-oriented service provisioning is the sharing of information across departments, but also with outside agencies. As such external stakeholders should also be included in the architecture. The municipal departments communicate with external organizations to collect information, such as the chamber of commerce who

owns and controls a registry of businesses, the police, fire and justice departments,

Another factor is the allocation of responsibility. When the terms of a permit changes and the permit request involves multiple departments; who is responsible for updating the permit terms on the Internet? If a business process changes, which organization unit is responsible for implementing the change?

5.2. Process architecture

There are 22 standardized products and a number of unstructured and not-described products and services. Service provisioning is centered around departments. Customers go directly to the departments when requesting a certain product, although some managers mistakenly consider the service-center as a one-stop shop. The business processes of these products and services were analyzed and described, including the supporting information systems.

The people involved tend to focus on the service delivery processes. This is a too narrow focus as can be derived from the main process phases depicted in Figure 1. First, politicians and public managers need to formulate policy in close interaction with its constituents. Next the policy needs to be implemented which could be supported by information systems.

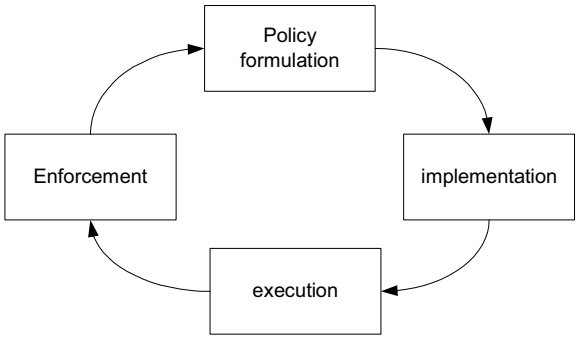

Figure 2: Main processes phases

For example, after liquor permits have been granted, the permits should be stored in a database. The number of a certain permit can be obtained from this database. When there is an enforcement process, like a check on the hotel and catering industry, the enforcers might want to have an overview of the permits per business. Which is not possible in the existing situation. For policy formulation reasons you might want to know why permits request are rejected, which geographical area has many liquor permits, but also to determine the effects of implementation of a new policy. This information might be used to renew the policy and implementation of the new policy.

5.3. Application architecture

Delft municipality has application architectures based on a plethora of different software standards, exchange formats, computing languages, platform, and operating systems. They have both packages as well as custom-made software in the front and back-office. Available applications include financial, human resource and various workflow and document management system. Many of the systems have fixed and rigid structures, and some of them are not well or not documented.

The most advanced system is the web-based applications based on a modular design available in the front office. A number of components have been developed that can be reused using scripting languages. The municipality provides about 300 products to citizens and another 50 products to business. Information about most of the products can be found on the web site. Only a small number of the products can be ordered and paid for using the Internet. There is not systematic approach or strategy for making products online. Managers are very afraid that their web-development department might turn gradually into a maintenance department. The updating of existing products might become more time-consuming that developing new components and scripts.

A small number of the applications have been integrated using a permutation of application integration technology. Delft has pursued a point-to-point approach in integrating new systems into its existing IS architecture. Based on request of public managers an ad-hoc connection between front- and back office application was made without considering maintenance efforts.

The current services provision over the Internet can be positioned in the catalogues and transaction phase of Layne [18]. Delft has a web-presence containing product information, there are downloadable forms for a limited number of products and for some products it is possible to conduct online transactions. In the latter case, most transactions are performed without any direct integration of front- and back-office applications. The stages of horizontal and vertical integration [11], characterized by integration of information systems across different functions and departments, are still far away.

5.4. Architecture modeling and visualizing

A simulation and animation model of the existing situation was developed. A screenshot of the animation model is shown in Figure 1. This model was used to identify the issues that should be addressed by the architecture under development.

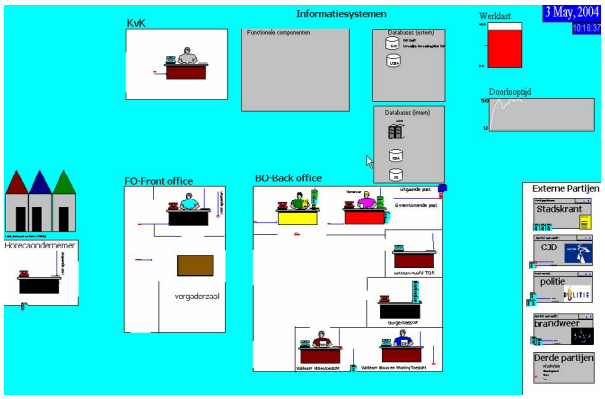

Figure 3: Screenshot of the 'as is' simulation model

Each resource like a human being, customer, department, identification component, or legacy system is modeled as an object. The visualization shows the time-ordered dynamics of events. Events could be tasks performed by human being, information systems processing a request and the interactions between objects. An example is the authentication process; a person is trying to access a website, the web server processes this request and interacts with software component to grand permission. The interactions between object happen at an organizational, business process and application level, but also between levels, e.g. the interaction between a user and an information system.

The model was used to explicitly identify problems in the architecture. Apart from the problems discussed in the preceding section the main challenges can be summarized as:

- Municipality employees are not continuously available for customer during working hours. As customers often approach persons instead of departments or the municipality, the employee availability depends on persons who might be on leave, attending a meeting, have a lunch brake, might be sick etc.;
- All kind of information systems having overlapping functionality exist;
- Making products online available and the one-to-one integration of applications might lead to a spaghetti;
- Lack of coordination of customer channels such as Internet, call center and physical office;
- No integral customer views. Customer data and interactions are not stored at some central place. Instead they are in the head of the people. When on employee does not grant a permit, the customer might try to get the permit from another employee;
- It is not possible to acquire information about the number of permits granted in a particular geographical area;

As can be seen from this list of problems, few of them have a purely technological nature and most of them can only be solved by a complex interaction on various architecture levels. In the opinion of the people involved in this action research, a reference architecture should address these problems.

6. Reference architecture

A reference architecture needs to be derived solving the problems identified in the proceeding sections and using the enterprise architectures discussed in section three. During a brainstorming session the essential elements, which should be part of reference architecture were determined.

1. Introducing of an account manager role, which serve as a focal point for all customer-interactions. A customer, having a question, should always approach the account manager and never contact a back-office employee directly. When the account manager is not able to answer the question, the account manager can forward the questions to the back-office employee. This back-office employee can contact the customer if more information is needed;
2. The account manager should be supported using a website. Customers should be able to request products using web forms;
3. The development of a knowledge system. The basic idea of the growth path is that each week a new customer question should be entered in a knowledge system. The knowledge system can be a simple FAQ and gradually move to a fully operation knowledge system;
4. The use of a customer relationship management system. The idea is that after introducing the system each client interaction would be stored and this would gradually lead to a system filled with customer information;
5. The use and/or development of shared components, including authentication, identification, payment, digital safe, form

generator, content management system, workflow systems;

6. The introduction of 'process managers'. These managers are responsible for acquiring and maintaining an overview of a business process crossing multiple-departments and agencies. They are responsible for identifying the need for changes, communication for the need for changes to the information systems department and so on.

Similar critique might be given to those elements, as critique we gave on existing architectures at the beginning of our research. The elements are too abstract, vague and have a bit technical focus. To overcome these drawbacks, these core elements were translated to an integrated, reference architecture at the organization, business process and application level. The reference architecture was developed by first involving persons on an individual basis. At a later stage a group session was organized during which the reference architecture was presented and modified. The translation is a time-consuming process, and took more effort than expected beforehand. The availability of the model of the existing situation helped to stay close to the existing practice.

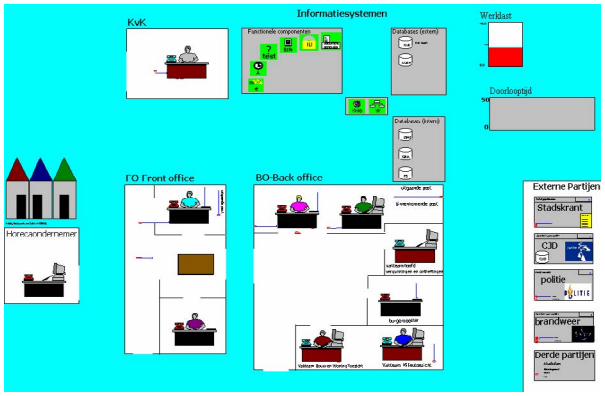

Figure 4: Screenshot of the 'to be' simulation model

A discrete-event simulation model was constructed of the reference architecture as depicted in Figure 4. This model shows how the organization has hanged (use of an account manager), how product requests are processed by the organizations and how the new application components are used (at the top of the picture). Thus not only interactions within the organization, business process and application layers were modeled, but also interaction among these layers.

This simulation model of the reference architecture was presented to the people involved in the development of the reference architecture during a number of group sessions. This resulted in some minor updates.

The simulation was also used to access the benefits quantitatively for the situation the whole reference architecture would be implemented. The main reason for having a quantitative part is that the city council and managers, which were not involved in developing the reference architecture decides either to accept or reject the reference architecture.

1. Total ordering time is the total time necessary for executing activities concerning the application for a certain product or services;
2. The ordering lead time of customers is the time between the first contact moment and the submission of a service/product request;
3. Total lead time is the difference between the confirmation received by the requester minus the submitting of the request by the businesses to the agency;
4. The tardiness is the ratio between the number of permits that exceed the due date of 5 weeks and the total number of requests;
5. Status information lead time is the time between the submitting of the request by a business and receiving the answer of the municipalities;
6. Total working time is the total time needed to process a product/service request, this includes time to send reminders, time needed for public hearings and so on;
7. Availability of the front office is the percentage of the time that the employee is available when customers ask a questions. In the current situation this also include the availability of the back-office employee when this person is contacted directly by an employee. This is surrogate for the number of times a customer wants to contact the municipality and got a no response;
8. Utilization or workload front-office is the total time employees are performing an activity divided by the total working time of the employees;
9. Utilization workload back-office is the total time employees are performing an activity divided by the total working time of the employees;
10. Number of reminders submitted is a surrogate for the responsiveness of other organizations and efforts necessary for obtaining the required information to process a product or service request.

Table 1: Quantitative simulation output for a scenario

Performance indicator	Unit	mean	st.dev.	mean	st.dev.	change	
1. Total ordering time customer	hrs	7.21	0.25	3.73	0.14	48.27	Y
2. Ordering lead time customer	days	12.39	0.08	10.66	0.13	13.93	N
3. Product/service request lead time	days	35.45	0.49	25.07	0.23	29.28	Y
4. Tardiness	%	14.46	0.02	6.79	0.03	53.04	Y
5. Status information lead time	hrs	16.64	0.41	0.82	0.37	95.07	Y
6. Total working time per product/service	hrs	41.89	0.86	19.90	0.64	52.49	Y
7. Availability	%	61.99	0.49	98.54	0.35	58.96	Y
8. Utilization front office	%	54.58	0.33	48.61	0.36	10.94	N
9. Utilization back office	%	92.24	0.49	79.92	0.43	13.36	Y
10. Number of reminders submitted	#	4065.00	24.85	3995.00	30.96	1.72	N

Although it is conventional to talk of evaluation in terms of costs and benefits these words often imply too close a focus on financial or other 'hard' measures. Therefore evaluation should not only based on measurable benefits, by also on non-measurable disadvantages and benefits, side effects and affects within the enterprise environment. The animation element helped to identify these elements and also supports reasoning about the implications of the reference architecture. A presentation was given and the animation model of the reference architecture was presented to the city council and management. They decided to accept the reference architecture and asked to make films (.avi files) of the time-ordered sequence in order to distribute it to all employees in the municipality.

7. Discussion

In this paper a reference enterprise architecture for a municipality was developed using action research. Architectural efforts should be measured on the degree to which it contributes to its success. Our *aims* were to create a shared understanding of the situation where the municipality is right now and to create a vision that is shared and agreed on by managers, technical experts and administrative staff. According to the people involved we succeeded in accomplishing these aims.

The development of a reference architecture can be viewed as a kind of negotiation process between departments. At the beginning of the development process all departments had various ideas at different levels of details. During this process they shared their ideas, and the ideas became understood and diverged into shared ideas.

The main advantage of the simulation of the reference architecture is not found in the quantitative evaluation. The modeling of interdependencies among and within architecture layers, the visualization, and the development process of creating a shared model are probably the crucial elements contributing to an accepted and understandable architecture.

Discrete-event simulation is an instrument to deal with this mix of problems about design complexity, uncertainty, modeling, and communication. It is a way of describing and modeling complex, interdependent processes. When the models are based on actual case data from government business processes, as in this research, they can provide useful estimates of impacts in terms of costs, benefits, and process changes. The models and animation themselves also provide a powerful tool for communicating to diverse audiences about the new systems and processes being designed. Such tools can help speed up the usually reluctant pace of innovation in government agencies. They can be otherwise quite slow in adapting such approaches as they lack sufficient insight into the pros and cons of proposed changes. So, much effort has to be put in communication of the implications in order to get management commitment and to support decision-making.

At a more detailed level, the modeling, and visualizing to applications, business process and organizations helped to get grip on the following problems.

- Acquire an overview of cross-organizational/departmental business processes;
- Identifying inefficiencies/redundancies in processes;
- Determine quality and functional requirements that can be used as starting point for system development projects;
- To clear ambiguous requirements;
- To avoid speaking in tongues by translating the reference architecture into a discrete-event simulation model;

- The participants involved in the development processes created a shared understanding;
- Supporting the discussion about benefits of the reference architecture;
- Supporting discussion about divisions of investment costs over departments;
- Supporting discussion about the allocation of responsibilities, e.g. who is responsible for maintaining and updating a cross-departmental process;
- Communication of the reference architecture to people only indirectly involved and interested in the architecture using films.

These elements should be considered when adapting an enterprise framework to the own circumstances. Our models were focused on providing solutions to local problems and not to develop models to be accepted on a wider basis. Initially, the requirements for this development have been generated bottom-up: the special municipalities' needs drove the design of the e-government architecture. Public managers realize more and more that for mature e-government development, there is a need for a sophisticated and more-centrally managed architecture function. The reference architecture developed took into account overlap of functionality of applications within departments. A similar architecture study can be performed across municipalities or even across more heterogeneous kinds of public agencies. Not only application functionality, but also complete services might be shared and bundled in some kind of centralized agency. So further research should be focused on of drafting an overall public administration architecture.

8. Conclusions

In this paper we discussed the development of a reference enterprise architecture for a local government agency. The reference architecture consists of elements at an organizational, business process and application level. The architecture relates applications, software components, business processes and organization structure. Our modeling approach helps to translate vague concepts to a better level of detail. Enterprise architectures are more than a description using some kind of modeling technique. An enterprise architecture should be understandable and agreed on by all the stakeholders. Visualization helps to create a shared understanding and to gain the necessary stakeholder commitment.

Architecture incurs not only at a technological but also at a stakeholder-level. The reference architecture is negotiated instead of optimal in some respect. Structure reinforcement, use of power, resource constraints, conflicts, but also shared interest, the need to solve shared problems, sense of urgency to develop a reference architecture characterize such a development process. The joint efforts of an architectural approach combined with discrete-event simulation can provide insight into the architecture and bring the architecture inline with the changing needs of the environment.

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