EU-China Information Society Project

Research on e-Government User Requirements
and Architecture Standards in Yantai

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Executive summary

The research project of e-Government User Requirements and Architecture Standards was conducted from August to October 2008 following approval of extension by the EU Delegation in Beijing. The project was organized into two main stages: 1) the requirements analysis and systems design; and 2) e-government systems architecture and standards, with a particular focus on interoperability and data sharing.

The research work was broken down into two periods, the first stage focusing on issues around user requirements analysis, system design and organization of the development work and the second phase dedicated to eGovernment systems’ architecture, standards and interoperability.

An initial workshop defined the scope, methods and techniques of the research will be defined. The research looked specifically at eGovernment User Requirements Analysis and Architecture Standards in more granular detail as well as focus on setting up structures and systems for improving the elicitation of the user requirements and the design of eGovernment applications; the system architecture; and the structure and organization of the development work in the project. The approach consisted in gathering input directly from users and beneficiaries about current issues and improvement areas in eGovernment User Requirements analysis and Systems design, as well as in the system development projects and architecture standards. Concrete proposals were made for

- Communicating the concept and advantages about system architecture in the context on eGovernment services oriented to citizens and business.
- Organizing the analysis and development job in the informatization office, and making clear the responsibilities
- Choosing tools for user requirements elicitation
- Further training needs in system analysis and design for technical personnel in the Yantai informatization office.

This research was designed to enhance the ability of Yantai demonstration project to construct and provide customer-centric services with efficiency in development, easier maintenance and interoperability capacities, in line with EU best practices and thus to increase the uptake of existing and new services in the area.

It is particularly important for Yantai demonstration project to develop the next step in the development of eGovernment services, given the success in the construction of the portal and Yantai informatization office’s commitment to deliver quality eGovernment services with efficiency. The research has helped Yantai demonstration project to assess their current status in terms of eGovernment application design, development and system architecture, reducing costs thanks
to reusability and economy of scale; shortening the implementation time of new projects; and improving manageability of projects and of practical solutions.

The research was carried out locally in Yantai demonstration project area and elicited the opinions of users, beneficiaries and potential beneficiaries of eGovernment User Requirements and Architecture Standards based on e-Government services.

The research was conducted primarily by international short-term senior expert Liu Kecheng, professor of Applied Informatics and E-Business, Director of the Informatics Research Centre at the University of Reading in UK, whose contribution consisted primarily in analysing the data collected during the first stage and the interim findings. Prof. Liu also conducted workshops in Yantai, prepared this report, presenting overall findings and recommendations at a final workshop in Yantai.

**Objectives:**

In the first phase, seminars and workshops were conducted, with an aim to bring relevant stakeholders and development team up to speed. The key principles and methods of requirements engineering were introduced through training in several sessions. Requirements collected from early investigations from different stakeholders were documented and analyzed, to identify conflicts and find a method for conflict resolution. In the second phase, activities were focused on the examination of the existing architecture to address the issue of interoperability between information systems. Approaches and methods for systems architectural design were introduced and evaluated, which led to a selection of some agreed methods, e.g. UML and SOA methods. These methods were applied to some cases derived from real examples of the development’s practice. The case studies led to some common understanding of the systems architecture and to agreed principles of architectural standards.
1. Background and Motivation

This research project, based on the work carried out in Yantai’s e-government demonstration project, aimed to focus on the e-government User Requirements and Architecture Standards in the city. The research work were divided into two periods, the first stage addresses the user requirements, systems analysis and design, and the second phase deals with e-government systems’ architecture, standards and interoperability.

The motivation of this project rooted in several aspects. In witness the increasing number of e-government initiatives in recent years, governments have paid more attention to the User Requirements. But there seemed to lack an effective user-oriented approach to requirement analysis in current methodologies for e-government systems. E-government systems are suffering from semantic ambiguity embodied in the user requirements. The development of an approach for a user-oriented requirement analysis for e-government systems, which take into account the specific features and complexity of e-government services, seems to be necessary. The principal activities in the research project include the following.

1. To facilitate the key stakeholders to articulate their requirements
The effective use of e-government systems is not only dependent on the interaction with organisations and social systems, but also involves proper reengineering of government processes. The requirements analysis and specification is a complex undertaking and will deal with a whole range of stakeholders. The development and implementation of e-government systems have been the focus in the e-government projects in Yantai, while a number of issues continue to be addressed from the stakeholders' viewpoints. E.g. why should there e-government systems, and what are the scopes and functions of the systems? It was regarded that insufficient attention has been paid in previous studies, and no clearly agreed objectives of the systems were achieved. The research aimed to provide examples for identifying stakeholders and articulate their requirements for e-government systems.

2. To aid systems analysts in requirements engineering
Due to the specific features and complexity of e-government systems, analysts face special challenges in that the traditional methods for information systems for enterprises cannot be directly applied. The research is useful in that it examines the differences between the e-government and other types of information systems.

3. To contribute to the development of the theory and methods for information systems

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Theories and methodologies of information systems have often been technology-focused rather than user-oriented. Through this research the requirements analysis is divided into two parts: user requirements analysis and systems requirements analysis. In the systems development process a new phase is introduced in which users will be invited to provide their requirements. Traditionally only the systems analysts will be engaged in requirements engineering, but the research project has explicitly defined a phase for users' input in requirements elicitation and modelling.

The research helped Yantai demonstration project to assess their current status in terms of the e-government application design and implementation, and to examine the systems architecture, with an aim to reduce costs, shorten the implementation time of new projects and improve the manageability of projects and of the implemented solutions.

The following major activities were formulated (c.f. the original terms of reference of the research project):
1. Identify the specific research purpose, objectives, scope and methods in the research.
2. Determine the research outline and methods.
3. Through the initial workshop to present knowledge of user requirements analysis practices for user centric e-government systems in EU and China and also of key issues in organizing the system development, specially regarding to explicating the responsibilities of every stakeholder in the e-government projects.
4. Through the second workshop to present knowledge of system architecture (process modelling, data modelling and standarisation, application architecture, software architecture, reference infrastructure) and interoperability, and their implications in e-government services delivery.
5. Encourage the adoption of user centric systems design techniques in Yantai Informatization office.
6. Introduce and disseminate the e-Government User Requirements and Architecture Standards in Yantai demonstration project area.
7. Improve the consistency and standardisation of the research, taking into account local constraints.
8. Use the surveys in Yantai to enhance the future construction of e-government services for citizens and villagers, and establish the project in Yantai as a model of best practice for other cities in China.
9. Further raise awareness of the EU-China Information Society project.

The research project actually started in August and was completed in October 2008, through a series of training lectures, workshops and work sessions on real live cases. The development team in Yantai has benefited from this research
project in terms of enhanced capability and skills of information systems development. They adopted the newly learned skills and techniques into their work immediately during this project, which led to improved quality of e-government solutions and services.
2. Requirements Engineering: methods, techniques and relevance in e-government systems development*

The challenge facing e-government developers is profound: How can we ensure that we have specified the system that properly meets stakeholders’ needs and satisfies their expectations? An effective requirements engineering process is the best solution to start with. The requirement engineering process can be described in five distinct steps: Requirements Elicitation, Requirements Analysis and Negotiation, Requirements Specification, System Modelling, Requirements Validation, Requirements Management.

2.1 Requirements Elicitation

Requirements elicitation is certainly not as simple as it seems. The reasons include: (1) The boundary of the system is ill-defined or the customers/users specify unnecessary technical details. (2) Customers are normally unsure of what is needed, because of poor understanding of the capabilities and limitations of their computing environment. (3) The requirements change over time.

Sommerville and Sawyer (2000) suggest a set of detailed guidelines for requirements elicitation. The work products produced as a consequence of the requirements elicitation activity include:

1. A statement of need and feasibility;
2. A bounded statement of scope for the system or product;
3. A list of customers, users, and other stakeholders who participated in the requirement elicitation activity;
4. A description of the system’s technical environment;
5. A list of requirements and the domain constraints that apply to each;
6. A set of usage scenarios that provide insight into the use of the system or product under different operating conditions;
7. Any prototypes developed to better define requirements.

2.2 Requirements Analysis and Negotiation

The work products noted above form the basis for requirements analysis. The analysis categorises requirements and organises them into related subsets, explores each requirement in relationship to others, examines requirements for consistency, omissions, and ambiguity, and prioritizes requirements based on the needs of customers/users.

Sometimes customers and users ask for more than what can be achieved; it is also common that stakeholders propose conflicting requirements. The systems

engineers must reconcile these conflicts through a process of negotiation. Customers, users and stakeholders are asked to prioritise requirements and then discuss conflicts in priority. Risks associated with each requirement are identified and analysed.

2.3 Requirements Specification

In the context of computer-based systems (and software), the term specification means different things to different people. Some suggest that a “standard template” should be developed and used for a system specification, arguing that this leads to requirements that are presented in a consistent and therefore more understandable manner. However, it is sometimes necessary to remain flexible when a specification is to be developed.

The system specification is the final work product produced by the systems and requirements engineer. It serves as the foundation for hardware engineering, software engineering, database engineering and business process engineering. The specification bounds each allocated system element, and describes the information that is input to and output from the system.

2.4 System Modelling

In order to fully specify what is to be built or developed, we would need a meaningful model of the system. From the model, it would be relatively easy to assess the efficiency of workflow and personal requirement. It is important to evaluate the system’s components in relationship to one another; to determine how requirements fit into this picture, and to assess the “aesthetics” of the system as it has been conceived.

2.5 Requirements Validation

Requirements validation examines the specification to ensure that all system requirements have been stated unambiguously, that inconsistencies, omissions, and errors have been detected and corrected, and that the work products conform to the standards established for the process, the project and the product.

The primary requirements validation mechanism is based on a formal technical review. Although this review can be conducted in any manner that results in the discovery of requirements errors, it is useful to examine each requirement against a set of checklist questions. E.g. are requirements stated clearly? Can they be misinterpreted? Checklist questions like these help ensure that the validation team has done everything possible to conduct a thorough review of each requirements.
2.6 Requirements Management

Requirements for computer-based systems change. Requirements management is a set of activities that help the project team to identify, control, and track requirements and changes to requirements at any time as the project proceeds. It begins with an identification activity. Each requirement is assigned a unique identifier that might take the form:

<requirement type><requirement #>

Once requirements have been identified, a set of traceability tables are developed. In many cases, those tables are maintained as part of a requirements database so that they may be quickly searched to understand how a change in one requirement will affect different aspects of the system to be built.

Several seminars and workshops have been conducted on the requirements engineering to ensure the necessary understanding and the capability of applying in Yantai’s e-government systems developments, as elaborated in the next chapter.
3. Requirements Engineering and Systems Design in Yantai

Training workshops and interactive working sessions were conducted in Yantai during the project. The main themes of various training workshops include requirements elicitation, analysis, modelling and validation.

This part of the research project is focused on requirements engineering for e-government systems. During the project, various research activities have been conducted to enhance the capability of the software development team. Lectures and interactive workshops introduced the requirements engineering methodology, object oriented requirements modelling (i.e. UML) and norm analysis for embedding business knowledge and rules into systems design. Live examples on the re-engineering of the Citizen Card System were used to engage the development team which helped the team to examine and improve the quality of their work of systems analysis and design. The presentations and lectures were carefully prepared to support the themes of requirements engineering, mixed with a series of interactive working sessions in which we worked together with the software development team on the analysis and design of the software systems. The outcomes from these interactive working sessions served as the foundations of the systems architecture and functional design, directly useful to the current systems development project.

3.1 Thematically Focused Training

The key theme of the training was methods and techniques for requirements engineering. Two topics of lectures were first delivered in Yantai. One is business solution design – functional requirements using Use Cases. The second one is business solution design – process modeling with activity diagrams. Both lectures were built on the existing knowledge and experience of the Yantai team, and aimed to draw the team to actively participate in the training and to enhance their capability of systems analysis and design using UML methods.

Yantai Municipality’s Integrated Information Centre is the organization responsible for the development and implementation of the e-government systems in Yantai. In the past years, the Centre has performed a number of e-government projects, successfully developed and delivered a number of systems. In the meantime, the Centre has built a team with strong expertise and skills.

One of the software solutions the Centre has been involved in the Citizen Card system. In this project, the Centre was responsible in the requirements elicitation and formulation, to define the business and systems requirements. The systems itself was developed by a software company. However, since the
implementation of the Citizen Card, the business requirements have been changed and more services have been envisaged to be delivered by the Citizen Card system. There seemed to be a need for a major reengineering of the system. Due to the consideration of the importance of the Citizen Card system and the key role of the Centre in Yantai, it has been decided that the Centre will itself undertake the reengineering. One strategic consideration is that the Centre’s software team would use this opportunity to further build its expertise and skills. The EU expert in this research project provided the guidance and technical support to enable the team to adopt the methodology of the service oriented architecture, and object technology from requirements elicitation to systems design.

3.2 Working Sessions on Systems Analysis and Design

The lectures were supplemented with working sessions on real problems the software development is experiencing. The Yantai software development team was asked to present with slides of the problems they have been working on. Questions and discussions that involved Prof. Kecheng Liu, Dr. Lily Sun and all members in the team helped clarify the understanding of all parties. After the plenary discussions and clarification, the whole software team was broken into 3 working groups to focus on each part of the Citizen Card system. Working closely with Prof. Liu and Dr. Sun (an EU expert of another demonstration project who made contribution in this case), each group produced the requirements models and design documents which were then presented to the whole class for critical review and improvement.

3.3 Business Requirements for the Citizen Card System

The existing Citizen Card system provides a small set of functions which meets part of the business requirements. This existing system is one of the sources of the business requirements. The team followed the methodology of business requirements, and performed a four-stage exercise of requirements engineering: requirements elicitation, analysis, documentation and requirements validation. The requirements engineering has been introduced to the team in early training workshops, and was further elaborated in this research project.

The business requirements were elicited from various sources: 1) the business processes supported by the current Citizen Card system; 2) the functionality of the existing Citizen Card system; 3) the new requirements gathered from the stakeholders based on their experience of using the current Citizen Card system. Figure 1 shows the entire work flow of using the Citizen Card system to support business processes in different stages in the lifecycle, which serves as the departure point for the design of the next generation of the Citizen Card system.
Figure 1. The workflow model of using the Citizen Card system to support business
3.4 Functional Design of the Citizen Card System

The functional design was conducted using the Unified Modelling Language (UML). Use Case diagram was one of the main UML techniques adopted in the requirements documentation and systems design. Several versions were produced through a series of discussions with stakeholders and the members of the team.

The following diagrams (using UML techniques) show the design of the Citizen Card System in Yantai.
Figure 2. Business Requirements of the Citizen Card Systems (a use case diagram)
Figure 3. To top up the value of a card.

Figure 4. To top up the value of the card at the counter.
Figure 5. To top up the value of the card with a deposit account
Figure 6. To make a payment with the card.

These design diagrams were the result from several rounds of critical evaluation and "work-through", after being presented and discussed at the design workshops in Yantai. They now serve as the basis for the technical design of the Citizen Card system.
4. E-government Systems Interoperability and Standards: challenges, importance and relevance*

The second part of the research project is on e-government systems interoperability and standards. This part of the work involved training through lectures and discussions relating to the practical problems the Yantai team faced.

4.1 Definition of the Interoperability

According to the European Interoperability Framework (IDABC 2008), Interoperability is defined as follows,

“Interoperability is the ability of disparate and diverse organisations to interact towards mutually beneficial and agreed common goals, involving the sharing of information and knowledge between the organizations via the business processes they support, by means of the exchange of data between their respective information and communication technology (ICT) systems.”

Interoperability is not integration, nor compatibility or adaptability. Rather, it is best understood as a shared value of community. It has 3 dimensions which are depicted in Figure 7.

![Interoperability Dimensions](image)

4.2 The Benefits of Interoperability

The benefits of interoperability could be discussed from the view of interoperable levels, and from the view of beneficiaries.

At the technical level, the benefits amount to dramatic savings in time and cost deriving from the avoidance of ad-hoc or point-to-point solutions, and the resulting exchanges are likely to be more reliable and require less maintenance. At the semantic level, the benefits will be even more dramatic. In the worst case, when data exchanged is not directly usable due to semantic mismatch, very labour-intensive and time-intensive actions are needed to process data for reuse at the receiving end. Interoperability at the organisational level, the benefit are highly significant in that they enable certain processes and activities to take place, and certain objectives to be met, that often or normally would not be possible. At the political level, the benefits of interoperability are that it enables policy makers to set and achieve their priorities. At the legal level, the benefits are about enabling all stakeholders to meet their legal obligations.

From the view of administrations, the benefit of interoperability includes:
1. Helping the government service providers to do their jobs better: more efficiently, fulfilling their obligations faster at lower cost;
2. Facilitating the reuse of data and functionality which can lead to reduction of overall department, agency and total government IS development costs;
3. Improving the management decisions by facilitating aggregation of data;
4. Speeding up the development of public services and supporting systems;
5. Leading to better decision making: allowing data collected by different agencies to be aggregated, and serve as inputs to better, more informed decisions;
6. Allowing for better coordination of government services resulting in higher added value to citizens and businesses;
7. Speeding up public services development;
8. Reducing ICT costs and enhance ICT affordability;
9. Promoting international cooperation: Providing additional tools that can be brought to bear against certain cross-border problems such as fraud and other crimes (trafficking, pollution, illegal arms trade, etc).

The benefits to businesses and industry include:
1. Reduction of administrative burden;
2. Enabling the service aggregation that is required to implement one-stop-shop interface to government services;
3. Allowing for better coordination of government services resulting in higher added value;
4. Increased and fairer competition, levelling the playing field through the migration towards and use of open standards; this opens the market, especially to smaller companies that might not be able to otherwise participate or compete and add their creativity to the marketplace;
5. Unleashed growth of new markets.
The benefits to citizens include:
1. Reduction of administrative burden;
2. By increasing the flow of information between administrations, agencies and other entities, citizens get more accurate and complete information in their dealings with governments, and are therefore better informed;
3. Citizen-centric delivery of one-stop-shop services through a variety of channels;
4. Enabling the streamlining and simplification of eGovernment services offered to them (e.g., via integrated/single window-type applications), including significant reductions in administrative burden;
5. Facilitating access to e-government services using eID and eDoc;
6. Increased mobility afforded by the seamless availability of e-government services in the cross-border context;
7. Increased citizen participation and use of public services via reaching for inclusion of all citizens, thereby enhancing democracy;
8. Reduce ICT costs and enhance ICT affordability used to provide eGovernment services meaning a more efficient use of citizens' taxes;

Interoperability also results following benefits to all:
1. Avoidance of vendor lock-in results in lower costs, to administrations to develop services, plus more freedom of choice is available to citizens and businesses as a result;
2. Increasing the number of suppliers of standards-based products should lead to increased competition;
3. Increased competition deriving from the lowering or elimination of barriers (resulting from the migration towards open standards) Unleashing creativity of more persons leading to better solutions, and generally accelerating the technology evolution cycle;
4. Ability to easily fulfil various legal obligations that otherwise would be difficult or impossible;
5. Creates jobs and growth.
5. E-government Systems Interoperability in Yantai

Interoperability at various levels and data interchange with other existing systems is essential. But it has been difficult to form an agreement for semantic interoperability and a standard format for data interchange. A practical approach has therefore emerged in the design and implementation of semantic interoperability and automatic data interchange.

![Diagram of data exchange between Citizen Card and other systems](image)

**Figure 8. Interoperability: data exchange between Citizen Card and other systems.**

With systems that are in operation before the Citizen Card, the data formats of the early systems would be adopted, e.g. China Mobile, China Unicom, banks, water, electricity and other companies. With the new systems that are built after the Citizen Card, the data formats developed by Yantai Informatisation Centre will be adopted. E.g. the public transportation system is a younger system than the Citizen Card, so it will adopt the data standards set by Yantai Informatisation Centre.

Another technology adopted for data interchange between the Citizen Card system and other existing systems is IBM Websphere MQ. The MQ component is attached to each side of the communication, which has to be agreed by the owners of the other systems, e.g. some utilities companies. The efficiency of such an approach is low, as each communication will have to involve several rounds of sending information and receiving confirmations. However, this will not require any change of the data structure of the systems involved, which is a practical constraint to any data exchange between the Citizen Card and other systems.
The next possible technical solution the Yantai’s development team will explore will be an intelligent message broker, which can be possibly attached to the Citizen Card system. The intelligent message broker should recognise the source of the message to detecting the IP address therefore automatically invoke the appropriate algorithm for data conversion. The investigation is already on the way, though may not be completed in this research project.

**Figure 9. Current solution for data exchange.**

**Figure 10. Next technical solution for data exchange.**
6. Conclusions

The research project on e-Government User Requirements and Architecture Standards in Yantai was completed successfully, largely due to active participation of the e-government systems development team in Yantai Informatisation Office.

The first part of the research was mainly on the activities such as training and working sessions with a clear focus on the methods for requirements engineering. The training was combined with practical examples from the team’s real problems, which enabled them to apply the theory and methods learned directly to their work practice. The systems analysis and design of the Citizen Card system was used as a real-life case study, which not only enriched the learning, but also enhanced the quality of the design of the e-government application.

The second part of the research project placed emphasis on the systems architecture and interoperability. The latest work of European Interoperability Framework was used as a theoretical and practical basis for the introduction of the interoperability concept. Taking that as a baseline, the term could quickly relate the issues of interoperability to their own work. This part of the research project therefore not only brought a theoretical perspective to Yantai’s team, but only provided an opportunity to examine the practical problems of data exchange between the Citizen Card system and other related systems in Yantai. The investigation of the current solution to and future possibilities for data exchange and systems interoperability has been started well and will possibly continue in a fruitful direction into the foreseeable future.