DESIGN AND EVALUATION OF BUSINESS PROCESS ORIENTED ASSESSMENT TECHNIQUES TO DETERMINE THE QUALITY OF INFORMATION EXCHANGES

-DEMONSTRATED IN PUBLIC ORGANIZATIONS-

A DISSERTATION

SUBMITTED TO THE SCHOOL OF COMPUTING

AND THE COMMITTEE ON GRADUATE STUDIES

OF DUBLIN CITY UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF

DOCTOR OF PHILOSOPHY

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September 2013

DECLARATION

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work, and that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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ACKNOWLEDGMENTS

Foremost, I would like to express my sincere gratitude to my advisor Dr. Markus Helfert for the continuous support of my Ph.D. study and research, for his patience, motivation, enthusiasm, immense knowledge, and constructive criticism. His guidance helped me throughout my research and during the writing of this thesis. Without his supports and persistent help this thesis would not have been possible.

I would like to thank the Irish Research Council (IRC), who funded this research over the past years. This research in my thesis could not have been completed without the assistance and support of IRC.

Sincere thanks to the School of Computing at Dublin City University, especially those members of my doctoral committee for their input and accessibility. In particular, I would like to thank Dr. Cathal Gurrin. I would not have enjoyed my research work without his support and engagement. In addition, I would like to thank our school secretary Ms. Patricia Lacey. She has personally and professionally assisted me work through my Ph.D. time. Furthermore, I am very grateful for all of the Business Informatics Group (BIG) members. Without all of the group discussions and engagement, my research would not have been possible.

Finally, and most importantly, I would like to thank my husband Damien. His tremendous support, encouragement, quiet patience and love were undeniably the bedrock upon which the past years of my life have been built. I thank my Irish family – the Keogh's, for their incredible supports in every aspect of life. Many thanks give to my parents and other family members in China, for their faith in me and for allowing me to be as ambitious as I wanted throughout my life journey from China to America and to Europe.

ABSTRACT

This thesis investigates information quality (IQ) of information exchange in public organizations. A clear relation between the quality of information and success of organizations has been acknowledged, but approaches for analyzing information quality on the basis of higher abstraction level have been lacking. When examining organizations, limited understanding of information processes relating to information exchanges are often observed. As the example of emergency medical service demonstrates, this is particularly true within public service organizations. In this thesis, a set of techniques for IQ analysis are developed and evaluated, namely quality assessment for information exchange (QA.IE) techniques. This extends previously developed methods and provides a novel way to assess IQ, complementing data oriented approaches that have been often proposed in research in the last years.

Design of the QA.IE techniques is undertaken in the public service within the emergency medical service, where information exchange utilize various forms of media and are known to be of critical importance. The research follows a design science (DS) approach. The analysis is based on data from interviews, in depth field investigations, and surveys. Evaluation of the QA.IE techniques are carried out in the operating room within a large hospital in Ireland and Counter of Lost Wallet (BPC) for e-Citizen service in Portugal. Within the work, an evaluation framework was developed which formed the basis for evaluating the techniques and is comprised of demonstration, design principles, interviews, and Moody and Shanks factors.

The resulting QA.IE techniques provide models to evaluate the state of IQ in information exchange with consideration of enterprise contexts. The results can be utilized as guidelines when planning and assessing information and information exchange related matters, and facilitate digitalization for improvement. Suggestions concerning further development for future use of the techniques are formulated, and consolidated into principle for IQ assessment. This thesis thus contributes theoretically to the development of a new approach for analyzing IQ of information exchange.

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CHAPTER 1: INTRODUCTION

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INTRODUCTION

1.1 OVERVIEW

The phenomenon of information sharing and information exchange has long been discussed as a necessity for information system effectiveness. Literature on this phenomenon ranges from discussions of technical aspects to social implications, from collaboration within organization to inter-organizational alliances and from private sector to public sector [1, 2]. Due to the growth of digital business, public organizations have shifted from a model that emphasizes information protection to one where cross-boundary information sharing by digitalizing the information management. In the meanwhile, studies of public sector involve topics usually mentioning information exchanges as one of the key problem areas [3, 4]. For example, in public healthcare services, health information is not utilized to its full potential to support effective and efficient care due to fragmented information creation, exchange, and storage [5, 6].

A crucial issue concerning information exchange in this research is the quality of information itself that is collected, transferred, and stored. It is acknowledged that information quality (IQ) becomes an important topic for academic and practical researchers particularly in today's digital world. The inherent complexity of the domain contributes to the variety of approaches and perceptions. As a result, most researchers do not differentiate clearly between aspects of data quality (DQ) and IQ. Consistent with previous studies, we do not differentiate between DQ and IQ and refer only to IQ for the purpose of this research. It has been stated that there is a clear connection between the quality of information and success of organizations. Poor IQ costs billions in society and economic impact [7, 8]. In the public sector a number of initiatives address IQ issues at international, European, and national levels. For example, the Data Quality Act in the US which is considered as guidelines for ensuring and maximizing the quality, objectivity, utility, and integrity of information disseminated by federal agencies [9], and the European directive on reuse of public data [10].

However, efforts on IQ from information exchange perspective are very limited in public sector. Even though organizations have increasingly invested in improving IQ they often still find themselves stymied in their efforts [11]. The problems are often caused in a dynamic pattern such as cross-boundary information flow. IQ of information transfer and exchange is challenging enough within one organization with clearly defined boundaries. Yet, we are witness to a rapid increase in networking and cross-boundary services in a dynamic information exchange pattern.

Tools have been developed for assessing and analyzing IQ [7, 8, 12-14], but they are mainly utilized with respect to information systems (ISs) or information technology (IT) focusing on data level [7, 8, 12-14] . For a significant class of information issues involved in information exchanges, it is not possible to solve the "IQ problem" by simply working with data or information. Unfortunately, this solution is not commonly understood but the results leave very little doubt about the effectiveness of the traditional (pure-data) approach [15, 16]. Information exchange is described as process of reciprocal giving and receiving information between the actors across the locations with purpose [17]. In this sense, information exchange is a process centric activity within contexts. This brings urgent attention to information exchange issues that occurs within the context factors such as the actors, the location, the object, and the means etc. Work from Auinger et al. also suggests that information exchange need to target at both technical and organizational aspects such as business processes and organizational trust and goal [18-20]. Although recent contributions have underpinned the importance of context, [21-23] examining IQ in information exchange topic is lacking in foremost IQ studies. This is particularly prevalent in public sector, where information sharing is complex and often controversial.

In this study, public sector is referred to enterprises which the State/Territory and local governments separately or jointly have control over. These include national and local governments, agencies and charted bodies that deal with either the production, ownership, sale, provision, delivery and allocation of goods and services by and for the government or its citizens [24]. Information management and information exchange in cross boundary public sector is closely related to business level contextual factors such as organizational goals and cultures etc. [25].

To address this, quality assessment techniques for information exchanges that are related to enterprise contextual factors are investigated, hereafter termed quality assessment for information exchanges (QA.IE) techniques**.** The assessment results facilitate examining the causes of poor information exchange. It is designed, demonstrated, and evaluated in public organizations, where groups of professionals from different disciplines work together sharing relevant information for effective outcomes of citizen-focused services [26].

1.2 Problem Statement

The research topic of the present thesis is a set of techniques to assess and identify the causes of poor IQ based on information exchange involved contextual factors. Information exchange becomes an increasingly important topic due to the growing networks, and indeed a body of research that relates to social, political, and technical information exchange have been conducted [27]. However, the quality of the content – the exchanged information itself – has been poorly examined. This is particularly evident in public sector where information sharing and information management has been a complicated issue. If IQ is to be addressed at all, the focus must be at a low data level ensuring that information exchange involved contextual factors are not considered.

IQ exercises concern information systems, information technology, data warehouse and such low level data elements that are based on statistical analysis. As a result, information issues exist at the information exchange processes and organizational boundaries. In the case of digital applications that heavily depend on enterprise IQ (artificial intelligence, performance reporting, enterprise resource planning, etc.) a typical approach to the IQ problem usually starts and ends with the activities scoped to the physical data-storage layer such as relational databases. Given that in service application information exists within the context of a business process related factors, all attempts to solve the IQ problem at the purely physical data level are not efficient. That is also why with numerous attempts to improve IQ over a number of decades, no satisfactory outcome has resulted [16, 28]. Information is usually scattered and often changed within or between organizations. Challenges are encountered when conflicts of organizational, technological, and other issues exist, which leads to a very difficult task to ensure the quality of information and information exchange.

Therefore, the scope of this research relates to public sector and underpins the need to investigate and develop, on one hand, analysis of information quality and, on the other hand, influential contextual factors of information exchanges. An enterprise is an aggregate of contexts that are composed of people, technology, and information, performing functions and tasks in defined organizational structure, for agreed purposes, and responding to events [23, 29]. In this research, public sector is seen as enterprises. The combination of these two points of view in public organization domain is novel.

IQ is a well-established concept, however there is still a critical need for a methodology to assess how well organizations exercise and ensure IQ in today's dynamic environment. It is a challenging task particularly in the public sector which deals with large quantities of information to serve citizens and is the backbone of a country operation. Recent research by the Audit Commission of the United Kingdom showed that only 5% of Councils are regarded as having excellent IQ, with many acknowledging that their information problems are fundamental [30]. Other examples of poor information in public sector are constantly highlighted in the media. For example, six million citizens incorrectly taxed over the past two years in the UK and more than £210 million of benefits being paid to the deceased over the last three years [31]. It is not only the direct damage done by poor quality information but the associated damage to the reputation of public bodies that increases the mistrust that may suffer from.

From another real case observation and assessment in the public emergency services, it is found that limitations on quality of exchanged information are highlighted. In the past year close observation and examination in the emergency medical service (EMS) within the Dublin County region in Ireland were conducted. Information that is shared and exchanged across boundary is critical in patient care delivery, and complex contextual factors are involved in the information exchange processes. However, it is found that information is managed and assessed in separate databases is evaluated without considering related contextual factors such as organizational goals, business processes. While regarding the information exchange management, the content of the information quality is not included. The need of the investigation arose because they experienced the symptoms of poor information control over routine tasks involving a mix of manual and automated information

processing and sharing (i.e. poor document control, poor information tracking, and loss of unacceptable number of information), and they are struggling to find efficient improvement plans.

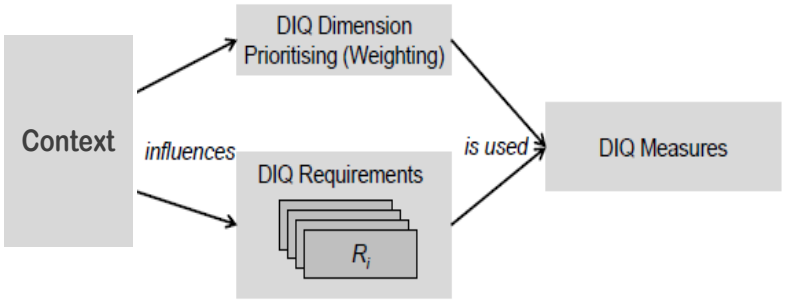

Figure 1-1. A context-oriented IQ research framework [32]

Similar challenge in collaborating was also observed in literature related to IQ [14, 33-35]. Information exchange occurs within the context of organization (location, actor, and purpose), process, and technology. Indeed a recent paper identifies that IQ measures need to consider context as an important influence on the prioritization and requirements [21]. Review of literature and conducted research suggested that the importance of IQ measurement is influenced by various context factors [32]. Figure 1-1 showed that contextual factors should be considered for IQ measures.

It is anticipated that the development of the QA.IE techniques with consideration of contextual factors will facilitate examination in areas for poor information exchange, and therefore increase the potential for success in information management efforts. This is especially true for dynamic information exchanges but examination here is lacking in attention. In addition, the research will advance the body of knowledge on IQ study through a series of field engagements and the development of new assessment artifact.

1.3 Research Objective and Questions

The objective of this thesis is to design and evaluate a set of techniques that enable examination of information exchange quality, and the causes of poor IQ in information exchanges. This contributes to development of methodologies and models for IQ analysis and assessment, and to operationalize these techniques for information exchange management.

As a corollary of this objective, this thesis aims to produce the QA.IE techniques for practical development work in question regarding (i) IQ and (ii) related to information exchange involved contextual factors. The quality of information cannot be improved independently of the processes that produced this information and of the contextual factors in which it is utilized [13]. Demonstration of this research in public sector domain is shown, viewed from an enterprise perspective.

The research objective provides us the research framework, which is illustrated in figure 1-2. It shows that enterprise contextual factors should be considered for IQ of information exchange assessment by deploying business process concept. Key areas of investigation are: (i) define effective assessment techniques that consider contextual factors in an enterprise level, (ii) identify an approach that relates the contextual factors to information elements for a context-based IQ assessment and the cause examination, (iii) provide instruments and means to measure and analyze IQ. Key stages of this research relates to the IQ assessment layer within the research framework: An adopted Business Process Model (BPM) where rich contextual factors can be captured, Information Profile where the contextual factors and exchanged information content is organized accordingly, and IQ Analysis where IQ assessment and improvement recommendations are provided. BPM defines the exchanged information within multiple organizations because it overarches organization and application systems that interact with each other [36]. It then allows to assess statically the "right piece of information from the right source and in the right format is at the right place at the right time" [13] which will be structured in the information profile in form of what, when, who, and how under the dynamic information exchange processes. And finally the IQ analysis provides concrete IQ measurement and assessment methods and metrics for the exchanged information. The results allow identifying the areas that led to the poor quality of information exchange.

This research employs Design Science (DS) methodology, which is a normative science that focuses on creating an artifact to obtain given goals. DS proposes that the end artifacts can be constructs or concepts, models, methods, and instantiations. In this study, the QA.IE techniques are presented in forms of models as a final artifact. The QA.IE techniques is designed based on the literature (rigor) and EMS field study (relevance), and evaluation by

demonstrating and testifying the techniques in three public service cases where information exchange entails great complexity is conducted. During the research a specific evaluation framework within DS was developed for validation of the design artifacts.

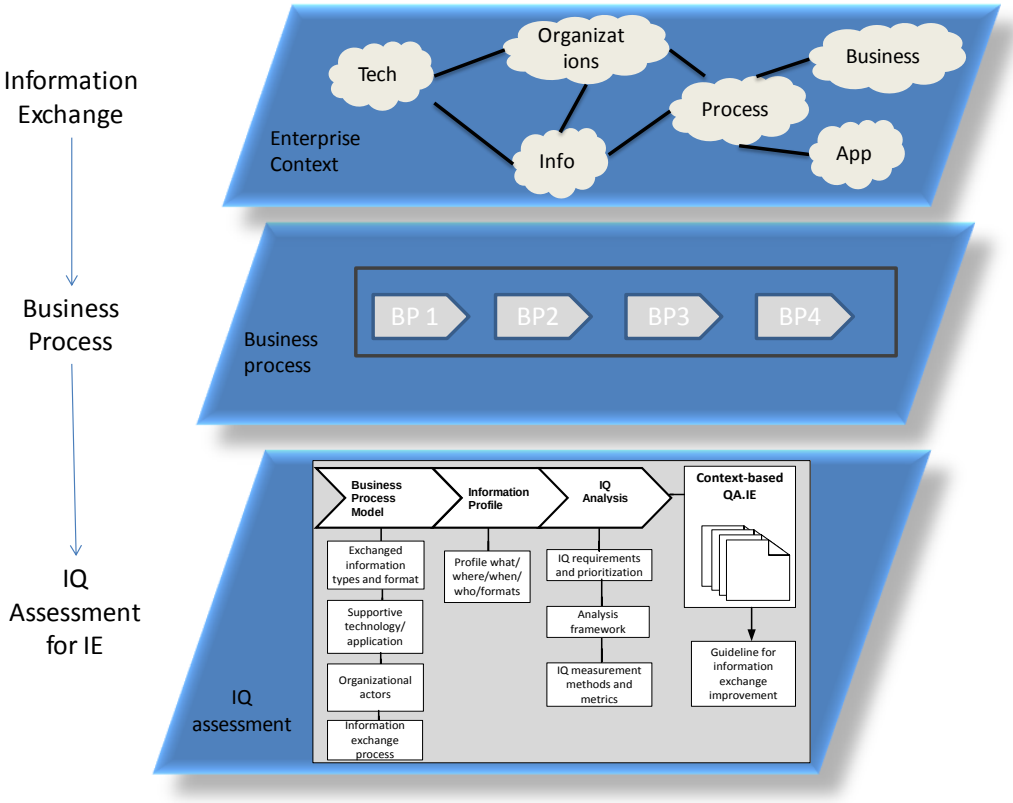

Figure 1-2. Research overview

To achieve the objective aforementioned, the following research questions have been formulated for exploration based on Figure 1-2:

In order to design and evaluate the proposed QA.IE techniques, it is essential to define the criteria of an effective IQ assessment that considers contextual factors. The defined criteria are also used for evaluation purpose. Therefore the first research question is stated as:

(1) Theoretical Development (Rigor): What criteria are related to IQ assessment for information exchange?

   a) What contextual factors influence cross-boundary information exchange in public sector?

b) Which are the most important contextual factors for information exchange in this domain?

c) What IQ assessment approaches are employed in the scope of this research?

(2) Empirical Findings (relevance): What is defined as an "effective" IQ assessment for information exchange in practice?

a) How does public EMS agency in practice manage information between organizations and information sharing?

a) Considering the various contextual factors involved in an emergency response, how would the enterprise contextual factors affect IQ for all level of involved organizations?

b) What are the existing requirements regarding IQ dimensions in the EMS case?

In line with increasing networking among organizations, many new opportunities are created but severe problems may also arise. Improving information flows within various organizations is difficult because, for example, the precise course of information flows may not be known and information about factors affecting them may not be readily available. The quality and content of the information itself sheds light on the operations of the business processes and related contextual factors. One of the challenges for IQ assessment is IQ measurement that is based on the information exchange involved contextual factors. Based on these considerations, the third question is formulated as:

(3) Design: What approach to synthesize the knowledge base and empirical findings for IQ of information exchange assessment*?*

a) Which design principles should follow to ensure the techniques meet the IQ and information exchange requirements?

b) What is a suitable description for information flow and information organization?

c) How to connect the exchanged information to the related contextual factors?

d) How to identify and prioritize IQ requirements and measure IQ?

The evaluation will follow the identified criteria and apply in the real cases. In addition, an instantiation will be developed based on the design of QA.IE for its implementation. To achieve this, the forth question needs to be answered:

(4) Evaluation: To what extent do the proposed QA.IE techniques provide effective information exchange quality assessment and improvement in practice?

a) Does the designed artifact meet the criteria that are pre-defined for its research purpose?

b) Academically would this designed artifact fit in related body of knowledge?

c) How can these proposed techniques be applicable and useful in practice?

1.4 THESIS ORGANIZATION

Figure 1-3 depicts the relation between the various chapters in this thesis. Thesis proceeds by presenting the research approach in Chapter 2. Chapter 3 presents the theoretical foundation of this research. Chapter 4 presents the empirical foundation of this research. Drawing on the theoretical and empirical foundations, Chapter 5 presents the design theory and principles. Subsequently evaluation is carried out in Chapter 6. Research findings and conclusions is presented in Chapter 7. The thesis is concludes this thesis with a reflection on the main findings and research approach.

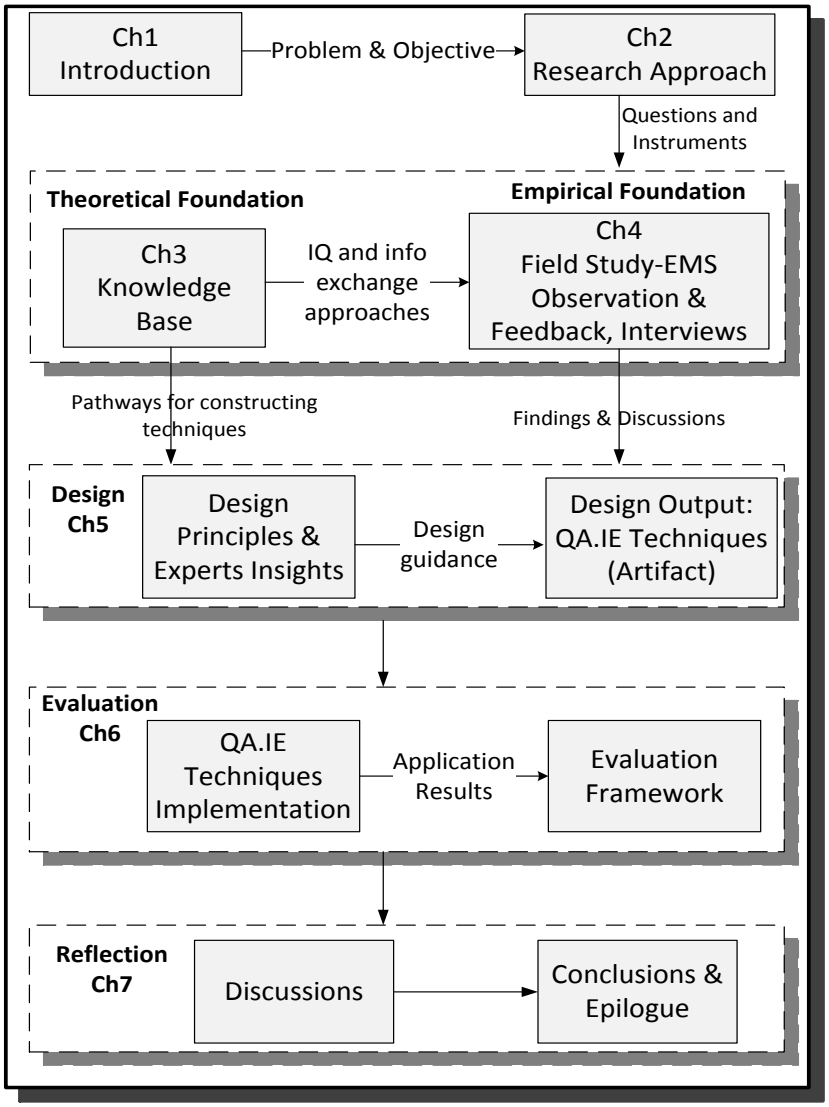

Figure 1-3. Thesis structure

CHAPTER 2: RESEARCH APPROACH

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RESEARCH APPROACH

As discussed in the previous chapter, the objective of this research is to design and evaluate QA.IE that examines the causes of poor information exchange quality, scoped in public organization domain. Achieving this objective is difficult. First, there is little empirical data on the design of IQ assessment techniques for information exchange in public sector. The majority of research in this domain focuses on either technical perspective such as separate information systems, or social political perspective such as information exchange influential factors. Second, there are no directly applicable theories on assuring IQ that we can apply and evaluate in this domain. Finally, examining the causes of poor information exchange quality for public sector services is a complicated problem. There are several stakeholders, problem components (e.g. organizational, technical, political), and potential solution spaces (e.g. organizational rules, structures, power relations) that need to be considered when examining the quality information [37-40].

As mentioned in Chapter one, observation from EMS case – a good case to examine information exchange in inter-organizational public service – reveals unsatisfying information exchange quality, both with the content of the information itself and the process of information exchange. Understanding the problem and conceiving a solution are identical and simultaneous cognitive process. Therefore, it is vital that problem-solving processes are structured and facilitated so that the best solution is achieved within pre-established limits. According to [41], Rowe states that human problem solvers are rarely in a position to identify all the possible solutions to settle for choices that satisfy the problem definition at a certain point in time. Addressing the problems require researchers grasps a new understanding of the problem structure or the relation of aspects within a problem [42].

One coherent research methodology that allows researchers to understand and solve relevant problems in a creative yet rigorous manner is the DS approach. This approach implements Kurt Lewin's proposition: "if you want truly to understand something, try to change it" [43]. This approach is not simply about changing, but also improving an environment. This

recently revived approach in the information systems domain is used since it allows focus on structuring the problem under investigation, prescribing a satisfying solution and evaluating the solution. Moreover, this approach provides researchers an opportunity to go beyond explanation, towards research that generates design knowledge relevant for practitioners. This chapter continues with an elaboration on our DS research approach, including the research philosophy, research questions and instruments.

DS has its roots in engineering and the science of the artificial [44]. It can be considered as a problem-solving paradigm with emphasis on the end products and the solution [45]. Design research is a normative science that focuses on creating an artifact to obtain given goals. The prescriptive design research paradigm should result in a "prescriptive design theory which integrates normative and descriptive theories into design paths intended to produce more effective information systems" [46]. It is characterized by a system of principles, practices and procedures required to carry out a study. It aims to overcoming research paradigms, such as traditional descriptive and interpretive research, in which the outputs are mostly explanatory and often not applicable in practice [47]. Design Science Research (DSR) is defined as developing knowledge that can be used by professionals in the field in question to design solution to their field problems [48].

Hevner et al. [46] argue that the end products of a DS cycle may include constructs or concepts, models, methods, and instantiations. In this research, the proposed QA.IE is presented in forms of models as final output. Following this approach this research starts with a relevant problem and design by an interactive search process and by building identifiable artifact – method followed by evaluation (utility and efficacy must be evaluated rigorously).

Figure 2-1 outlines the main research cycles, research questions (RQ), units of analysis and methods specific in this research. Figure 2-1is in accordance with the DS framework that proposed by Hevner etc. [46] . Three cycles are emphasized in this framework, the relevance cycle, a rigor cycle, and a design cycle. Good DSR often begins by identifying and representing opportunities and problems in an actual application environment [49]. Thus, the relevance cycle initiates DSR with an application context that not by provides the requirements as inputs for the research but also defines acceptance criteria for the ultimate evaluation of the research results. Translated to this research, the application context is inter-organizational services. An important question here is, does the design artifact improve IQ of

information exchange? The output from DSR must be returned into the environment for study and evaluation in the application domain, in this study that is the public services.

The rigor cycle depicted in figure 2-1 provides past knowledge to the research project to ensure its innovation. It is contingent on the researchers to thoroughly research and reference the knowledge base in order to guarantee that the design produced is research contributions [50].

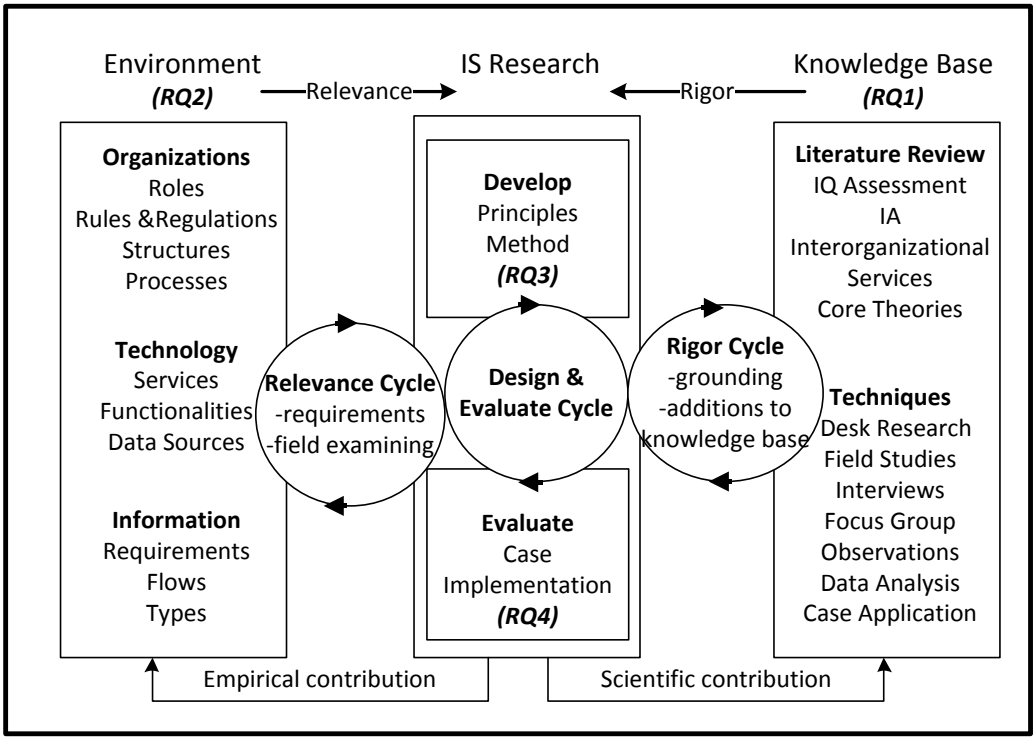


Figure 2-1. Research methodology framework (based on [46]).

The design cycle is the heart of any DSR project. This cycle of research activities iterates more rapidly between the construction of an artifact, its evaluation, and subsequent feedback to refine the design further. The design and evaluation theories and methods are drawn from the rigor cycle. According to [51] "the major knowledge to be gained from design research is in the form of 'design' principles to support designers in their task. Obviously those principles cannot guarantee success, but they are intended to select and apply the most appropriate knowledge for specific design and development tasks'.

Considering these three cycles, it is concluded that DSR research emphasizes the interplay between theory, methodology and empirical reflections. On accordance with Figure 2-1, three research cycles can be expected: (i) construction of knowledge base, (ii) empirical analysis of the problem, and (iii) theory and concept development and evaluation. Evaluation is

considered as an integral part of the design cycle. Elaborate on the cycles is presented in the next subsections.

2.1 Rigor Cycle: Construction of the Knowledge Base

The knowledge base contains the accumulated body of knowledge. It pertains the phenomena of interest, the existing artifacts aimed at achieving the given purpose, and their evaluations, which are based on previous research. It contains the results of prior design research in the form design ideas, techniques and tools [46]. Considering that the objective of this thesis is to assure IQ of cross boundary information exchanges in public sector. Two foundations are needed to be established in our knowledge base. The first foundation needed to establish in the knowledge base is on cross boundary information exchange contextual factors. Researchers have emphasized the descriptions of cross boundary service and influential factors for information exchange in public sector. Accordingly, the first two sub questions (1a and 1b) of *what context factors influences cross-boundary information exchange in public sector and of which are the most important contextual factors* are formulated. Answering the stated question requires us to analyze literatures on information exchange in public sector.

The second foundation is on defining and measuring IQ. Studies that have investigated information exchange mention several examples of poor IQ. Yet, since these studies focused on the performance of information exchange, regarding the content of the exchanged information itself are without assessment. Investigation for IQ assessment techniques and covering topics need to be scoped. Overview the assessment methods for IQ from existing approaches governing the design requirements or the processes arriving at them. Drawing on this purpose, question (1c) of *What IQ assessment approaches are employed in the scope of this research* are formulated.

Literature review is used to investigate these three sub questions. The literature review allows developing an understanding of the status of the research on IQ and information exchanges. Since this thesis is information system focused research, ACM (Association for Computing Machinery) digital library is selected for the literature searching. ERIC (the US Educational Resources Information Center) is also selected because it is the world's largest education database, which facilitates a complete and comprehensive searching. This study aims to employ the concept of business process and is based on information architecture characteristics, the literature for statements of ‘information architecture’, ‘business process, or ‘information and business processes are also surveyed. The literature review reflects on the

availability and capability of current state-of-the-art concepts, methods, technology, and applications that have been developed to address IQ issues in public services. Also the core theories in literature enable to formulate testable predications of a class of solutions and their behaviors, or the associated design process. Chapter 3 presents the results of the rigor cycle.

2.2 Relevance Cycle: Empirical Analysis Using Field Research

Equipped with the approaches for assessing IQ in this research scope, as well as theoretical foundations for examining IQ, the second cycle of this research is presented. The main activity of the relevance cycle is empirical observations and analysis from a cross boundary service domain: Emergency Medical Service (EMS) in Ireland. Case study with EMS professionals to find the answers from practice is conducted. Key characteristics of a case study method as adapted from are [52]: (i) the phenomenon is examined in a natural setting, (ii) the data are collected by multiple means. (iii) the complexity of the unit (one or only a few) is studied intensively. (iv) no experimental controls or manipulation are involved. (v) the investigator may not specify the set of independent and dependent variables in advance. (vi) the results derived depend heavily on the integrative powers of the investigator. All these fit this research purpose of explore and design an artifact of how to solve the problem in practice.

Emergency medical service (EMS) in public service is selected due to the reason that EMS is information exchange across multiple organizations entails great complexities including the requirements for the IQ. The chain of organizations that involved in the emergency delivery including the operating units of the call center, the dispatch center, the ambulance, and the hospital, as well as the regulation authorities are engaged in this study.

The data collection for the present project was done following the general principles of conducting case studies [53]: (i) written material ranging from memoranda to media meetings to formal in-person meetings, (ii) organization charts, personal records, maps, graphs, service statistics et cetera, (iii) open-ended and semi-structured interviews, use of informants and seminars, as well as (iv) absorbing and noting details and actions in the field environment. Twenty formal and informal discussions with general practitioners (paramedics, emergency call takers, the ED administrative, physicians, nurses, and health services researchers) are conducted, namely to obtain the enterprise description, business process documentation and some datasets. These data were collected through field visits on location at each participating organization as well as through follow-up phone and e-mail conversations.

Scholars have suggested the use of field studies when investigating contemporary problems that lack empirical descriptions in the literature [54]. In this cycle, investigation of the second research question is focused. This question is divided into three sub-questions.

Since literature is somewhat superficial on the existing IQ assurance in practices, the first sub-question (2a) is formulated: *How does EMS agency in practice manage information between organizations and information sharing?*

Field observations and feedback of EMS staff in action provided the researcher with very rich data. This form of data collection allows the researcher to collect information on all levels of the object under investigation. The observations provided insights on information exchange activities and current information management, and it remained to judge the specific aspects to organize the contextual factors information from the information flow.

Observing EMS case in action provides the researcher with very rich data. This form of data collection allows the researcher to collect information on all levels of the object under investigation. Even though the observations provided in depth insights on information management activities and flow, it remained difficult to judge the IQ and information exchange experienced by the public sector workers. Participant observation is a poor method for generating statistical results, but its use was essential to address the topic of this study. In order to deal with this limitation, surveys are selected as they can measure the IQ and information exchange concerns and requirements perceived by the public sector. A survey is a means of "gathering information about the characteristics, actions, or opinions of a large group of people, referred to as a population" [55]. According to Pinsonneault and Kraemer [56], surveys conducted for research purpose have three distinct characteristics: (1) to produce quantitative descriptions of some aspects of the study population, (2) the main way of collecting information is by asking people structured and redefined questions, (3) information is generally collected about only a fraction of the study population (a sample) but it is collected in such a way as to be able to generalize the findings to the population. Drawing on the understanding of survey and field observation, the second sub-question (2b) asks: *Considering the various contextual factors involved in an emergency response, which contextual factors of information exchange affect IQ for all level of involved organizations?* Asking this question is necessary for gaining insights on the impact of specific contextual factors have on the IQ from the practitioner and user point of view.

For the quality assessment of the exchanged information, questions of IQ requirements and measurement are the key elements. Accordingly, sub-question is formulated: (2c) *What are the existing requirements regarding IQ dimensions in the EMS case?*

This question is asked because different domains emphasize different IQ dimensions and measure techniques when it comes to IQ assurance.

Firstly, three empirical cases are chosen to narrow the dimension in this EMS domain before engaging the practitioner in fields. Case survey combines advantages of survey research and qualitative care studies, as it allows capitalize on richness of case material while using quantitative analysis [57]. The IQ requirements as keywords to survey problems are used in the case studies. Three empirical cases are studied: a cardiac arrest as a day-to-day emergency case; a typical car accident in rural areas, and one major incident that more than 6 casualties are involved. The case examples are documented by case protocols to ensure reliability [58]. These cases are selected based on two key criteria. The first criterion is that these cases are well documented and evaluated by EMS committees. The second criterion is that these cases are complementary in terms of the incident types. The main objective of our case survey was to identify and describe IQ related problems which occurred during the response the incidents.

Followed by the shortlisted IQ dimensions that found in the empirical cases, expert interviews are conducted and it also allows us to find out how to generalize the IQ dimension identification approach. As mentioned earlier, twelve experts were interviewed. With 'experts' it is referred to senior information system manager and directors from public authorities. Alongside academics and policy makers, these managers are in fact the audience of this research. Three main criteria guided the selection process:

- The respondents needed to have at least five years of experience in their fields;
- The respondents must occupy a senior position in either rescuing or information system management;
- Taken together, the sample should represent the main EMS agencies in Ireland.

The results of the relevance cycle should help us in understanding the information exchange for assuring IQ in the public domain. It also assist explore the approaches identified in the previous cycle. Moreover, by observing the information management activities, organizational roles, and information exchange involved contextual factors, this cycle should

also help specify a more precise and realistic design and evaluation approach. Elaborating on the design cycle of this research is continued in section 2.1.3.

2.3 Design Cycle: Synthesizing Knowledge Base and Empirical Findings

The third cycle of this research draws on the findings from the previous two cycles. In this cycle, I investigated the research question 3: *What approach to synthesize the knowledge base and empirical findings for IQ of information exchange assessment?*

Design is interpreted in a broad sense, involving "solving problems, creating something new, or transforming less desirable situations to preferred situations" (p.507) [59]. Accordingly, design theory refers to a set of concepts, beliefs, conjectures and generalized scientific laws by which designers map design problems to solutions [51]. These theories are aimed to give knowledge support to design activities.

Such bundles of knowledge encapsulate and organize three interrelated elements: a set of requirements, a set of methods that meet these requirements, and a set of principles guiding the design process. Table 2-1 captures the main elements of our design approach.

Requirements/Goals	A set of IQ requirements that need to be assured under certain contextual factors with consideration of the characteristics of cross boundary information exchanges.
Methods	Measures for achieving the set of requirements or goals.
Design principles	Knowledge which, when applied increase the likelihood of assuring information exchange IQ. These procedures are derived logically from literature and empirical field studies and can be sued creating other instances of artifacts that belong to the same class.

Table 2-1. Main elements of the design approach

Following this, investigation in developing the design principles is firstly conducted, which answer the first sub question 3a) *which design principles should follow to ensure the techniques meet the IQ and information exchange requirements?* In order to develop the design principles that guide the artifact design, investigation on IQ and information exchange requirements is necessary. To elaborate in detail, interviews are used again to identify the challenge and importance of IQ and contextual factors in information exchanges. This method for consulting the experts since this instrument allows for in-depth, qualitative data collection. In interview studies, sample size is often justifies by interviewing participants

until researching ‘data structure’[60]. Interviews were analyzed by relying on established methods for handling qualitative data [60]. To compare the results of the interviews, the text analysis application ATLAS.ti is used. ATLAS.ti is designed to offer qualitative-oriented social researchers support in their activities concerning the interpretation of text [61]. With linear textual data, such as transcribed interviews, as a starting point, segmentation and coding of the text alternates with the building of conceptual networks and hyper textual structures [61].

Based upon the defined requirements results, a suitable approach to link IQ and information exchange together for quality examinations is subsequently looked into. Since information exchange is process focused concept, business process and information contents should be connected for assessment. Therefore the research question of 3b) is formulated: *What is a suitable description for business process and information?* Elaborate on our literature knowledge and research experience, information architecture is chosen, which emphasizes business process model and data model. Details presented in section 3.3.

To assess the quality, the last design question is investigated 3d): *How to identify and prioritize the IQ requirements and measure IQ of the exchanged information?* The answers are rooted from IQ literature and the findings from EMS empirical case.

The main result of the design cycle is a prescriptive design approach for information exchanges. The design output are synthesized from the data collected from three sources: literature, field study findings, and interactions with academic and practitioner experts. Alongside the empirical findings, the synthesis replies on existing literatures that are applied, tested, and extended through experience, creativity, intuition, and problem solving capabilities of the researcher [45]. The design principles are developed to guide develop the proposed artifacts – QA.IE techniques.

The designed output is a set of business process oriented techniques for information exchange quality assessment, named QA.IE techniques. These techniques comprised three stages which provide the information exchange involved contextual factors to the information examination through business process modeling. Accordingly, the cause identification can be chased back to the context factors.

2.4 Evaluation Cycle: Case Implementation and Feedback

The final cycle of this research involves an evaluation of the proposed artifact. Evaluation is an assessment process, which enables the DS researcher to understand the problem addressed by the artifact and the feasibility of the approach for its solution [62]. Accordingly, the fourth and final research question is formulated as *to what extent do the proposed QA.IE techniques provide effective information exchange quality assessment and improvement in practice?*

Following [63], evaluation is viewed as an assessment of whether the designed techniques are proven to make difference to the current practice. The framework proposed in [64] is chosen in this study, which aims to help science researchers to build strategies for evaluating the outcome of DS. This framework identifies what is actually evaluated, when the evaluation takes place, and how it is evaluated. To answer the third question, different authors are based to propose a method with steps outlined to evaluate a DSR artifact method. The evaluation method entails the following steps: A) Case application to demonstrate the artifact, and how to use it to solve the research problem; B) The artifact meets the criteria of design principles; C) Feedback through interviews with researchers and practitioners; D) The Moody and Shanks Quality Framework to evaluate the produced stages [65]. Moody and Shanks quality factors are selected because it is considered as one of most scientifically and practically comprehensive yet precise quality assessment [64]. The authors conducted 5-year research program into evaluation and improving the quality of modeling. A combination of field and laboratory research methods was used to empirically validate the Moody and Shanks factors. All these four validations and demonstrations are used as feedback to improve our method, as suggested in the DSR to avoid the traditional descriptive and interpretative research [66].

The demonstration of the artifact showed that it was possible to: a) Apply the proposal using real case studies; b) Obtain representations from the organization that are considered to satisfy the requirements present in BPM [67]: coherent, comprehensive, consistent, concise, and essential; c) From the obtained models, assess the information quality in inter-organizational service domain; d) identify the causes of poor information exchange quality and present improvement plans. In other words, it was possible to demonstrate the artifact's utility, and how to use it to solve the research problem. Three case applications in public services are selected: inter-organizational information exchange in EMS, intra-organizational information exchange between hospital department in surgery operating room, and Institute of Construction and Real Estate (INCI) in Lisbon.

To decide whether QA.IE techniques meet the design principles, eight relevant researchers for discussions are chosen. Participants' profiles involve relevant academic and practitioner researchers in Ireland, Germany, and Portugal. The same researcher group for those three cases is selected to ensure the consistency. The six design principles are introduced and explained to the researchers, followed by the case implementation results. Lastly, individual rating and explanation is presented. Scientifically this approach would be a proof of the consistency and efficiency of the designed artifact.

The feedback from interviews the same practitioners is selected. The case demonstration is referred and relevant researchers' feedback are collected on whether or not: a) validate the importance of the research problem; b) understand and agree with the obtained approaches, which revealed some possible improvements; c) the artifact allow them to find the problem area by profiling and measuring the IQ based on contextual factors, which leads to an improvement plan; and d) confirm the importance of the proposed techniques (artifact as models), promoting in more effective and quality information exchange. Interview questions are presented in Appendix - B.

From the Moody and Shanks Quality Factors of general quality factors of: Completeness- refers to whether the designed artifact contains all quality requirements for information exchange; Integrity- the designed artifact is consistency of design, actions, methods, measures, and outcomes. Flexibility- is defined as the case with which the assessment method can reflect changes in requirements without changing the techniques itself. Understandability- the case with which the information quality, information assessment, and enterprise context concepts and structures can be understood; Correctness- is defined whether the artifact is valid (i.e. conforms to the rules of the design techniques). This includes diagramming conventions, naming rules, definition rules, and rules of composition and normalization; Simplicity- means that the techniques contain the minimum possible constructs; Integration- is related to the consistency of the artifact within the rest of the organization; Implementability- is defined as the case with which the artifact can be implemented within the project time, budget, and technology constraints. The factors are rated among a selected focus group from specific cases that implemented the designed artifact.

Instruments and approaches for artifact evaluation are explained in Chapter 6, section 6.1. The Evaluation framework is structured in table 2-2.

Proposal main outputs \ Evaluation criteria		Demonstration of the artifact	Design principles	Interviews with practitioners	Moody and Shanks Factors							
					Completeness	Integrity	Flexibility	Understandability	Correctness	Simplicity	Integration	Implementability
BPM	Construction Model (ATD)											
	Process Model (PSD)											
	State Model (OFD)											
Information Profile	Context Information Organization											
	Context information Prioritization											
IQ Analysis	IQ Metrics											
	IQ Measurement											
	Improvement Identification											
Caption: ✓ for accomplishment; ◔ or partial accomplishment; ✗ for not accomplished; ? for results in progress; <empty space> stands for not applicable.												

Table 2-2. Evaluation framework

2.5 SUMMARY

This chapter elaborated on the methodological approach that guided us throughout the research project. Why choosing to employ DSR approach is explained. Based on the research objective, this chapter recalled the four research questions. Following the DSR approach, our research consists four cycles: rigor cycle, relevance cycle, design cycle, and evaluation cycle. Each cycle expects to generate the output. In addition, each cycle required us to employ different research techniques, including literature analysis, field observations, focus group discussions, interviews, and case implementations. Figure 2-2 below presents the research approach in this research.

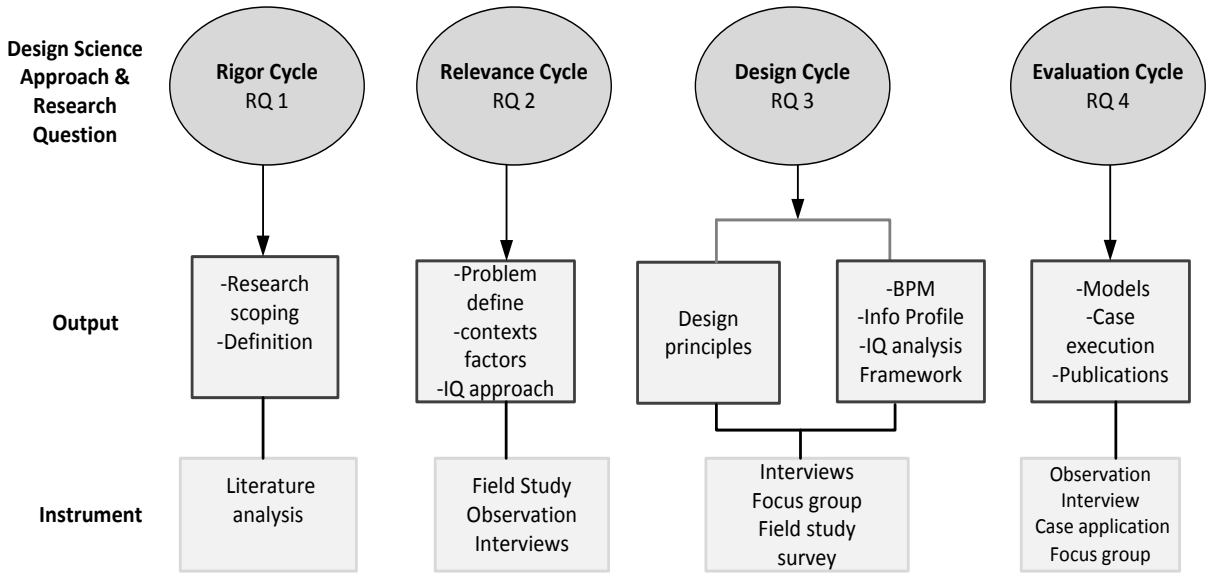


Figure 2-2. Research approach summary

The instruments of field study, observation, and interviews are repeatedly used in relevance cycle, design cycle, and evaluation cycle. With various purpose and objectives, these instruments are suitable for this research. Table 2-3 suggests the purpose, differences, and connections of these instruments in each cycle. Detailed methods and approaches are explained in each chapter.

Cycle and Purpose	**Field study & Observation**	**Interviews**	**Focus Group**
Relevance Cycle: Understand the problems and needs for IQ and information exchange quality assurance	Broad range investigation on EMS case: daily information exchange process, quality problems and challenges. 10 formal and information infield discussions carried out.	Unstructured interviews. 13 interviewee profile	
Design Cycle: Investigate the current IQ and information management approach. Seek IQ and information exchange requirements for quality assurance. Develop design principles.		Semi-structured interviews: 10 selected managerial level professionals.	5 IT and IS experts 9 researchers
Evaluation Cycle:	Understanding and modeling	Structured	5 or 6

Examine the applicability and effectiveness of QA,IE techniques in theory and practice	the business processes, information exchange involved actors, location, supported ICT, information types and elements.	interviews: executive level practitioners. Interviewee size varies from 5-8 depends on the selected case.	professionals from each case related authorities. 6 researchers are gathered.

Table 2-3. Overview of instruments used in each cycle

CHAPTER 3: KNOWLEDGE BASE-THEORETICAL DEVELOPMENT

3

KNOWLEDGE BASE- THEORETICAL AND LITERATURE FOUNDATION

This chapter provides a review of the relevant literature upon which this thesis builds. There is a need to unearth what is already known about a particular field in order to identify the gaps in literature. Review of possible approaches to bridging the gaps is necessary as knowledge base and foundation. The overall purpose of this thesis is to find pathways to assess the quality in the information flows. In the first section, review on previous literature to understand what information really is and how information can be assessed and measured. Fully understand the precise construction and structure of information is necessary, since it is information that the main activities are built upon. Hitherto, the meaning of information and the exchanging of the same have been treated implicitly. The second section, literature on the context factors for cross boundary information exchange will be reviewed to determine the most important and relevant contextual factors in literature. The third section reveals literature on enterprise and information architecture (IA), in combination with information business process provides rich foundation for the reasoning of our approach to bridge the gaps. The forth section provides theoretical ground for this research, including the idea generation, design and development approach. Summery is presented in the last section.

3.1 INFORMATION QUALITY

3.1.1 Information Quality Overview

Awareness of IQ as an issue emerged slowly during the early years of computers, when researchers gradually developed a notion of the need to measure data quality, and began the work of convincing others of that need. In early 1960's Trublood [68] focused on what was at the time the newly emerging field of operations research. He recognized a fundamental set of changes in information needs, pointing out that operations research not only provided new forms of information, it also demanded it. Not long afterward, literature began to emerge in which a conceptual model of IQ was taking shape in the context of information technology. Among the key concepts were the separation of roles between different information actors as well as the identification and definition of various aspects of IQ [69]. Most research during

this period focused on accuracy, Feltham observed that "relevance, timeliness, and accuracy are often listed as desirable attributes of information" [69].

For most of the next three decades, researchers explored a variety of ways to conceptualize data quality [70-72]. Ballou and Pazer [73] similarly recognized that goes beyond accuracy alone, observing that errors can be "amplified or diminished by processing and noting that it has become apparent that IQ is a relative rather than absolute term. They proposed a theoretical framework and algorithm for calculating the effect of tradeoff.

With growing volumes and complexities of data resources, managing data and information quality becomes an important success factor in the twenty first century [74]. Researchers find the issue of data quality or information quality challenging and address problems from various viewpoints and disciplines, including computing science, library and information science, management information systems, and business communities. Researchers have increasing concentrated on company environments and business information [14, 21, 75-77]. IQ became a well-established concept, and it has gained increasing attention during the last years in different fields with different focus. The concept IQ has been used to a greater extent than the earlier decades, for instance, the impact of IQ on service quality, the effect of IQ on supply chain performance, the IQ analysis in cooperative information system [78]. Studies of IQ in cross boundary information exchange such as in the present thesis – have not been undertaken.

Usage of the terms of IQ and DQ is highly inconsistent from one research to another. Many researchers consider the terms to be synonymous and treat them as such; others do not. While exploring this issue of terminology, [79] conducted a survey of session titles for papers presented at the International Conference on Information Quality during the eight year period. They found no discernible pattern distinguishing the use of the terms. Besides, a thorough exploration of the terms *data* and *information* was conducted in hopes of resolving this dilemma before moving on to define the compound terms of DQ and IQ [80]. Instead of finding resolution, he found numerous instances in which, if a distinction was to be made, one term was defined by its relationship to the other, leaving neither term well-defined. Given these findings in the literature, the terms will likewise be treated as synonyms in this research unless specifically noted otherwise. From practical point of view, when the term IQ presented to the practitioners, they are explained that data and information is treated as synonyms. From

all the conversations we recorded, any term referred as “data” is seem the same as “information”.

3.1.2 Information Quality Framework

It was not until mid-1990s that IQ research began to coalesce around a common framework. In particular, [12] proposed a framework derived from ISO 9000 for use in categorizing DQ research. The review of the literature presented us with a number of definitions of IQ. Regardless of the differences in IQ definitions, researchers in the management, communication and information technology literature have built a consensus around conceptual frameworks and lists of IQ dimensions that can be used to describe the characteristics that make information useful for the users. The concern for better IQ is reflected by efforts to model, improve, measure, and define it [77, 81, 82]. As the research further developed, attention towards information processes for IQ improvement, for instance, Wang proposed a Total Data Quality Management (TDQM) that adapts the widely used Deming quality cycle to encompass a continual cycle [83]. Fundamental to the TDQM process is that information treated as information product (IP), a valuable assess that should be produced as part of a well-defined production process, rather than the traditional view of data as a by-product [76]. Many researchers highlighted the importance of paying attention to the process [33, 34, 76, 84]. The objective is to deliver high-quality Information Processes to information consumers. To achieve this objective, the MIT IQ research group developed data production maps [73, 76] that use data flow diagram [82]. The flow of information is important in understanding the nature of the information, yet IQ research on the information flow from information exchange perspective is limited.

In the past few decades, numerous frameworks and dimension lists have been proposed and some prominent frameworks are reviewed and their characteristics are summarized. The frameworks are intended to be applicable to a very broad class of information systems [7, 85-87]. Typically, these use a small number of components or dimensions of IQ to group a larger number of IQ criteria or characteristics. Researchers have looked at various ways to conceptualize and define IQ dimensions as usefulness, desirability, and meaningfulness, accuracy, relevance, completeness, accessibility, timeliness, security, timeliness etc.[72, 77]. The most important classifications of quality dimensions are provided by Wand & Wang [81], Wang & Strong [13], Redman [88], and Bovee [80]. Appendix –C presented a large number of dimensions and criteria associated with IQ, and the definition of each dimension.

During the past ten years, the trend of information systems have been migrating from hierarchical/monolithic to a cooperative based structure [89]. Issue of IQ has become more complex and controversial as a consequence of this revolution. In the cooperative information systems, complex information exchanges processes within different operating sources are involved. As a consequence, the overall quality of the information flows across units can degrade over time if the quality of both information exchange processes and information are not assured [78]. Therefore, existing IQ frameworks provided comprehensive sets of dimensions that are applicable to this domain. One of the most popular and referenced frameworks was proposed by Wand & Strong [83], and since then has been applied to many cases and research. The need to have a core reference point for IQ measurements as information exchange in a cooperative structured information system evolves, and thus it is critical as practicality of developing more frameworks to suit the dynamic and complex situations in information exchanges.

3.1.3 Information Quality Assessment and Measure Methods

According to [86], IQ assessment is defined as the process of assigning numerical or categorical values to IQ dimensions in a given setting. They organize IQ assessment into three layers: the IQ metric layer, the IQ dimension layer, and IQ assessment methodology layer. The IQ metrics represent different IQ problems, and they dispose of how to evaluate IQ regarding those problems. The IQ dimensions are characteristics of the information such as accuracy, completeness, timeliness, consistency among others. These IQ dimensions are connected to corresponding IQ metrics. One dimension can be linked to multiple metrics and vice versa. The IQ assessment methodology layer contains IQ assessment models, frameworks, and methodologies. Components in this layer use a set of IQ dimensions to measure IQ. IQ assessment methodology employs a set of IQ dimensions which are linked to different IQ metrics.

Improving the ability to measure quality has been an object of significant interest for the public sector for the past decade, reflecting the notion that measurement can serve as a tool for improvement. Currently, there are a number of different approaches for measuring IQ. On the one hand IQ can be measured with subjective perceptions from information users, and on the other hand it can be measured based on the intrinsic quality characteristics of IQ dimensions. Most IQ assessments fall into either objective or subjective method [8]. Subjective assessment methods typically use surveys or interviews with information consumers to measure IQ. Lee et al. [7] developed a measurement technique known as A

Methodology for Information Quality Assessment (AIMQ) which measures perceptions of each dimension of Wang & Strong model [13]. This technique has been used as the basis of several studies requiring IQ measurement. Pipino et al. [8] presented three functional forms for developing objective IQ metrics. These are (i) simple ratio, (ii) minimum or maximum operation and (iii) weighted average. Each functional form is appropriate to specific quality dimension, for example simple ratio is considered useful for measuring completeness, consistency, accuracy, and conciseness. Appendix – D summarized the dimensions and metrics that have been acknowledged in IQ studies.

Researchers have produced a number of frameworks, classifications and definition for IQ. For example, Ge and Helfert [90] analyzed different frameworks and their research implications. As their research suggests, the frameworks are developed within various contextual factors and applied to different scenarios. IQ frameworks have been developed in order to classify dimensions that will allow for IQ assessment. Fehrenbacher and Helfert [32] identified that IQ measures need to consider context as an important influence on the prioritization and requirements. This research is based on the widely used frameworks with a view to assure the quality of information within contexts in an enterprise business level.

Tools and methodologies have been developed for assessing and analyzing IQ [7, 8, 12-14]. These have mainly been utilized in individual organizations. IQ of information transferring and sharing is challenging enough within one organization with clearly defined boundaries. Yet, we are witnessing a rapid increase in networking, including intra organizational and inter organizational business. This brings an urgent attention to information-related issues when information shared across boundaries. The existing IQ assessment and improvement methodologies are either data or data process-driven strategy. Data-driven highlights improving the quality of the information by directly modifying the value of information, and data process-driven emphasizes improving quality by designing and redesigning the processes that create or modify information. Literature provides a wide range of techniques to assess and improve the quality of information. Overtime, these approaches have evolved to cope with the increasing complexity of IQ in the information systems. For the purpose of this research, an overview on prominent IQ methodologies is presented. Based on Batini et al. [91], table 3-1 below shows an extended list of methodologies extracted for this paper with short and extended names, types of strategy, types of information system, domain focus and the main reference.

Methodology	Extended Name	Focus of IS Type	Data or process Driven Strategy	Domain focus	Main Reference

TDQM	Total Data Quality Management	Monolithic	neither	Database	[83]
DWQ	The Data Warehouse Quality Methodology	Data Warehouse	Data-driven	Data warehouse	[87]
TIQM	Total Information Quality Management	Monolithic & Distributed	Data-driven	Data warehouse	[14]
AIMQ	A methodology for information quality assessment	Monolithic	Data-driven	Database	[7]
DQA	Data Quality Assessment	Monolithic	neither	Database	[8]
IQM	Information Quality Management	--	neither	web	[92]
ISTAT	Italian national bureau of census methodology	Cooperative	Process-driven	Database	[93]
DaQuinCIS	Data Quality in Cooperative Information Systems	Cooperative	both	IS	[94]
QAFD	Methodology for the Quality Assessment of Financial Data	Monolithic & Cooperative	neither	Finance	[95]
CIHI	Canadian Institute for Health Information methodology	Monolithic & Distributed	Process-driven	Healthcare	[96]
AMEQ	Activity-based Measuring and Evaluating of Product Information Quality (AMEQ)	Monolithic	Process-driven	Manufacturing Industry	[97]
CDQ	Comprehensive methodology for Data Quality management	Cooperative	both	Database	[98]

Table 3-1.Overview of IQ assessment approaches

In the past ten years, the focus of IQ assessment shifted from data focused to data process, and from monolithic to multiple systems, and the focus is foremost low data level focused. Another observation is that the main IQ focus has shifted from general frameworks describing IQ dimensions to application or domain specific approaches [22], but lacking of

studies for the public domain. Scholars proposed some specific methods for assuring IQ in different contexts. Often, these conventional methods include data cleaning and normalization [99], data stewardship [14], dimensional gap analysis [100]. Usually, these approaches employ control techniques (e.g., edit checks, database integrity constraints) to assure IQ. While conventional methods have proven to assure good IQ in less dynamic and single organizational environments, these methods are not sufficient for addressing the IQ challenges when information flow is highly attached to the dynamic high organizational and political involved public domain. The methods firmly rest upon technical optimization algorithms and solely addressing isolated IQ variables such as correctness and overload. Consequently, the conventional methods suggest comprehensive, costly, and lengthy technical interventions instead of socio-technical principles that are easier to understand and implement. The social aspect comes from the organizational and political views.

As result of the broad impact of IQ, the existing literature draws upon different approaches to identify and prioritize quality dimensions, to measure and improve the IQ assessment in various disciplines. In order to identify the criteria for an effective IQ assessment, further categorization of the existing IQ literature is presented. Searching is focused on the publications in ACM Journal of Data and Information Quality. The attempt is not to provide a comprehensive review of all, but instead, for the four pointed areas abovementioned, subcategorizing the representative works to classify the criteria is focused. All the approaches cover areas of quality dimensions, measurement methods, and problem analysis and insights for improvement.

In general, these methodologies can be classified into three categories: (i) complete methodologies, which provide support to both assessment and improvement, and address both technical and enterprise issues, (ii) Audit methodologies, which focus on the assessment phase and provide limited support to the improvement phase, and (iii) Operational methodologies, which focus on technical issues of both assessment and improvement phases, but do not address enterprise issues. Figure 3-1, based on [20], summarizes and classifies the popular methodologies focused areas for IQ assessment. It illustrates IQ methodologies regarding assessment and improvement as well as enterprise or specific quality dimensions. Information exchange issues addressed in cooperative information systems marked in red. Process-driven strategy as IQ assessment are underlined and italicized. Noticed that enterprise context is not considered in a process view towards the information exchange issues. This research attempts to bridge the gap by considering the enterprise context with process view.

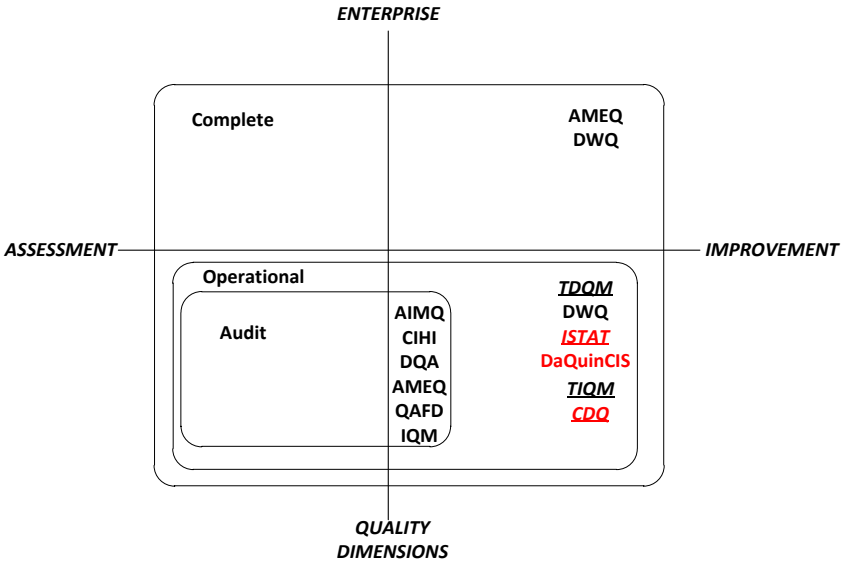


Figure 3-1. A classification of methodologies, adapted from [20]

3.1.4 Information Quality Challenges in Public Sector

When public bodies hold inaccurate, incomplete or outdated information, avoidable tragedies result from poor decision. A number of technical initiatives and developments have taken place to address the issue of poor quality information in public sector. Local authorities are large and complex organizations delivering a wide range of services where core information – normally related to people – is required for many purposes. There will often be many variants of the same information shared across the carious functions leading the confusion and poor service delivery at the operational level. Information is collected and stored because the organization intends to use it for some purpose. The purposes are infinite. The information may be statistics to measure performance or to determine future policy. It may be personal data to deliver services to an individual or charge them for those services, and so on. In every case to achieve the objectives of the original purpose, it is essential that the information is "fit for purpose". This means it must have a definition and meet a specified level of accuracy, currency, and scoop emus be known and understood by all parties, and be "fit for purpose" in the shared situation. Within the efforts to improve the IQ in public sector, yet failures to use and share information appropriately are reported continuously every year [31]. Poor information practice also makes fraud easier and less detectable and enables other forms of cybercrime.

Healthcare, as a significant component of public organization, has been addressed as one of the most challenging in IQ studies [101]. On a daily basis the media reports on the impact of poor IQ in the healthcare sector [102]. The challenges facing the IQ community within

healthcare domain are immense as the tools and methods which collect, process, and use the healthcare-related information are in a constant state of flux. An effective quality based information for healthcare is considered far from sufficient [5]. Information is generated, exchanged, and stored with involvement of various processes, actors, and locations etc. and that are essential to understanding IQ. Healthcare is known as a service involving various disciplines and its information management has long been a complicated issue. Healthcare planning and delivery rely heavily on information from management, administrative and clinical sources – nearly all healthcare activities involved gathering, analyzing, exchanging, and using information. One possible way to facilitate information exchange is to utilize new advances in information technology (IT). IT has revolutionized the healthcare industry by allowing for electronic storage and transmission of information. However, while healthcare's use of IT continues to expand, it results in significant lower satisfaction than in other industries [103].

While healthcare, and other similar public organizations, has been experimenting within a multiplicity of integrated information sharing initiatives, the problem appears is that the lack of considerations to non-technical factors, for example, the information contents itself, the processes, and other organizational factors.

In this thesis, for IQ assessment and analysis is extended to an enterprise level for the information due to the nature information exchanges: assess information and detect IQ problems based on enterprise contextual factors. Specifically design, demonstrate, and evaluate these techniques in public sector domain is focused, a typical cross boundary service with complicated information exchange issues.

3.2 Cross Boundary Information Exchange in Public Sector

To ensure cross-boundary information exchange quality, an understanding of factors that influence information sharing and information exchange is critical. Combined with characteristics of information sharing in public sector, influential factors in this particular domain can be identified for theoretical development.

Information sharing is considered an important approach to increasing organizational efficiency and performance. With advances in information and communication technology, exchange and sharing information across departments and organizations has become more feasible. In the public sector, government agencies are also aware of the importance of

information sharing for addressing policy issues and public health. One of the earliest researches conducted in the area of information sharing in public sector is a study carried out by Dawes [3]. Dawes reviewed the pertinent literature to identify the associated factors that influence information sharing and exchange in public sector. Further to Dawes's research, a recent research conducted by Yang [104], summarized that research in information sharing and information exchange focuses on the interpersonal, intra-organizational, and inter-organizational levels [104]. For the purpose of this research, which is aimed at an enterprise level, I only focus intra and inter organizational information exchange.

3.2.1 Intra-Organizational and Inter-Organizational Information Exchange

Within organizations, there is a trend to encourage groups to share information and knowledge [105]. Wheatley [106] points out, however, bureaucratic model, information flows in organizations are strictly controlled. According to Yang and Maxwell [104], there are various factors that can influence intra-organizational information sharing: organizational structure, organizational culture, characteristics of information, information technology, trust and power [104].

Premkumar and Ramamurthy [40] point out that interoperability across organizations represents cross-boundary information sharing. Pardo et al. [39] point out that leaders and IT executives in the public sector have increasingly recognized the importance of inter-organizational information exchange to improve the efficiency of government agencies. However, sharing of information can involve complex interactions between participating agencies.

Pardo etc. [39] point out that leaders and IT executives in the public sector have increasingly recognized the importance of inter-organizational information sharing to improve the efficiency. Literature defined and viewed influential factors from three primary contextual perspectives, organizational, technological, and policy [39, 107, 108]. With the advancement of information technology, the effectiveness and efficiency of inter-organizational collaboration can be enhanced. Different organizations have various types of hardware and software in their information systems, and it is a challenge to integrate information systems of different platforms, data standards, schemas and qualities [108-110]. Researchers indicated that exchanging information can involve complex interactions between participating organizations because of their different origins, values, and cultures [25, 39, 111]. Policy has a strong influence on the exchanging and sharing of information across organizations,

especially for organizations in the public sector [39, 107, 111]. Legal and policy regulations can facilitate relationship building, risk reduction, and trust development in inter-organizational information exchange and sharing projects when specific guidance provided [108, 112-114].

In most developed countries, governments guarantee public services to the entire population. As discussed in section 3.1.4, public service is one of the most important national domains yet information management still achieved limited results. Mounting evidence indicates that errors and inefficiency towards intra and inter-organizational communication [115-117]. Communication failures, particularly those due to an inadequate exchange of information between different authorities contributions to the unsatisfying results [117]. To address this problem, many approaches proposed, for example, Pirnejad etc. [118] analyzed the literature and summarized factors that influence intra-organizational communications and to reduce medical errors [114]. Social, technical, and organizational factors are the major factors need to be enhanced.

Schooley and Horan [119] proposed a conceptual framework that guides the Time-critical information service (TCIS), that is, public services that are highly time and information dependent. TCIS outlines the factors of technological systems, business processes, and information flow in operational dimension influences cross-organizational information sharing, in addition, organizational dimension and governance dimension are discussed. TCIS framework is demonstrated specifically for healthcare EMS domain.

In this research, the information content quality is connected to the most important and relevant contextual factors for the quality of information exchange assessment. In addition, these factors provide perspectives to identify the low quality areas and possible improvement approaches. In response to RQ 1a), *organization, technology, information, process* and *trust* are identified as the relevant contextual factors for intra-organizational and inter-organizational information exchange, shown in figure 3-2. There are sub elements under each influential factor. These factors and sub elements provide the data for empirical survey, which will be described in section 4.5.

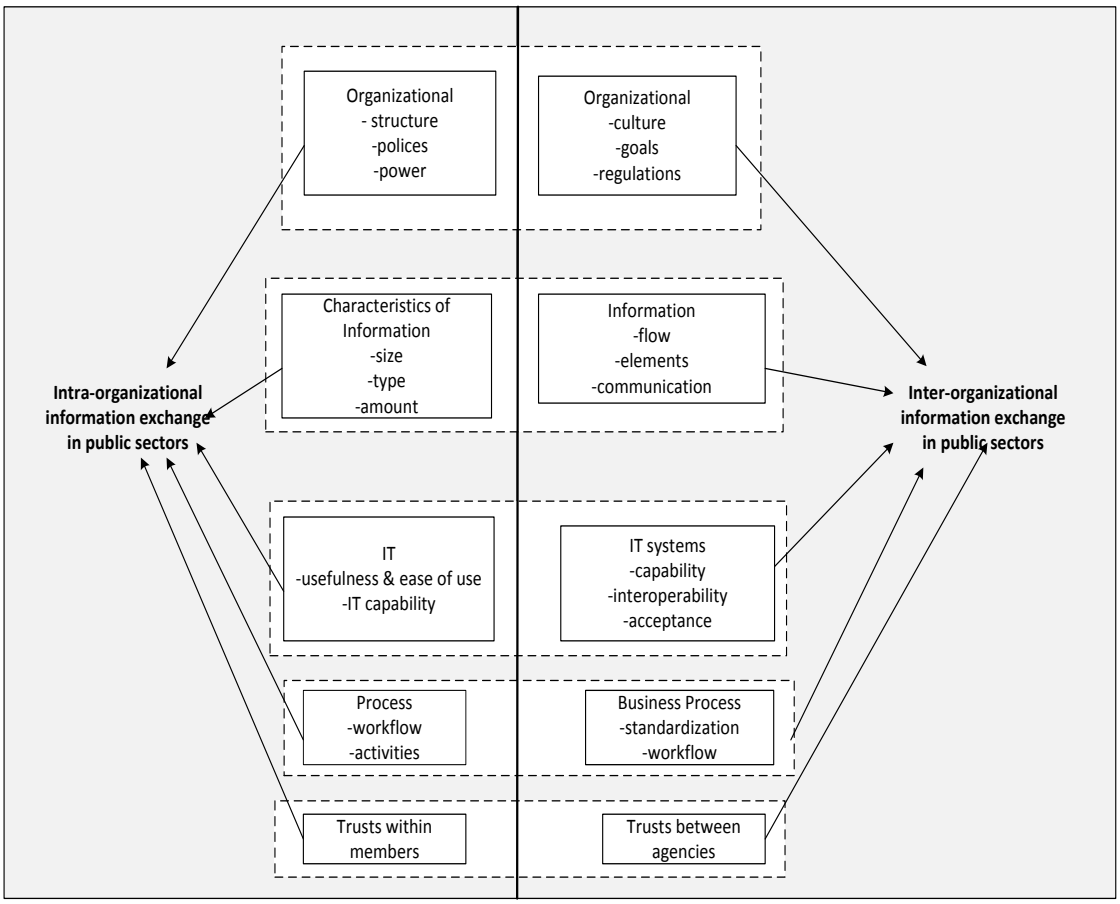


Figure 3-2. Comparison of factors in intra-organizational and inter-organizational levels

3.2.2 Organizational Communication

The numerous ways of organizing and describing organizational communication perspectives have been tied with prevailing organization theories. Aula and Siira [120] defined organizational communication as follows: "communication is a process that takes place in a certain organizational context and in which people together, through messages, create, maintain process and work on meanings." Information exchange not only includes written and verbal information communication. A distinctive characteristic of discussions on communication is that the borders between disciplines seem to be so high that, for example, literature on organizational communication does not include the same references as literature on information research, and vice versa [121]. In organizations, information and productive processes are inherently interrelated. Organizational information processing can also be understood as including those research traditions that have emphasized organizational communications [122]. According to process discipline, communication is transmission or exchanging messages between sender and receiver. This means communication is an exchanging process [120]. Organizational information processing can also be understood as

including those research traditions that have emphasized organizational communication, and vice versa [123]. Literature explained that information processing view probably is the most influential view among organizational theorists during the last three decades [123]. Different ways of organizational communication has been modeled. As the focus of in this thesis is on quality of the information content and not on the vast field of communication, the choice was made to go through only selected perspectives from various literatures that contribute to the information quality consideration. This section briefly outlines the factors that affect communication quality, which assist identifying the poor information exchange causes based on the assessment results and guidance for improvement.

Jonkers et.al [124] discussed four basic social processes that require communication: (a) reaching understanding, (b) coordinating action, (c) building relationship and (d) strategically influencing others. Empirically derived classifications of organizational communication goals also exist. Other useful perspectives to the communication process are:

- Contextualization: provision of explicit context in the message [125].

- Control: a matter of overseeing and, if necessary, adjusting the communication process to assure effective communication. It may be done by (i) planning the pattern of communication process, or (ii) testing and adjusting based on feedback during the process [126].

- Perspective taking: the communicators actively one another's point of view, avoiding information and message left outside of its scope.

Daft and Lengel [127] argue that a message is liable to be misunderstood most frequently when cognitive complexity is high, for example in non-routine situations involving a complex exchange of views. Contextualization is necessary in these situations. Within multiple parties involved services such as those investigated in the present project, cognitive complexity appears to be high. Control is required when a given situation is perceived to be complex and when the probability of communication error is high. In public sector, particular control through planning seems crucial. It appears to be closely related to IQ considerations. Another noticeable perspective mentioned in organizational communication is that the success of organizations depends on their capabilities to process information. Organizations can be viewed as processors: organizational information processing capacity consists

essentially of logistics of information flow and the capacity to interpret that information. This reemphasized the connection of processes and information exchange.

Organizational communication research has mainly been conducted both in the business management field and in the communication field, and I follow these studies to apply to public organizations.

Literature on organizational communication offer essential insights into the topic of the present project. Information quality cannot be assessed and analyzed in a vacuum, but it is intertwined with communication principles and practices. Information exchange is a highly context based concept that the insights from communication literature would be important to this research. Such knowledge is essential in understanding and examining information exchange quality.

3.3 Enterprise Information Architecture and Business Process

To address the problem and motivation mentioned in Chapter 1, one of the challenges confront is how to connect enterprise contextual factors to IQ assessment. Information exchange is a dynamic process focused concept involving different contextual factors to complete the information being sent, received, and stored.

As described earlier, in this thesis, public sector is seen and analyzed as enterprises, based on this definition.

In order to statically measure the dynamic information and connect to the various enterprise contextual factors, information architecture (IA) is deployed in this research. In this thesis, when I refer to IA, it is actually referred to the Enterprise IA, since information among the enterprise contextual factors has been dealt with. This section introduces the concepts of IA within an enterprise, adapting the IA characteristics to lead the proposed QA.IE development.

3.3.1 Enterprise Information Architecture

The term architecture is not without ambiguity, even in building the construction. It can be viewed as the art and science of designing the built environment or the product of such a design. Thus, the term architecture can encompass both the blueprint for building and the general underlying principles such as its style [128]. IA was originally a term related to what is called today “Information Design”. The term IA was first coined by Richard Saul Wurman [129]. No single term universally describes an encompassing framework for managing

information as a resource. In this context, IA combines the background theory, design principles, structures, and diagrams representing the practical meaning of managing and gaining insight from information [130]. For our specific purpose towards information exchanges, I adapt from [131] to define IA as the following:

> *A high-level map of the information requirements of an organization aimed at identifying major information categories and their relationships to other components that supports the information exchange processes.*

Within enterprise architecture (EA), various descriptions of IA exist in the literature, each with their respective proponents. These range from very narrow to all-encompassing, nevertheless, most IA definitions converge on the attributes, structures and interrelationships among information assets (Ross and Weil, 2006). Whether focused generally on business environment or specifically on intranets or online communities, facilitating information sharing has been mentioned as one function of IA. In terms of EA, IA focuses on information and how they relate to other components such as processes and functions. IA specifies principles, technologies and models which link the information content to the organization, process, service and technology of the architecture [29]. For example, IA describes and provides principles for implementing and analyzing effective information sharing management in alignment with the organization structure, the process specifications, and available technology. IA defines and establishes the information component of the EA by providing abstract representations of corporate information. This is where information requirements are specified at a high level, typically as subject areas, entities, and relationships. These relationships characterize how and by whom information is used and where it flows from and to. The IA is used for understanding the information needed and used by people in performing tasks and business processes [132]. Information is created by processes and tasks and is shared with other processes and tasks [29]. In short, IA ensures that information is being described consistently so it can be managed, understood, compared, shared and composed in a coordinated manner across the enterprise.

3.3.2 Information Architecture Characteristics

In the last decade, information management and business process concepts have been fused in usage in information systems studies [65, 104, 133-140]. Growing attention on process-focused approach for information studies becomes important [33, 76, 84, 94]. A typical representative is IA which connects the information to business process, because IA is an information view on business processes. IA not only addresses the static information

structure organization, but also the dynamic process-centric view to map and visualize the information flow [131, 141-144].

Fisher [145] outlines a static view of 'information-centric' and a dynamic approach that is 'business process- centric':

- Static view: focuses upon structures of information elements, such as logical data model, data standards, meta-data, and taxonomy or classification [141, 145-147].

- Dynamic view: focuses upon processes and how information is created, managed, and used, such as a BPM, an information workflow model, and a data flow diagram [148-150].

Figure 3-3 presents an understanding on trend and focus of IA based on timeline. IA is originated with static structure for information management. Researchers initially identify and employ the need for flexible IA in considering of the increasing complex information environment. With the increasing dynamic requirements, researchers begin to focus upon process and how information is created, managed and used [148-150]. From the time trend, it shows that more and more attention has been focused on dynamic aspects. As dynamic concept is developing, such concept is applied back to and strengthened the context of static IA [150, 151].

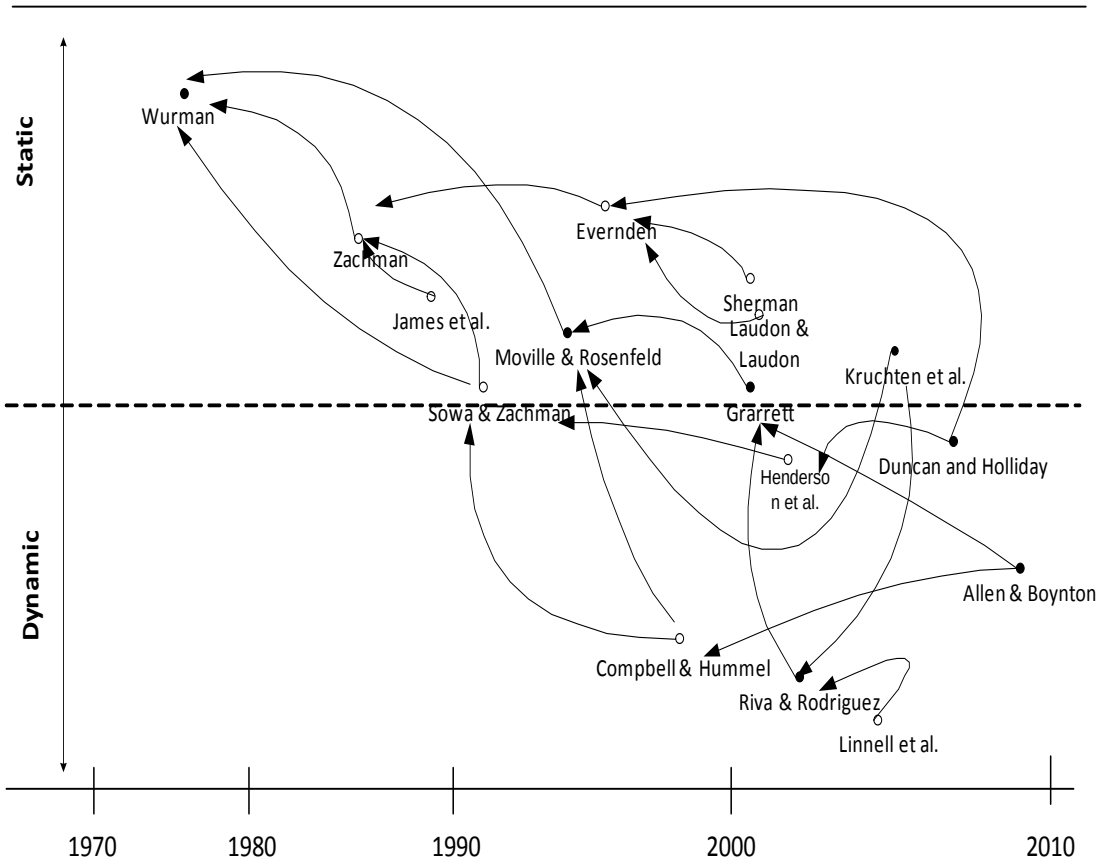


Figure 3-3. Information architecture research

Visualizing the information entities and attributes is another feature of IA that the visual presentation of abstract information spaces and structures facilitates rapid assimilation and understanding [147, 152-154]. In this sense, it brings to the notion that visualization of information supports the assessment of IQ along IQ dimensions. IA characteristics are extracted in Table 3-2 from the existing literatures [46-50], which are the foundation for this proposed QA.IE techniques design.

Static View	**Dynamic View**	**Visualization**	**Organization**
- Data model -Data standard -Meta-data -Taxonomy or classification	-A BPM -An information flow diagram -A data flow diagram	-Facilitate assimilation and understanding -Allows evaluation of IQ measurement along the processes	High-level organize the information for certain function activity to build a common and consistent information foundation.

Table 3-2. Characteristics of information architecture (IA)

For the static view, Data Model is chosen, more specifically, Object Fact Diagram (OFD) that is proposed from DEMO, in this research. According to [155], three concepts are important in IA: Information Entity, Attribute, and Relationship. An important issue is to address how

DEMO is related with IA. From the characteristics observed from DEMO models, OFD denotes some characteristics that is related to the IA, such as the object classes. This is a particular example of an item from a DEMO model that can be linked to the information entity from an IA models. Another example is that with the Object Property List, it includes some items (such as property types) that can be related to the attributes defined from each information entity in IA. This approach views an application's domain in terms of entities that have attributes and participate in relationships.

For dynamic view, BPM is selected. As IA relates business process activities to information, the concept of IA is followed to understand the information flow in relation to business process. Other alternatives could be data flow diagrams and IP-Maps, however these approaches are less comprehensive than IA, which not only presents dynamic process view, but also information view such as OFD data model.

Characteristic of Organization is noticing as it is builds information as common ground to support and integrate the enterprise. An enterprise is supported with several components such as technology, organization, application etc. Based on semantics, pragmatics, and the activity theory, and some "contextual" approaches, Leppänen [23] distinguished the context domains of purpose, actor, action, object, facility, and location. As discussed, assessing the IQ of information exchange, I identify the most relevant contextual elements from an enterprise view. I identify the most cited enterprise components from 45 articles in information system and management literature of Enterprise Architecture, Enterprise Ontology, Enterprise Management, and Information Architecture. Figure 3-4 shows the enterprise components mostly cited are **Technology, Information, Business Process,** and **Organization**. These findings consistent with the identified influential factors of information exchange in public sector, which can be referred to section 3.2.1.

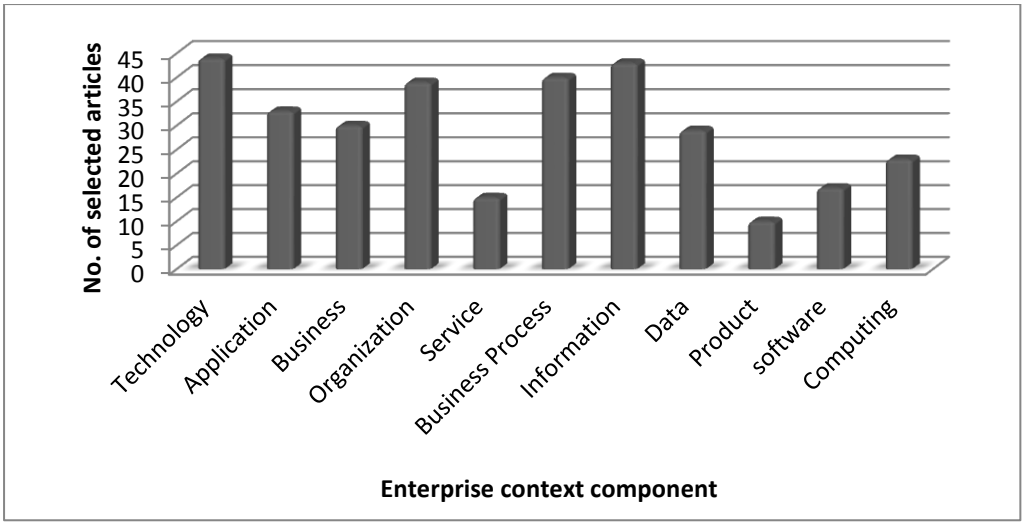


Figure 3-4. Information architecture research

3.3.3 Information Architecture and Business Process Model

IA suggests BPM connects the information dynamically to other enterprise elements. Business process models are described as graphic-oriented representations of sequences of activities, typically showing event, actions, and links in those sequences from end to end [25]. It plays the function of integrating the enterprise, where an aggregation of contexts that are composed of people, information, and technologies, performing functions agreed purposes, and responding to events [36]. In order to capture the content of the exchanged information, moreover, to extract the involved enterprise context information, I need to examine the information exchange processes across the organizations. For our study, BPM is selected because it is particularly well suited to cross-functional perspective, classifying activities and identifies important elements in understanding the information exchange. Underlying concepts that are used for process modeling usually include or combine these three basic descriptive views [156]: (i) Functional View – focused on activities as well as on entities that flow into and out of these activities. (ii) Behavioral View – focused on when and/or under what conditions activities are performed. (iii) Structural View – focused on the static aspect of the process. It captures objects that are manipulates by a process as well as the relationships that exist among them. These views allow us to capture the information exchange factors in a rich contexts of who, where, when, what, and how. [157] summarized a list of representative business process modeling approaches, shown in the table 3-3 below.

Authors	Approach	Brief Description
Dijkman, Dumas, and Ouyang **[158]**	BPMN	A standard notation for capturing business processes. Its diagram s can be used to represent various actions and models that provide a small set of notation categories.
Sadig & Orlowska **[159]**	FlowMake	A design and analysis methodology for workflow modeling, which includes a set of constraints to verify the syntactic correctness of the graphical workflow specifications by graph-reduction algorithm.
Deichert & Dadam **[160]**	ADEPTflex	A graph-based modeling methodology which supports ad hoc changes to process schema. A complete and minimal set of change rules is given to preserve the correctness and consistence property, which provides a comprehensive solution for applying complex and dynamic structural changes.
Van der Aalst et al **[161]**	YAWL	A Petri Net based workflow language, which supports specification of the control flow and the data perspective of business processes.
Liu & Pu **[162]**	Activity Flow	Provides a uniform workflow specification interface and helps increase the flexibility of workflow changes by supporting reasoning about the correctness and security of complex workflow activities independently from the underlying implementation mechanism.

Table 3-3. Business process modeling approaches, adapted from [59]

While much academic literature is dedicated to various topics related to BPM, some drawbacks have been studied [163]: lack of complete choreography that these models may suffer from when the representation of the involved business processes do not reflect explicitly the correct transactional patterns of human acts of communication; lack of formal semantics, incompatible and redundant representations of business processes in the model. In order to unambiguous and coherent models of business processes, assuring its completeness and correctness [164] concluded that design and engineering methodology for organizations (DEMO) can be used to overcome the drawbacks and improve consistent graphic-oriented business process models. DEMO is rooted in the Performance in Social Interaction (PSI) theory, and is perceived as a model for describing and understanding the enterprise construction and operation. It is an enterprise context based concept that is considered the highest conceptual model and helps ensure integrated enterprise [165]. Due the PSI theory, DEMO methodology assures that the observed business transactions are structurally correct and complete. This quality gives DEMO properties that no other known modeling language can offer. Therefore, it is decided to relate our work to the DEMO modeling approach as a suitable BPM approach.

3.4 Core Supportive Theories

The related work presented in section 3.1, section 3.2, and section 3.3 provide the research topics in IQ, information exchange, and enterprise information architecture. From which the literature gap and foundation can be followed to lead this research development. This section gives three core theories that support the proposal in this research. Work System Theory is chosen because it proposes that information and processes are closely connected. This claim backs up the proposal of information should be assessed in an abstract and enterprise level. Coordination Theory is presented because it supports that information exchange is dependent on other elements to ensure the quality of the exchanged information. Lastly, the Social Exchange Theory is selected considering this theory can be a supportive pathway for our research approaches.

3.4.1 Work System Theory

The Work System theory (WST) suits the research background of this proposed research because WST represents the challenges described in Chapter 1. Unlike narrower theories that express relationships between several primary constructs, WST is potentially "interesting" [166] as a body of theory in the information system (IS) field because it links a well-defined big view of IT-reliant systems in organizations with more detailed concepts and theories for analysis explanation, design and action. WST is conceived as an integrated body of theory that encompasses static and dynamic big picture view and that provides scaffolding for layers of concepts that support analysis and design efforts which are useful in our research. In this research, the processes and information are focused, as claimed in WST, processes and activities are devoted to processing information [167]. All work systems use or create information, which in the context of work system analysis is expressed as informational entities that are used, created, captured, transmitted, stored, retrieved, manipulated, updated, displayed, and/or deleted by processes. In this thesis, information exchange processes are connected to the informational entities and attributes that are used, created, captured, transmitted, communicated, retrieved, and stored. During the information exchange processes, other elements such as technology, participants are involved. The elements of the work system are shown in figure 3-5.

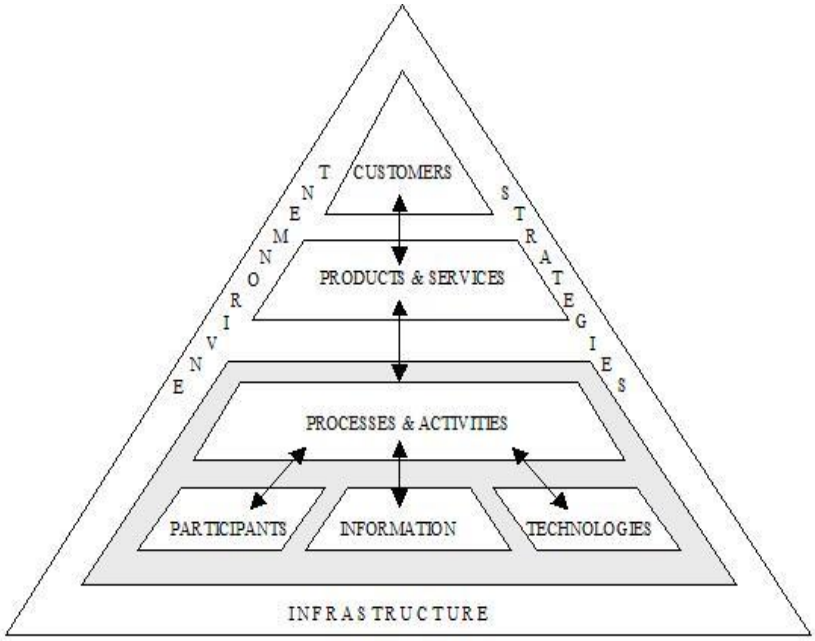


Figure 3-5. The work system framework

The Work system framework is a visual representation of static view of a work system's form and function during a particular time period; minor adaptations may occur within that configuration. It consists of nine elements that should be included within a basic understanding of the work system: customers, product or services, processes and activities, participants, information, technology, environment, infrastructure, strategies. The WST describes the involvement of various contextual perspectives in a sufficient fine granularity to build the basis to view the information systems [167, 168]. This again supports the claims in our research. Information exchange issues occur within the enterprise context of the Processes, Organizational Participants, Information, and Technology, and these should be addressed to ensure the information exchange quality for organizational improvement.

3.4.2 Coordination Theory

Coordination Theory suggests identifying the dependencies between the tasks the different group members are carrying out and the coordination mechanisms the group use to coordinate their work and then considering alternative mechanisms [169]. Numerous scholars from various research domains studied the construct of coordination, including multiple organizational settings (e.g. [170], [171]). [172] define coordination as managing interdependencies between actors, goals, and activities by means of various mechanisms. The need for resources is the most important factor that stimulates inter-organizational coordination [173]. Coordination has traditionally been defined from an organizational-design perspective where rules, modalities, and structures are used to meet the information-

processing demands of the environment [174]. Existing literature (e.g. [175]; [173]) on coordination emphasize the management of resources (e.g. information, technology, personnel) through well-understood administrative coordination mechanisms (e.g. task assignment, resource allocation, input integration). Larsson and Finkelstein [57] outlined some coordination mechanisms provided in. Scholars have proposed various modes for implementing and measuring coordination including coordination by program or feedback [176], impersonal versus mutual adjustment [175] and formal and informal mechanisms [171]. Taking an contingency perspective, Thompson [177] defines three types of coordination: standardized, planned, and mutual adjustment. Under standardization, from static viewpoint, there are established rules or routines for how people should coordinate their activity. In some task environments, team members must plan their coordination processes in relation to the immediate tasks that they need to perform, for example, patient handoff in the emergency room. When the task environment is not easily standardized or planned, from dynamic viewpoint team members have to coordinate through continuous mutual adjustments to each other's activities. This requires constant communication to make sure that coordination requirements are clear and that members perform activities with minimal confusion and maximum utility [178], for example, during a fire rescue emergency incidence, the team members will need to identity with whom to connect, notify them when they sent information, transmit and identify the nature of the information, confirm that the information has been received and any subsequent synchronization of when to respond to it. In contrast, from digital information perspective, if they can standardize on a shared database, with a standardized structure, with synchronized notifications, additional human actions for connection, confirmation and synchronization can be virtually eliminated. Hence, digitalize information can facilitate moving from the more costly mutual adjustment behaviors to less expensive standardization.

Drawing on the information processing perspective, Galbraith [179] postulates that in order for organizations to achieve coordination across and between its contingencies, organizations need to process and monitor information. Yet, information is costly, so organizations must balance their need to process information with their ability to do so. Whenever this match is not present, meaning, whenever the organization processes or evaluate too much information or too little information, the organization is misaligned; there is a misfit between its contingencies.

Malone and Crowston also emphasized the management of interdependencies among information and activities. These authors characterize various dependencies on the process level and a variety of coordination mechanisms that are useful as building blocks to solve information management problems in organizations. According to this process centric view of coordination, a process consists of three types of elements: resources, activities, and dependencies. Resource is produced, and/or consumed during a process; for example, tangible documents and written texts, technological application, people, and intangible verbal communication are resources in an information management process. An activity is a partitioned action that produces and/or consumes resources, for example, 'collecting information' is an activity. Activities are themselves processes and I use the two terns interchangeably. A dependency is a relation among activities mediated by producing or consuming resources; for example, there is a dependency between 'receiving information' and 'transferring information'. This state is characterized more or less by symmetry among parties to the relations. Connections occurring are non-random.

The coordination theory provides foundation to assure IQ of information exchange. It suggests that coordination for information exchange is dependent on other elements in the organization. The presented background on coordination theory is closely to the information exchange improvement suggestions.

3.4.3 Social Exchange Theory

Research shows that several theory bases (transaction-cost theory, organizational theory, and political economy theory) have been used in the literature to explain inter-organizational cooperation [37]. Hall [180] articulates that the social exchange theory, developed from economics' Rational Choice Theory, is the "study of relationships and exchanges." Hall further states that there are multiple variations of the social exchange theory, but all that encompass the same assumption. That is, they all involve "exchange actors", "exchange resources" According to Hall [180], exchange actors are necessary individuals or groups of individuals that champion for the exchange. Exchange resource indicates that there must be a value in what is being exchanged between parties; this could be tangible, such as money, or an intangible, such as information, that has intrinsic value for the organization.

Social exchange theory has been used by IS researchers as the theoretical background to investigate different antecedents of organizational relationships through a lens of non-economic aspects that affect the formation of relationships such as power, organizational

goals, interdependency, and the like [181]. [182] posit that social exchange theory lays a suitable base in the business and organizational realm. Its established framework of organizational cooperation and information exchange makes it applicable to the quality study of information exchange in public organizations. Hall [180] further states that the social exchange theory could provide a useful mechanism to examine information sharing in "large distributed organizations" (p.2).

From organizational perspective, trust and power are the two most commonly studied aspects of social exchange theory. Research suggests that trust leads to communication openness and information sharing, commitment between organizations and therefore increases cooperation [173, 182, 183]. [183] emphasizes the role of power in exchange relationships stating that the relative powers of the parties in a relationship are determined by their relative dependence to each other [184]. The role of power in organizational relationships has been studied on interdependencies between organizations and organizational units. Dependence of on party to the other party in an exchange relationship is related to the need to maintain the relationship to achieve the desired goals [185].

This social exchange theory can be a supportive pathway for our research: to ensure and improve the quality of information exchange, it is necessary to ensure the organizational elements such as power, trusts, and organizational goals.

3.5 Chapter Summery

The literature findings discussed above and its impact on this research are summarized in table 3-4. Many IQ assessment methodologies are developed in IQ studies, however none of the existing IQ assessment approaches employs a process driven strategy to assess the quality of information exchange. Background of IQ and information exchange reveals the gap in current research. To address this, IA literature can be employed to assist bridging the gap and extend IQ research in the following way: define what an effective assessment that considers enterprise contextual factors, identify a suitable approach that links the business processes and information management, and identify the requirements and methods for IQ analysis and measurement of the information exchange. In addition, theoretical foundation of WST, organizational communication, coordination theory, and social exchange theory strongly indicated: (a) process and information are closely related and should be considered in conjunction, (b) to assure IQ of the information exchange and improvement plans,

organizational and social influential factors need to be considered. All the above suggest that IQ assessment with business process approach is well grounded in literature.

Research Concept	Key Observations	Impact on Research
Information Quality and IQ Assessment	Key tasks of IQ assessment are quality dimension prioritization, measures, and improvement. The approach proposed in this research is not addressed in IQ studies.	Bridges the gap and provides the assessment tasks for designing and evaluating QA.IE.
Cross-boundary Information Exchange	Understanding the factors influences information exchange in public organizations.	Scope the research investigation on influential factors which facilitate the causes of poor information exchange quality.
Enterprise Information Architecture	Relates information flows and business processes in a static and dynamic way. BPM Provides various views and key enterprise elements involved in business processes. Provide the most fundamental enterprise components.	Stages design of Information Profiling and BPM. Capturing the enterprise contextual factors for information profiling and IQ assessment.
Core Theories (Work System Theory Coordination Theory, and Social Exchange Theory)	Information, processes, organization, and technology should be considered together for IS design and management. Provide theoretical foundation of the influential factors for cross-boundary information exchange.	Supports our research of relating enterprise contextual factors to IQ assessment (Figure 1). Provides foundation for tracking information exchange issues, and improvement recommendations.

Table 3-4. Literature review summary

The literature review above leads to the answers for the first research questions of "*What criteria are related to IQ assessment for information exchange*".

"Effective" is defined as "adequate to accomplish a purpose; producing the intended or expected result" [186]. From the literature review and the case observation stated above, it is

concluded current IQ assessment is not effective. Information exchange is information centric process involving the supportive application systems, human or machines participants, organizational goals etc. contextual factors. Therefore, to produce an expected result for quality assessment, intention should aim at an abstraction level that information exchange involved contextual factors are considered. In combination of the literature findings from information exchange influential factors (section 3.2.1), component architectures of enterprise (Section 3.3), I identified that one of the criteria to be an effective in this research is connect information assessment to the enterprise contextual factors of Organization, Technology, and Process.

From the IQ literatures, IQ assessment approaches cover areas of quality dimensions, measurement methods, and problem analysis and insights for improvement. This observation suggests that another criterion is to include IQ assessment area of those three areas.

4

EMPIRICAL FOUNDATION – EXPLORATION OF INFORMATION EXCHANGE

4.1 INTRODUCTION

The previous chapter dealt with several IQ and information exchange issues and discussed some theoretical pathways for assuring information exchange quality. This chapter reports on the third phase of this research, which is considered as our empirical foundation since it provides an in-depth analysis of IQ and information exchange management in public organizations. As discussed in section 3.2, research effort has stressed the value of information sharing in public sector such as criminal justice [187] and services to citizens (e.g. tax processing, workers compensation insurance, forest service information) [3, 4, 105]. However, there has been limited attention given to the service performance benefits that result across a coordinated chain of service organizations in public [4, 188], such as EMS service that presents typical inter-organizational services in public sector. The EMS case is used as empirical foundation considering its unique and challenging dynamics and complexities to multi-organizational information sharing. The contribution of this empirical foundation was led by three research questions: 2a) *How does EMS agency in practice manage information between organizations and information sharing* (section 4.2)? 2b) *Considering the various contextual factors involved in an emergency response, how would the enterprise contextual factors affect IQ for all level of involved organizations* (section 4.3, 4.4)? 2c) *What are the existing requirements regarding IQ dimensions and measurement in the EMS case* (section 4.4)?

In search of answers, information management practice and communication management is considered in the EMS units in Ireland. As described in section 2.5, field studies allow investigate their current IQ and information exchange practice, including the challenges and expectations. In the EMS case, information exchange is critical to patients but experiencing poor quality control due to the non-integrated inter-organizational pre-hospital and hospital involvement. In the second scenario of the hospital case, similar information exchange issues occur due to complex multi-discipline intra-organizational information management.

Further to the discussions in chapter two, the field studies using a combination of different instruments are conducted. Firstly, care providers, information management, and communication in practice are observed. Here observation refers to the on-site note taking based on a predefined observation protocol. Secondly, several documents related to communication, information management, and patient handover procedures are examined. Thirdly, interviews and focus group are administered. It is concluded that adhoc opportunistic interviews with relevant experts and practitioners on site, for instance, requesting them to explain the perceived IQ and information exchange problems in more detail (see chapter 2 for more information on the field study approach). This chapter elaborates on the general structure of information exchange and information management in healthcare settings, both inter-organizational and intra-organizational. This elaboration is a necessary prelude to the field study data. This chapter presents the qualitative and quantitative data collected from each case study.

4.2 Case Investigation: Emergency Medical Service

Information management has long been a challenging area in EMS, especially the absence of EMS patient care data has hindered the development and evaluation of EMS systems. Recommendations and actions have been outlined, for example, EMS must adopt a uniform set of data elements and definitions to facilitate multisystem evaluations and collaborative research; EMS must develop mechanisms to generate and transmit data that is valid, reliable, and accurate; EMS should collaborate with other health care providers and community resources to develop integrated information systems [189-192]. Efforts on information/data sharing are emphasized yet in practice the effects are limited. EMS case in Dublin County is examined, which reveals their practice in managing information to assure performance and service quality.

4.2.1 Background of EMS Case in Dublin County

Dublin County's EMS has a unique combination of the fire department and ambulance services. Health Information and Quality Authority (HIQA) is an independent authority, one of their responsibilities is to ensure the quality and performance across EMS organizations including 9-9-9 Control Room, fire services, ambulance services, and health care facilities. Within this role the HIQA strives to find ways to use information to integrate service performance on behalf of their citizens.

In terms of information systems, the EMS system in Dublin has been innovative in some key areas distinguishing itself as an early system integrator, pushing data about emergency incident from computer aided dispatch (CAD) system to emergency responders. A priority dispatch system has been integrated into the CAD system which connects the Control Room to dispatch centers. Regardless of this heavy IT investment, they still find themselves stymied in their efforts to effectively use the information to improve the operation. The central challenge that HIQA faces is that they do not have a direct plan for the enforcement of IQ standards and regulations across EMS organizations. Although Pre-hospital Emergency Care Council (PHECC) is established for pre-hospital information system management, challenges to ensure information exchange with hospital personnel are still up front. In essence, the authority mandates certain levels of quality information exchange, compliance with designated emergency response times, health care provision protocols. Considering the information critical characteristic, the authority explores ways to examine the quality of information to ensure the quality of the services delivered.

This case exploration looks at the inter-organizational information integration initiative from the perspective of the contextual factors that inhibit or prohibit information exchanges in their current practice As identified in this research, the context factors are scoped to *organizational, technological, and process.* Based on those three contextual factors, examination are carried out on how much their IQ practice is connected to the context factors, and what are the most important sub elements when considering information exchange. Their current IQ management, and examine the most important IQ dimensions and determine their level of satisfaction are also investigated.

While seeking for answers on how EMS agency's in practice manage information between organizations and information sharing, how prototypical incidents are handled across fire, police, ambulance crew and medical personnel are looked into.

4.2.2 Observations on EMS Response

Witnesses to an incident place an emergency call by dialing 112. Call automatically routed to the Emergency Services Control Center closest to the place the calls originate from by Caller Line Identification (CLI). Stationary phone calls and mobile phone calls, the physical address and number data are automatically displayed. After getting an initial description of the incident, the 112 representative contacts the emergency dispatch center/the fire brigade. The ambulance and fire brigade dispatch centers have immediate access to the information

originating at the control room. Requests and confirmations move back and forth to coordinate the activities between the call and the dispatch center. The ambulance dispatch center can follow all ambulances and mobile medical units via GPS. In addition the paramedics in an ambulance send status updates by pushing dedicated buttons on a radio. These communications inform decisions about vehicle dispatch.

Personnel from multiple specialties coordinate at the incident site: police, ambulance staff, the fire brigade, nurses and doctors. The larger the incident, the more commonly accepted and understood the personnel infrastructure becomes. The incident response system is used for all incidents – big and small – throughout Dublin County. Establishing and maintaining effective information exchange both within and across agencies and distance – even short distances – is one of the greatest challenges in emergency response. Radio and mobile phones are used for in-person information exchange, which often disturbed by overhearing others talk around them.

A critical aspect of EMS work is the management of patients, their injuries, and their care. Even under the best circumstances, this work requires a series of handoffs from one responder to the next. This means that the information exchange during handoffs is critical for effective patient care. A Patient Care Record (PCR) is filled out for each patient. The main purpose of the record is to provide different professionals with a tool for registering of injuries, symptoms and on-site ambulatory care. The record contains a predefined unique person ID which is meant to track the person from the accident to the hospital. It is found the PCRs not completed, especially for incidents that involved several patients/victims. There was simply no time to complete them, let alone verbally sharing information with the hospital personnel before their arrival to the hospital. When patients arrive at the hospital with or without PCRs, they receive additional specific patient sheet for information fill up. Then the patient information will be registered and entered to the hospital Electronic Medical Record (EMR). Information exchange about patients is based on written records and mostly verbal. This results in severe problems for the hospital teams who find it is almost impossible to get information from the incident site where major incidents occurred. Crucial information is reported by ambulance staff to the receiving medical team, though this happens usually only once during transport because the ambulance workload is usually too high. Also, the infrastructure does not support automatic updates. Once the patient arrives, new evaluations

by the medical team are performed. Information about the patient is gathered over time and from multiple sources. This constructed view then itself is made explicit at the hospital.

For information management, PHECC and other healthcare authorities oversee the quality of information, including EMS dispatch, field data collection, and hospital recording and reporting. However, there are little medical records documented. In fact, documentation is rarely associated with each patient until after arriving at the hospital, when documentation is made though still incomplete. Instead, patients are produced and reproduced over time through verbal exchanges at each formal and informal handoff. Under this observation, all the information occurred during the incident is not evaluated at all. Information recorded digitally is monitored within each individual system. This means the IQ assessment results do not reveal the real problems as it is segmented information despite that it is all generated from one incident. Business processes and organizational goals are connected to the information management.

4.3 Descriptive Case Findings

The following section discusses organizational, technological, and process contextual factors to information exchange that were found though the fields study in this EMS case. To answer the research question 2b), information exchange involved contextual factors are investigated in a practical case. This section also discusses perceived performance implications of those information exchanges. The discussion below has been organized by each enterprise context as identified in the previous chapter.

4.3.1 Information Exchange Related to Organizational Perspective

The EMS agency spends a significant amount of its time developing relationships with cooperating organizations at quarterly meetings for the primary purpose of discussing, evaluating, and improving emergency care.

The discussion below related organizational issues to information exchange and information sharing, including *goals, culture,* and *policies and rules.*

Goals – The goals of the call center, ambulance center, and the hospital ED are different. They have organizational goals where the staff performance and quality is evaluated. In the call center, one of the goals is to ensure the emergency call is timely served and that the information is transferred to the ambulance crew. The ambulance center is to ensure that they reach the patient within predefined time, while the hospital ED is to receive and treat the

patient on time. Each unit only focuses on completing their tasks and goals defined to them. In this sense, information exchange is affected, for example, one paramedic stated,

> Sometimes we feel we are in the lower-level operatives and are briefed on a very limited 'need to know' basis and are often oblivious to the wider context and significance of our actions. Also, our concern is more with getting to the scene and reaching the patient within the required time. Exchanging the information about the location is our priority since that's the goal we need to reach. Sometimes, other factors, such as how quick and accurately we pass the information to the ED, would affect patient treatment, and we know that, but due to the pressure we bear, most of the time we prioritize sending the patient to the ED timely and leave the rest to the doctors.

Due to the separate goals for each unit, the IQ is defined differently without placing in the big picture. For instance, in the call center, IQ is defined as good when the caller information is accurately recorded and transferred within the required time; ambulance center would have good IQ when the information of time stamps are reached to each point; hospital ED count good IQ is when the patient treatment data is stored in the PHR system.

> Despite each unit reached their 'good IQ', patient satisfaction is still not ideal. The patients take the entire emergency care as one procedure. Often, they are not happy to be asked the same questions over again and again, to the call center, to the paramedics, and to the nurses, and to the doctors. Sometimes they are sent to the hospital on time, but because of the information disconnections and confusion their treatment was delayed or even the wrong treatment was performed.

Spoken by the operational manager in ED. The goal setting for EMS delivery should be coordinated with all the involved units to make sure it is patient-centered. The EMS Agency participants noted how their ability to access, aggregate, and exchange cross-organizational historical data grants them some degree of power to influence the quality of information from end-to-end performance.

Culture – Participants noted that there exists a gap between how service organizations view EMS and how customer/patients perceive the service. As an example, the PHECC sends and receives surveys to assess patient satisfaction with fire and ambulance/pre-hospital services. However, many of the returned surveys contain written explanations about issues at the hospital emergency department (ED) instead of issues relating to pre-hospital service. One EMS representative explained:

> These types of survey responses represent something that is obvious and that we've been aware of. A patient/customer's perspective of the service is that the 'pre-hospital' and hospital experience is an integrated, single event. Evaluation of service or information quality is rarely conducted in such a manner though.

From the organizations' view, they have a long history of evaluating their own part of a response. One ambulance provider stated:

> We talk about giving service in a patient focused way all the time. We believe in doing that. I don't think it's too difficult to imagine a patient's perspective. But we are a different organization than the ED and the fire department. We are not one big organization and we aren't seamlessly integrated.

Another cultural character in the EMS is the lack of trust in information that often exists between individuals from cooperating organizations. For example, paramedics described how hospital physicians appreciate paramedic comments more than others. Physicians at the more prestigious health care facilities tend to be less interested in paramedic comments. One paramedic explained:

> It's a matter of doctor's not trusting the information that we give them. Doctor's have way too much pride to believe everything we have to say or do. Distrusts between the senders and the receivers affect the quality of information exchange.

It is found cultural challenges to facilitating sharing of patient care information. For example, the culture of the ambulance service is one where paramedics have a great deal of freedom to choose how they will work in the field, coupled with a strong sense of responsibility to provide meaningful service. Each paramedic has his/her own preferences as to how he/she uses the PCR and other related tools/equipment and there are loose organizational standards for information collection in the field. One paramedic elaborated:

> The PCR sheets are always taken to a scene and enter data, but it turned out that some start the PCR en route to the hospital, some enter the information after delivering a patient to the A&E (ED) but before their next dispatch, and some wait all the way until the end of their work shift. Some write summary notes to shorten their reports and others spend a lot of time writing detailed report to cover their butts in case someone decided to use.

Participants noted the cultural issue stems from the dynamic nature of their work. Information entry is often dictated by the differing contextual factors of each emergency incident including the often unknown status of a patient's health condition. This contributes to the uncertainty of the information exchange quality as the information is not consistently recorded, shared, or evaluated.

Policy and rules– Information exchange quality is also influenced by how quality information is defined or the rules and definitions that described the information. For example, "response time" starts when a dispatch message is sent to a crew and the ends when the emergency vehicle parks at the closest practical point to the emergency scene. An EMS representative stated:

> This time segment measurement stops when a vehicle parks. It does not include any additional travel to the scene-up to the fourth floor of a building, across a football field, or inside a crumpled car that we can't stop.

Time stamp data are used to analyze EMS and fire crew response times as outline in the county EMS contract. Participants discussed how fire and ambulance crew monitor these segments in a "real-time" nature in order to help them meet contractual service obligations. One paramedic stated:

> We're watching the time very closely as we travel to an incident and we definitely feel pressure from our Chief to arrive before the 6 minute maker.

This does not in any way imply that arriving quickly is not motivated by helping a patient. But the time element provides a constant reminder to act quickly. An important organizational perspective to this phenomenon is the regulation and policies that the EMS agency has to mandate both information sharing and performance levels for fire and ambulance organizations.

In this case, horizontal information exchange is not enhanced. For example, the ambulance was usually concerned about reporting their time stamps and most of the time share limited information regarding the patient condition.

These rules and policies are paramount when sharing information across organizations, creating service level agreements, when comparing quality evaluation from one system to another, or when comparing quality over long periods of time.

4.3.2 Information Exchange Related to Technological Perspective

HIQA and PRHCC authorities have made significant efforts to collect and utilize incident information to manage service. As observed in section 4.3.1, the information systems used to collect, aggregate, and facilitate information exchange across organizations are two-way radios, mobile phone, software interfaces, papers, etc. There are three main separate systems for collecting, exchanging, and analyzing information – the aforementioned PCR, CAD, and EMR. An important "information type" collected across "pre-hospital" organizations is "time stamp" data, which enables the author to monitor pre-hospital time-related service, However, it is noted that very little information is aggregated and shared across all organizations including hospitals.

Ease of use – utility of information systems and data in the field has been discussed among the EMS agencies, for example, potable laptop was introduced to the paramedics. However, paramedics explained many difficulties and inconveniences. Because it is such a time critical service that real time information transferred through devices has to very simple and eases to use.

> When saving patient or saving data comes to choice, the earlier one is definitely the priority. When the introduced information system is complicated or inconvenient, it actually pull back our performance standard. Such as the portable laptop, it is such a big device to carry around, type or writing unrecognizable issues in fact took us longer to assess the patient en routing.

Therefore, when the system is not ease of use, the staff would resist adopting or embracing it.
IT capability – Sometimes a new technology or system is introduced and adopted, the IT capability has to be well managed. In this EMS case, IT capability composed of IT strategies, infrastructures of hardware, software, application, network, tools etc. At the moment, their strategy on IT is focused on infrastructure. Even with huge investment in technology, the results seemed not to reach expectations. Digitalized information is essential, if systems implementation is end-to-end performance oriented, productivity should be increased because of the integrity [193].

User acceptance – The level if the users accept and use the technology depends on various aspects. For example, technology 'ease of use', 'user competency in IT', monetary and other motivations etc. In EMS case, it seemed that users are often unwilling to use information systems. Without acceptance, discretionary users will seek alternatives, while even dedicated

users will likely manifest dissatisfaction and perform in an inefficient manner. In order to ensure the quality of information and information exchange, the means and channels to exchange information is essential. At the moment, most of information in this case is non-digitalized. Yet the paper written information exchange and oral communication cause problems, for example, upon the patient delivery, physicians at the receiving hospital had difficulty deciphering the written information by paramedics. Yet paramedics and physicians stated that when accurate patient information is collected and shared, their ability to deliver appropriate medical care can be greatly enhanced.

4.3.2 Information Exchange Related to Process Perspective

As discussed with the EMS authorities, information exchange quality is affected by business processes and vice versa. Under this context factor, it is revealed that *workflow* and *process standardization* is essential in the current EMS practice.

Workflow – It is agreed that automated data collection allows workflow changes, which impact the quality of information exchange and care performance. As one emergency medical technician (EMT) described:

> I wish all of our time reporting could be automated. It may not seem like much of an effort to report departure time and arrival, but when I know there is a severely injured patient waiting on help, I just want to focus on getting there and treating the patient, not on reporting our time or procedure or whatever. In those life threatening situations, we really don't record until after transport anyway.

Also, from the observation and discussions, it is found that workflow challenges associated with the flow of information from one organization to another. One challenge discussed was how a large proportion of incident information is transmitted via voice or hand-written communications and not captured or transmitted via information systems. The EMS and healthcare authorities discussed this issue and attempt to address it with information technology. For example, Dublin County introduced e-PCR system access to all county hospitals and healthcare facilities. However, a representative stated:

> Hospital staff rarely uses the system. They continue to reply on the traditional methods of receiving incoming patient reports. Basically, ED staff (nurses and doctors) rely on voice 'snapshots' from paramedics in combination with paper reports.

In addition, standardized EMS delivery process is found lacking, and attention on design and redesign emergency response processes from end-to-end perspective does not exist.

Standardization –the efforts to ensure the data collection and transmission either automatically or manually. There are two processes that appeared most unnatural and problematic: one is that the non-standardized and unstructured communication process about the patient and the incident on way to hospital and in the emergency department (ED). That is where the information is found incomplete, time consuming, and incorrect. Another process is re-entering the patient and treatment information based on the written PCR from the ambulance crew. High chances of inconsistent and inaccurate records occur during this manual process. Participants agreed that the quality of information exchange is affected by the process standardization.

4.4 Information Quality Identification to Ensure Information Exchange Quality

As emphasized, due to the amount of information, the evaluation of its quality is essential to ensure the quality of information exchange. This will allow selecting and prioritizing information according to quality dimension such as completeness, accuracy, timeliness, believability, and relevancy. It is necessarily to derive a set of IQ dimension which have to be refined and confirmed with deep involvement of domain experts. In this section, investigation on the IQ requirements in the EMS case is carried out, which also contributes to the answer of RQ 2c).

4.4.1 Information Quality Dimension Identification in EMS Case

As reviewed in section 3.1.2, IQ is a pervasive social concept and a key antecedent of information system success [194]. What is new in the past several decades is the explosion in the quantity of information and the increasing reliance of most segments of society on that information [97]. As a result multiple frameworks are proposed for capturing IQ requirements, each viewing and treating this concept differently. These requirements can be used as benchmark to improve the effectiveness of information systems and to develop IQ strategies [195]. As reviewed in section 3.1, the numbers of requirements proposed by scholars are very different. A more comprehensive overview of IQ requirements is provided by Lee et al [7] who suggest the categorization of twenty-one requirements in four categories. Even so, not all of these requirements are relevant for certain services and some of them are even correlated.

In this EMS case, in contrast to relatively predicable business environments, information and communication needs for emergency service are diverse in nature, reflecting the multiple purposes for information and communication requirements that occur at different times and locations with respect to an incident. Moreover, the multi-actor environment of an incident does not only create varying IQ description, but also raise the questions on how these dimensions can be assured in a temporary, fragmented and ad-hoc environment [165]. As described in section 2.2, three empirical cases are reviewed in order to narrow the dimensions in this EMS domain before engaging the practitioner in fields. Three empirical cases are studied: case 1 – a cardiac arrest as a day-to-day emergency case; Case 2 – a typical car accident in rural areas, and case 3 – one major incident that more than 6 casualties are involved.

The main objective of our case survey was to identify and describe IQ related problems which occurred during the response the incidents. Using the problems found, the aim is to shortlist the number of IQ requirements for designing IQ assessment approach. Table 4-1 lists the IQ dimensions and related problems pointed out in evaluation reports on the three empirical cases.

IQ Dimension	**Description of IQ problems in case studies**
Relevance	Relevant information is needed to support emergency operations of all kinds, but all three cases indicate that certain information delivered is not related to certain emergency task needs.
Accuracy	In emergency management, information about technical conditions revealed ambiguous and unreliable (case 2). Furthermore, the emergency starts out with a lack of information, which then turns into too much imprecise information (case 2 and case 3).
Timeliness	All three cases indicate that from dispatch center to mobile rescue units to the ED in hospital, the situation changes over time, information received in and/or delivered usually is not sufficiently timely.
Completeness	In case 3, “mostly, the information is incomplete, yet conclusions must be drawn immediately”. Complete information is not delivered in different complete levels of details (case 1 and 2), especially upon the patient arrival in the hospital.
Accessibility	“Needed information existed in the system but was not accessible” (Case 3). Case 2 and 3 shows that access to data across agency lines also needs to be

	improved to support interagency coordination.
Consistency	To enable information sharing, document content and format have to be consistent across agencies. Three cases revealed the inconsistency on written and verbal information.
Understandability	Information is transferred in a complicated or unclear language or format under emergency situation. For post-emergency management, the recorded information is not understandable for assessment or evaluation.
Security and Privacy	Patient Information is not standardized to the policies and processes (case 1 and 3). Information is not protected potential misuse of information (case 2 and 3).

Table 4-1. Description of IQ problems specifically pertaining to EMS management

These eight shortlisted IQ dimensions of *Relevance, Accuracy, Timeliness, Completeness, Accessibility, Consistency, Understandability* and *Security and Privacy* are followed.

4.4.2 Information Quality Dimension Prioritization Approach

To further prioritize the IQ requirements, evaluation on the importance of those IQ requirements using semi-structured interviews with professionals. The objective of the interviews conducted is to test if the selected IQ dimensions matched the requirement information managing that EMS practice is struggling with, and to find out which measurement metrics. If the IQ dimension matches the requirements, when a problem occurs and they need to assess IQ, a prioritized measurement procedure can be carried out. The interview reveals how various information managers from different organizations have different knowledge on several IQ requirements and metrics. Almost all the twelve respondents underline that the emergency organizations information systems and operation are designed, developed, and operated in a fragmented and separate way, making it hard to cope with IQ problems.

In the beginning of every interview the importance of high IQ during and post incident is explained and, the descriptions of IQ dimensions are presented. To ensure homogeneous participants first of all the overall goal during the work in a complex situation is questioned. By comparison of the mentioned goals and the weighing of the IQ dimension a potential dependency or the detection of a homogenous focus group can be derived. Subsequently, the filtered eight dimensions are presented to the participants by explaining every criterion in detail. It is highly important that the dimensions are clear to guarantee the same understanding and, if desired, they can question the definition. Afterwards the task is to sort the cards in different groups according to their importance. After sorting, the dimensions

shall be arranged according to the prioritization, at least in the first “most important”-group. The equilibrated classification of the dimension is a result as well. Throughout the interview the participants are welcome to comment their sorting (via “think aloud”) and to ask if anything is unclear.

4.4.3 Results

The sorting within the group is weighted for the analysis. Dimensions in the first “most important”-group get four points, the “less important”-group gets two points, and “not important”-group get zero points. If the dimensions are arranged according to their prioritization, the available points are split up. For example, if the criterion completeness, consistency, and relevance, are categorized into the first group and the participants assign completeness as the most important criterion, consistency as the second important and so on, completeness would get four points, consistency 3.5, and relevance 3 points. Every dimension in the most important-group gets more than 2 points and at most 4 points.

Finally, all numbers are summarized and hence, the highest scores present the most important IQ dimensions and the lowest score the least important ones. It is recognizable that all these eight IQ dimensions are rated more than 2 points. Figure 4-1 shows that the distribution of the presented IQ dimensions. All points of all dimensions are summarized and gathered, and hence a percentage distribution can be reached. After the conducted interviews accuracy, timeliness, and completeness are equally important, followed by accessibility, consistency, understandability, relevance, and privacy and security.

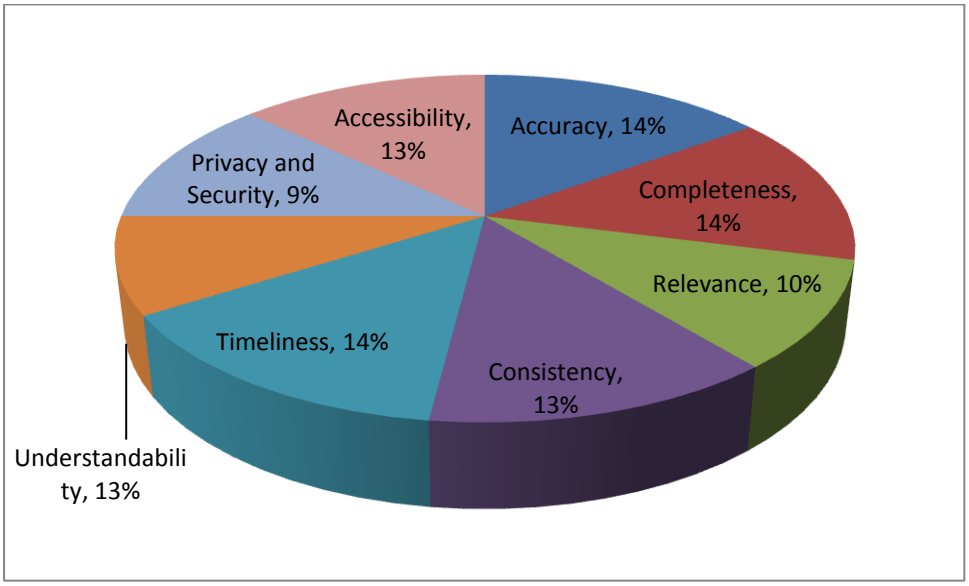


Figure 4-1. Distribution of the scored IQ dimensions

Although in general those are the agreed dimensions from the cross discipline users, further investigation on IQ prioritization is necessary due to various contexts. For example, technology users rank conciseness more important than completeness, whereas non-technology user regard completeness as more important [21]. Consequently this highlights the notion that IQ assessment should consider contextual factors.

4.5 Confirmatory Survey Conduction

From the above EMS case analysis, it is conclude that to ensure information exchange quality require one is required to consider the contextual factors and IQ. In chapter 3 I examined the enterprise contextual factors in literature, and in chapter 4 context factors are also investigated within EMS case. This set of contextual factors provided us with a first 'rough' sample of items for our survey. Literature and empirical case suggest the assessment techniques should consider organizational, technological, and business process contextual factors. Go beyond the EMS case, surveys on the relevant professionals in public sector are employed. 83 completed surveys were collected in the 17th Annual Healthcare Informatics Society of Ireland Conference. Over four days, the present conference attendants are requested to fill in the prepared survey. I obtained a 95% response, as almost 83 of the 87 requested professionals participated in the survey and complete the forms. Majority of the conference attendants have rich experience and knowledge in public services.

The first section contains a quick request on their occupation and experiences in public section. The second section is to select the sub elements under each context factor that are important to information exchange. The third section is to survey how much is context related to information exchange quality assurance in their practice. The last section is to rate the IQ dimensions in their practice. The final set of IQ and contextual factors related to information exchange items used in surveys is provided in Appendix – E.

An important decision needed to make before surveying the professionals was on the selection of the appropriate measures regarding the most related IQ and information exchange contextual factors. In chapter 3, the influential factors of information exchange and sharing are reviewed, presented in figure 3-2. Based on the context factors that are concluded in section 3.2 and section 3.3, sub elements are surveyed, defined in section 3.2, to 'fine tune' the elements under each context variables – organizational structure, policy, regulation, trust,

power, culture, and goals; technological acceptance, capability, interoperability, and ease of use; business process standardization, process management, workflow, and activities. In the empirical study, interview results showed that *culture, policy and rules,* and *goals* are the most concerned ones under 'organization' factor*; capability, ease of use,* and *user acceptance* are concluded under 'technology'; *workflow, process standardization,* and *business process management* seemed to be the most essential elements under 'business process'. These elements are used in the survey for the respondents to choose whether or not they are important for information exchange. The results showed that all the elements gained more than 65 out of 83 votes. That said the professional practitioners agree that those context factors and elements are important for information exchange management in public sector,

Participants' satisfaction on the selected context items of organization, technology, and process from their experience are surveyed. As reviewed these three constructs consist of various different aspects that can be judged using one or more survey items (questions). Moreover, experts on employing statistical data analysis techniques [196, 197] suggest that each variable should be measured with at least three items in order to safeguard construct validity (three items per construct rule). Therefore, this study generally prefers to adhere to this rule. The selected organization, technology, and process variables and their sub elements were measured as the second phase.

The third phase is to survey the IQ satisfaction relating to information exchange. In section chapter 3 I searched for IQ variables mentioned in literature, and in chapter 5 section 4.4 I investigated the problems and requirements of IQ that related to information exchange in the EMS case. The shortlisted results that the survey questions are designed based on are presented in figure 4-2.

The results of these surveys were analyzed using descriptive statistics in SPSS 17.0. Findings from the survey data analysis is presented as followings.

Since this study used multiple items to measure a single construct, it allows conduct a reliability analysis prior to calculating the average scores and standard deviations. Table 4-2 outlines the findings of the reliability analysis.

Variable	**Context/IQ Items**	**Cronbach's α**
Context _ Organization	Organization _Structure	.556
	Organization_ Policy	

	Organization_ Goals	
Context _ Technology	Technology_ Capability	.761
	Technology_ Ease of use	
	Technology_ Acceptance	
Context _ Process	Process _Work flow	.843
	Process_ Standardization	
	Process_ Business process management (discarded)	
IQ _ Timeliness	IQ_ Timeliness_ A	.878
	IQ_ Timeliness_ B	
	IQ_ Timeliness_ C	
IQ _ Accuracy	IQ _ Accuracy_ A	.689
	IQ _ Accuracy_ B (discarded)	
	IQ _ Accuracy_ C	
IQ _ Completeness	IQ _ Completeness_ A	.892
	IQ _ Completeness_ B	
	IQ _ Completeness_ C	
IQ _ Accessibility	IQ _ Accessibility_ A	.812
	IQ _ Accessibility_ B	
	IQ _ Accessibility_ C	
IQ _ Consistency	IQ _ Consistency_ A	.873
	IQ _ Consistency_ B	
	IQ _ Consistency_ C (discarded)	
IQ _ Understandability	IQ _ Understandability_ A (discarded)	.637
	IQ _ Understandability_ B	
	IQ _ Understandability_ C	

Table 4-2. Reliability analysis for information exchange contextual factors and IQ items

Table 4-2 presents the values for the Cronbach's Alpha, which is a measure for the internal reliability of a scale used for each construct. The items I discarded in order to obtain a higher Cronbach's Alpha are labeled with 'discarded' in the table. George and Mallery [198] suggest that the following norms for interpreting the Cronbach's Alpha coefficient: >0.9 is considered: excellent; >0.8: good; >0.7: acceptable; >0.6: questionable; >0.5: meager, and <0.5: unacceptable. Note that these norms assume a large data set (over 100 cases), whereas our data set contains 83 cases.

In the survey, the respondents are asked to indicate the level of quality and context involvement on a 7-point Likert-Scale. When analyzing the data, particular interests in the

average mean and standard deviation for each of the context factors and IQ dimensions are focused. The following graph in figure 4-2 provides the score for the different context factors in relation to information exchange quality.

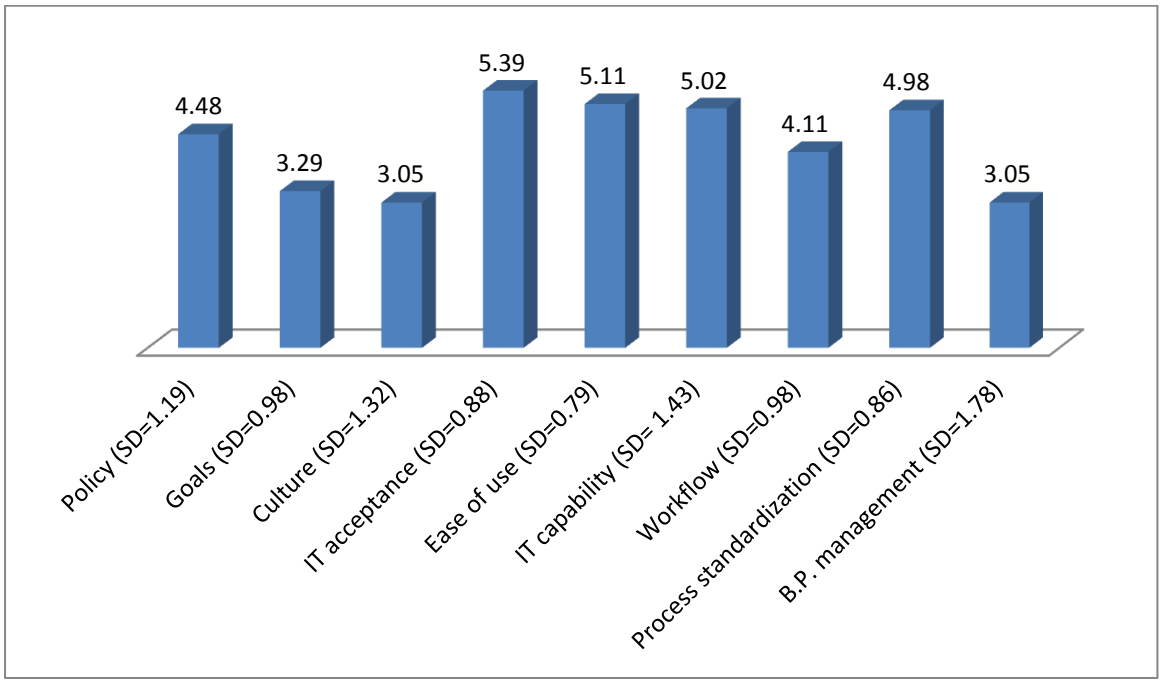


Figure 4-2. To the extent that information exchange is connected to contextual factors (n=83)

The average scores presented in the figure above indicate that the experienced respondents perceived very 'moderate' connection of contextual factors to information exchange quality. Organizational sub elements received rather low scores. The highest score is the technology involved variables. The standard deviation of the business process management seems to be the largest from this data set, while the respondents seem to agree least on the means of IT ease of use.

The following graph provides the score for the different IQ satisfaction related to information exchange in public sector where information usually created, transferred, and received in different formats such as verbal, written, and digital.

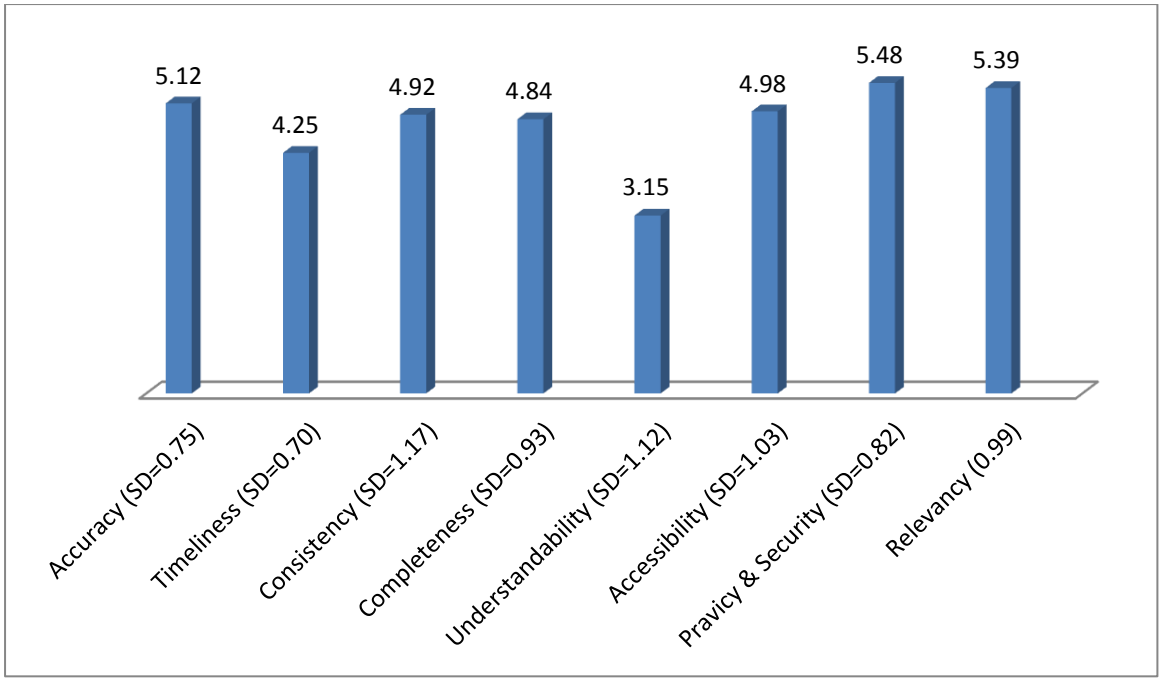


Figure 4-3. Information quality satisfaction for information exchange (n=83)

The average scores presented in the figure 4-3 above indicate that the experts agreed that overall IQ dimensions are somewhat 'moderate'. Understandability is relatively poor score compared to all. This indicates that the information is poorly recorded and transferred. Note that the standard deviations for consistency, understandability, and consistency are relatively high.

Generally, the surveyed respondents were disconnected with the context of information exchange quality assurance, despite the confirmation of the importance of context factors. This survey results provides guidance on the components and methods for the QA.IE techniques design. Following the design principles, the empirical case, the expert interviews and surveys, the QA.IE techniques can be conceptualized, this is explained in more detail in chapter 5.

4.6 SUMMARY

This chapter presents the findings of our field studies in Ireland EMS case and demonstrates the information exchange and information management in practice. As discussed previously, IQ being influenced by the enterprise contextual factors of technology, organization, and business process in this complex public service. Throughout this empirical study, answers to three sub-questions were set out.

The first sub-question (2a) asked about how cross-organization information being managed and shared in public EMS setting. As essential part of the field study, their day-to-day emergency response in Ireland was observed. The observations were conducted based on protocols crafted for studying the information management process, capabilities, and IQ issues. This question was investigated by collecting and analyzing observational data, available documentation and reports, informal talks with the staff and discussions with domain authorities. Cross-organization information exchange and information management takes place via multiple channels (voice, text and visual) were observed. Moreover, the roles and capabilities for information sharing are mostly sequential and non-standardized procedures for information exchange. In general, information is recognized as one of the most essential resource yet problems for information exchange are obvious.

Considering the various contextual factors involved information sharing, the second sub-question (2b) asked about how the enterprise contextual factors affect IQ the involved organizations. This question was investigated by using in filed discussions with the practitioners. The findings suggest that contextual factors of organization, technology, and business process are closely connected to information exchange in their daily operation. Elements of organizational goals, policies, culture, technology capability, ease of use, user acceptance, business process management, workflow, and process standardization are indicated to be very important and relevant to improve the quality of information and information exchange.

Following up the observational study in EMS setting, IQ requirements in practice are examined. The third sub-question (2c) asked about the existing requirements regarding IQ dimensions and measurement. To find the answer for this question, three case surveys and experts interviews were conducted. Issues and problems are found in IQ *Relevance, Accuracy, Timeliness, Completeness, Accessibility, Consistency, Understandability* and *Security and Privacy* through the case review. The quality dimensions for measurement are suggested to be prioritized according to the contextual factors and the measuring methods.

In summary, this chapter examined their current practice, challenges, requirements, and problems in information exchange quality control. Reflecting to figure 1-3, through the study and combine methods, empirical foundation is established to understand the IQ and information exchange practice in a real scenario. Together with the theoretical foundation from the literature, Chapter 5 of QA.IE design is possible: (1) information exchange needs to

define the involved contextual factors, (2) IQ assessment requires IQ dimension identification and prioritization, (3) IQ measurement should reflect to the contextual factors for poor information exchange cause identification and improvement.

Methods for conducting this field investigation are summaries in table 4-3 below. The findings provide an empirical foundation for designing the IQ assessment techniques for information exchanges. Using a typical complex information critical service in this public domain enables the adaption of the designed artifact to other public domains.

Method	Sample	Purpose
Field observation & discussions	EMS case with 20 practitioner discussions	Understand the problems in daily information exchange process, and how would the contextual factors affect the quality.
Empirical case survey	Three typical example cases in EMS scenario	Find IQ problems occurred in operating the EMS.
Semi-structured interviews	12 managerial level professionals in EMS	Identify the most important IQ requirements in EMS case.
Survey	83 practitioners from public sector	a) Identify important context elements b) Reveal their satisfaction level on IQ in their daily operation. c) Discover how much their daily information sharing and information exchange process is related to the context elements identified.

Table 4-3. Summary of the empirical case conduction approach

5

ARTIFACT DESIGN

This Chapter reports on the design cycle in the DSR methodology. This cycle integrates the findings from the rigor cycle (Chapter 3) and relevance cycle (Chapter 4) and precedes the evaluation cycle (Chapter 6). As discussed in Chapter 3, the available theories and literature do not provide directly applicable methods for assessing IQ of information exchange in public sector. Nevertheless, the literatures do provide some theoretical foundation that can help in synthesizing the design approach which guides the design of our proposed artifact – QA.IE techniques, presented as models. For instance, IA provides the pathways of structuring and dynamic adjustment to manage the quality of information flow. Core supportive theories validate our approach that assessing quality of information exchange should consider the interrelated elements in the enterprise.

This chapter draws on the combined findings from our theoretical and empirical foundation to synthesize the quality assessment techniques. This chapter seeks to implement this process in order to answer the third research question – *what approach to synthesize the knowledge base and empirical findings for IQ of information exchange assessment?*

Firstly, this chapter elaborates on the synthesized set of design principles, which consistently guide the artifact design. In order to define the design principles, it is necessary to identify the IQ and information exchange contextual factors requirements. The design of QA.IE techniques should be capable to meet these requirements and achieve the objectives. Experts from IT and information systems are interviewed to define the requirements. The qualitative analysis tool Atlas.ti is used in this study. An overview of method instruments are explained in table 2-3 in section 2.5.

Secondly, the current IQ and information management tool and method design are examined, in order to learn and capture their experience in practice.

Thirdly, design principles are synthesized to guide the techniques design. This study chose to coin a set of design principles rooted in IA characteristics, IQ studies, and the empirical

findings. Next, I employ the principles of design. Discussion with nine relevant researchers on the principles for designing QA.IE techniques are carried out. An overview of our design approach including methods, design steps, and outcome is presented in figure 5-1 below.

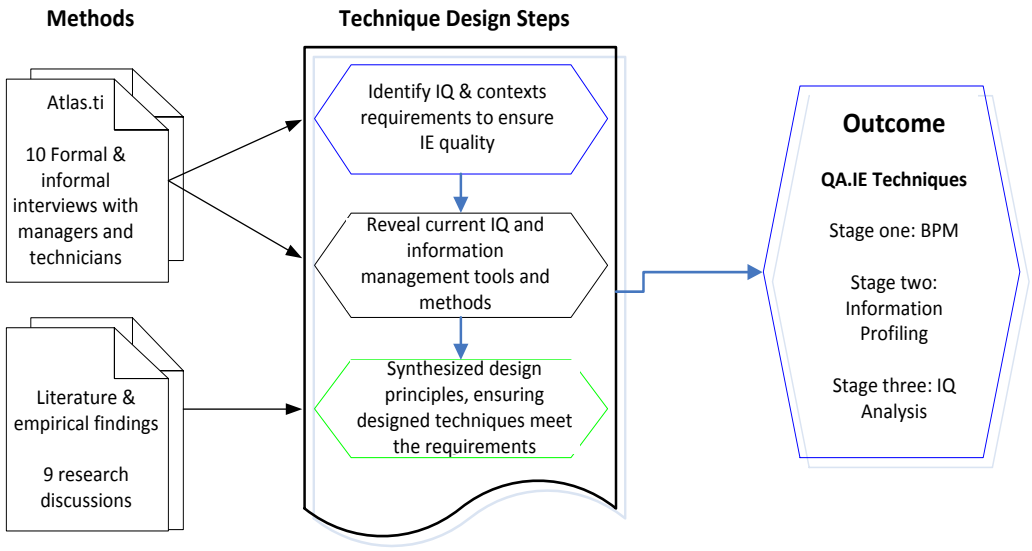


Figure 5-1. Design approach overview

5.1 Capitalizing Experts Design Experience

The previous chapter elaborated on the information exchange and IQ issues that are found in EMS fields. In today's digital world, EMS domain engages lots of resources to facilitate the service delivery. In parallel, many other forms of information communication devices are used to complement the process. Due to the diverse, complex, and important nature of EMS, this case provides rich environment to investigate and learn. It also allows us to gain some initial insights on practical design method and procedures for information and quality assurance.

This section aims to extend this understanding of requirements and importance for IQ in practice to validate that our proposed techniques are able to ensure these requirements. While the EMS field study did provide us practitioner perspective in a complex and information critical public service, there is still need to determine which are the requirements and pathways for assessing the quality of information exchange in public sector in general. In order to obtain a more in-depth understanding of current practices for IQ of information exchange assurance needs, as mentioned in chapter 2 I decide to consult experts. The interviews allow to take the information managers' perspective on IQ and information exchange assurance, and hence complementing the end-user and participants' perspectives

taken during the field study. Accordingly, the main objective of the interviews is to capitalize some design experiences on managing information approaches from the managers. Pursuing the strategy of engaging in discussions on the occurrences of IQ and information exchange problems, will facilitate capitalizing the design experiences of the practitioner and experts in addressing some of these problems.

While the research approach has been already discussed in section 2.3 and 2.5, this section provides more detail on how I conducted and analyzed interviews for the artifact design purpose. Through the interviews in this section, this chapter seeks to (1) gain insights in the current information management approach and their design process in public sector, and (2) capitalize on the problem solving experiences and current practices of experts. Considering these objectives, interview experts who do not only have experience in information management, but also have concepts and solutions for IQ assurance are chosen. 10 experts from public healthcare authorities in Ireland are interviewed. Each respondent is interviewed in person for approximately 30-40 minutes. Prior to the interviews, the objectives of this research and the type of topics in which were interested to this research were emailed to the respondents, to ensure that all the interviews adhered to the same general format. Each semi-structured interview began by stating the background of this research and assuring the participants that their organizational and individual identities as well as response would remain confidential. The interviews were guided by predefined interview protocol with peers. One thing to be aware is the explanations on the differences of DQ and IQ. Most interviewees view Data and Information as two different terms. Prior to the interviews, the interviewees are informed that in this study, DQ and IQ are considered interchangeable. Therefore, when the answers mentioned data or DQ, it is referred to information and IQ for results analysis. Topics include:

1. Information quality (IQ) dimensions and problems
    a) Are you familiar with IQ dimensions?
    b) Do you recognize some of these IQ problems (table 4-1)?
    c) How relevant/important do you consider these IQ dimensions (figure 4-2) as challenges in public sector of your domain?
2. Current information exchange management
    a) What project/approach do you have to ensure the quality of information exchange both intra and inter organizationally?

b) What perspectives you are looking into for quality assurance of information exchange?
c) What is the most satisfied and unsatisfied results you received from these approaches?

3. Business process and high-level view in managing information
   a) If/How business processes being engaged to the information management?
   b) Do you think it is important and necessary to ensure IQ of information exchange in within the context factors?
   c) What elements should be included in contextual factors of technology, organization, and business process?

4. Suggested measures and current practices
   a) How do you address IQ problems?
   b) Are there any measures or guidelines you use for assuring IQ?
   c) Do you recommend these IQ assessment approach for dynamic information exchanges?

Because the entire research is about information exchange and IQ, it is necessary to find out the answers to improve the quality of IQ in information exchanges. Question 2 focuses on identifying the current understandings on information exchange management and their approach in successful or unsuccessful results. In the previous chapters contextual factors are initially identified, now through interview question 3, the factors includes other elements can be confirmed with the practitioners' view, including all sub-elements that are considered important. The last challenge (question 4) is to capture the IQ management and measurement that are used in current practice. These interviews questions will lead to the artifact design, which is not only grounded from literature but also practice.

The data collected from the interviews re analyzed by using ATLAS.ti software. The interview transcription and observation notes were converted into electronic versions and saved as a Hermeneutics Unit. ATLAS.ti can be classified as a qualitative text analysis application, which is designed to offer support to qualitative-oriented social researchers in their activities concerning the interpretation of text. It includes the capacity to deal with large amount of text, managing of annotations, concepts, and complex structures [61]. The use of software and data coding makes qualitative data analysis procedures more systematic and guards against information-processing biases [199].

The process of data analysis was retrospective, seeking to replicate findings of the case study. The data analysis was an iterative process in the sense that data were coded and the emerging themes were explored immediately after several initial data collection activities. Several of the interview transcripts were coded repeatedly as the final coding structure emerged. It should be noted that the text was coded according to the interpretation of the researchers, rather than through matching the code with the exact words spoken by the interviewees. After coding was completed, redundant codes were grouped into code 'families' and assigned a descriptive construct name. For example, the individual codes 'accuracy', 'relevancy' and 'consistency' were all grouped into a single code family, which was then assigned the construct name "information quality" due to the relative weight of that code versus all others in the family. Weights were assigned based on the total number of respondents to mention a specific code. In order to retain the integrity of each interview's meaning, and not bias the coding, this process was conducted independently, with the results of these efforts compared only after code families had been created.

Using ATLAS.ti the researcher can draw actual "conceptual maps" consisting of boxes and connecting lines that depict the aggregated linkages between concepts mentioned within each interview. Within these conceptual maps, different codes and their mutual relationships can be visualized, generating an overview of relationship between the key concepts of the interview, both individually and in combination. For example, for the quotation "*many occurrences of inaccurate or incomplete information during transferring and reentering could have been avoided if the data stored in the systems and information exchange procedures would have regularly checked*", three dyads were created including "incorrect and incomplete", "data and information exchange", and "incorrect or incomplete information and checked" . These dyads were recorded for every transcript, and were aggregated based on the total number of respondent to mention each individual dyad. In order to enhance the comparative power of the displayed maps, numbers in the boxes were marked as the amount of respondents confirming the requirements as challenging.

5.1.1 Information Quality and Information Exchange Requirements

One of the objectives of the interviews was to explore whether or not the list of IQ and information exchange problems presented in Chapter 1 and Chapter 4 are acknowledge as important by the information managers. More specifically, it is important to identify the IQ and information exchange requirements are needed to be addressed when designing quality

assessment approaches. When considering IQ of exchanged information, most experts agree that all of these requirements listed in figure 4-2 are relevant issues in public sector. It is found that many public sector managers acknowledged that their information issues are fundamental in nature. Issues regarding privacy and security are deemed to be out of the scope for the design techniques in this research purpose. For dimension relevancy, it has been discussed that if completeness, timeliness, and accuracy are ensured, relevancy would be also ensured. In that sense, those two dimensions are removed from the list. One interviewee stated that *"we have big issues on IQ. If a user of our citizen records system can't find someone then we create another record – as a result one person features six or seven times on one system."* Duplication and inconsistency are mentioned several times by different participants. Information has been stated as inefficiency by several respondents, for example, "*We need to put structure into the information we have. At the moment we might have 40 versions of the same file stored in several different systems in different department and agent. And we realize that information is being created and stored in places other than the core database. If this continues we will make poor decisions because our information will not be accurate, up to date or consistent*." The following network view in figure 5-2 illustrates the importance of ensuring the various IQ requirements that are discussed with them.

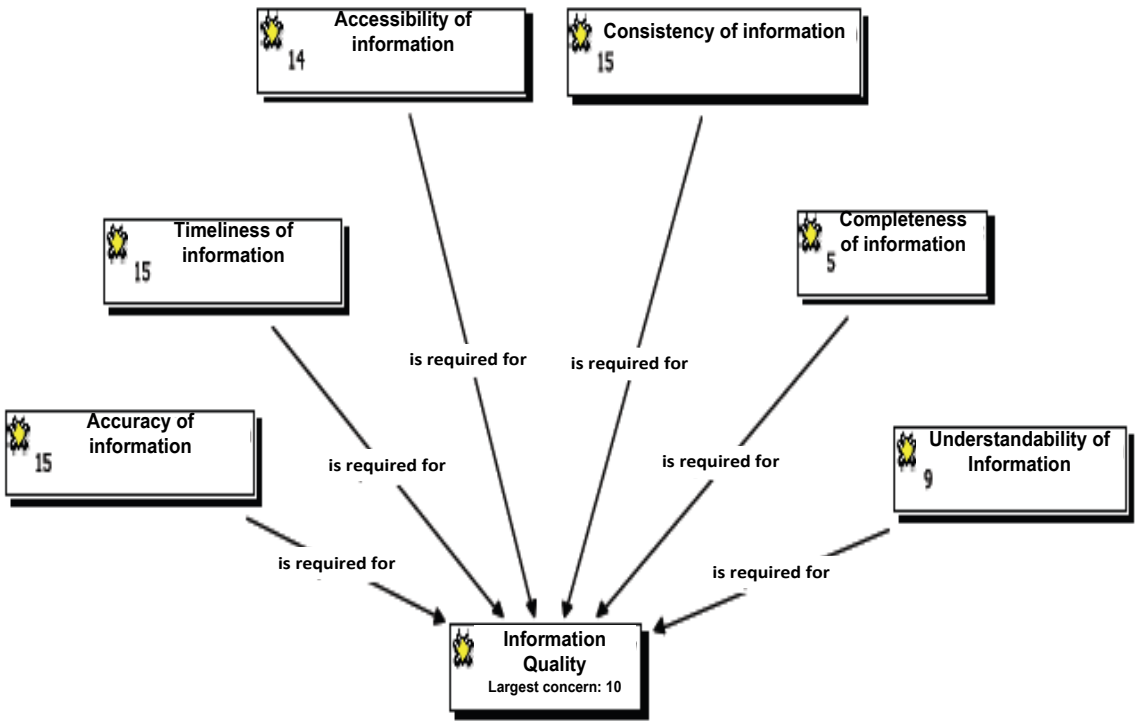


Figure 5-2. Information quality requirements

Figure 5-2 shows the confirmed IQ requirements for the total number of respondents. The numbers showed in the box means to what extent do they think it is very important. Note that completeness and understandability of information are mentioned by respectively five and nine respondents as very important, which are the relevantly low scores. All these respondents regarded IQ assurance as largest concern. The experts' feedback shows that the set of designed techniques should be capable to ensure the abovementioned the IQ requirement.

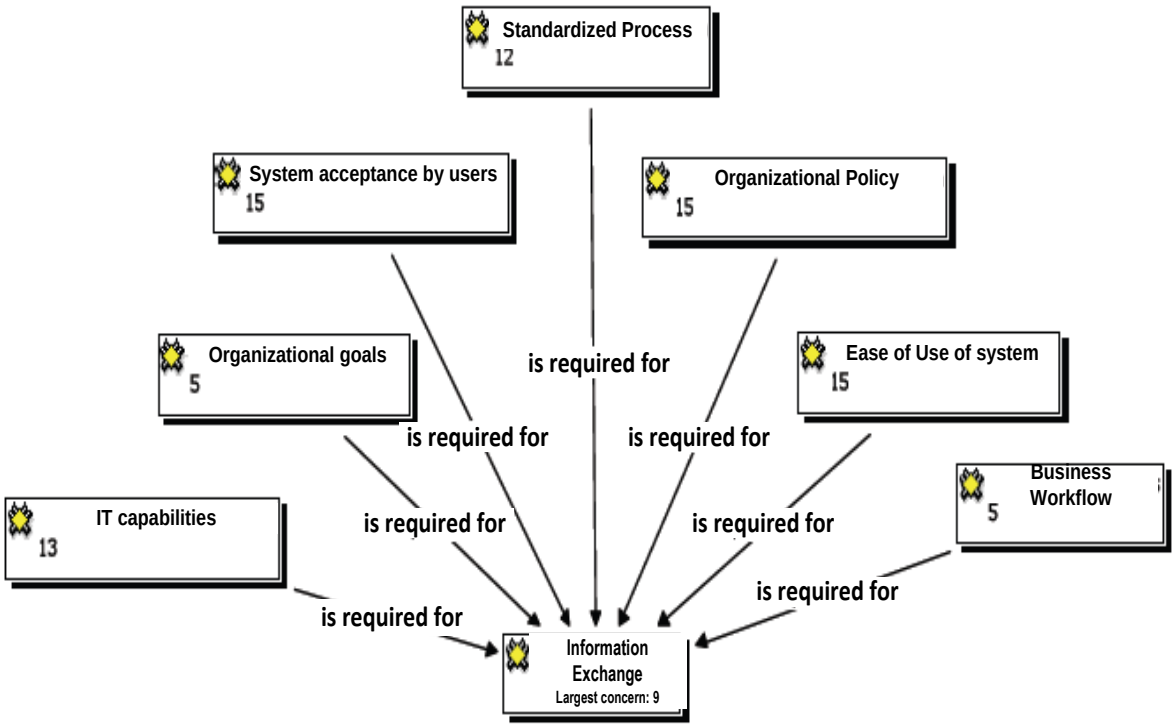


Figure 5-3. Information exchange requirements in public sector

For the information exchange requirement and importance showed in figure 5-3, most experts reached a consensus that organizational culture is overlapped with user acceptance in this research context, and business process management is too broad of a term. Therefore, we define the sub-elements as: *standardizing procedures* and *business workflows* are selected to be under the contextual factor 'process'; *goals* and *policy* are under the 'organization' factor of; and system *ease of use*, the *capability,* and *user acceptance* are under "technology' factor. Although business workflow and organizational goal showed a relevant low concern of being very important, those two elements still should be included.

5.1.2 Development and Current Approaches

According to the interviewees, it is found that IQ assurance programs were officially brought into practice around 2008 by the public bodies, most of which is integral to their efficient and effective operational performance. It concerns especially the datasets collected by such bodies, and the use that is made of such information. It is based on the premise that information needs to be properly managed as an asset and valued accordingly.

In government, information is used to justify the allocation of billions of euro worth of public money. The Comprehensive Spending Review and the National Census, for instance, both contain data that is used to justify important national policy decisions. One manager stated *"the government believes that we need to throw open the doors of public bodies, to enable the public to hold politicians and public bodies to account. I also recognize that this will help deliver better value for money in public spending and help us achieve our aim. Setting government data free will bring significant benefits by enabling businesses and non-profit organizations to build innovative applications and systems"*.

IQ apparently has become a significant topic for public sector. However, when it comes to information exchange either between public bodies or between departments, IQ is not adequately addressed. To improve IQ, database level is emphasized according to the IT managers. For instance, two classes of methods are discussed, namely, edit methods and record linkage methods.

"*Edit methods verify that data values satisfy pre-determined business rules. A mathematical model for data editing that is intended to minimize changes in data records and to assure that the substituted data values pass the edit rules*." This method is connecting the data to a business level. However, this method is only used at the tool design stage, once it is in implementation stage, the rules would not be assessed or changed according to the changed business, such as goals or policies.

Record Linkage methods have the task of identifying if two records are related to the same world entity. "*An automatic record linkage process generally consists of three phases: 1) pre-processing: it consists parsing data and replacing different spelling and abbreviations with a standardized format; 2) comparison for matching: in order to decide for matching or not two records, it is necessary to compare them by using exact or approximate string*

comparators; and 3) Decision for matching: an algorithm decides if declaring match, not match or possible match for two compared records." said the IT manger.

These methods and approach are sufficient to ensure the IQ accuracy, completeness, and relevance, but only at the information entering stage. IQ is not ensured when information is transferred and re-edited. The information exchange requirements are not met. It is agreed with the IT and general managers that information assurance needs to be connected to the higher business level, especially where information exchange is closely connected to the organizational goals, business rules, and operational systems etc. The current practice is able to detect the data problems, and the solution strategy is also focused on the data level. For example, in public healthcare organizations, data problems often occur when the data is retrieved, edited, and transferred, the automatic data detection software often prevents incorrect or incomplete data based on the predefined criteria (algorithm or rules), however the detected error results may still be an error after 'fixed' because the organizational goal changed. Data should reflect to the business objects and process. One of the information system managers said, *"at the moment, quality of information exchange is not assessed or evaluated, and there is no such systematic method or guidelines*". Information evolves through a sequence of stages consisting of data collection, organization, presentation and application. The flow of information contributes towards obtaining high quality performances and low defects. For example, the patient information can move out of the practice consults with the medical aids, specialists, and other third parties. The parties could return information back into the practice. Documenting and classifying the flow of information would indicate where the information is manipulated and when the usage of the information changes the context. The flow of information initiated by people and information in itself has no value except the fulfillment of purposes". This says that IQ, information exchange, information flow, and business processes should be closely connected.

From the discussions with the experts, it revealed that a more systematic and regular information exchange quality assessment and improvement can be very valuable. "*Exchanged information need to be highly assured, not only digital information, but also verbal or text information. From a manger perspective, the assessment procedures need to be specific and simple to follow. Pinpoint to the technological application, particular location or executer, or process steps will be great for time and efforts saving to identify the causes."* This information provide us a context-specify approach design: quality of exchange

information can be assessed under (1) technology or non-technology involved information exchange, (2) organizational actors or location that information exchange occurred, and (3) specific information exchange process. For the improvement strategies can be look into (1) Organizational goals and policies, (2) technology capacity, ease of use, and user acceptance, and (3) process standardization and workflow redesign.

5.1.3 Shaping Pathways: Suggested measures for Assessing IQ and Information Exchange

Based on the collection of interview transcripts, the suggestions for IQ and information exchange assessment are summarized, presented in table 5-1.

Design Experiences	**Targeted IQ issues**	**Mentioned by interviewees**
Conduct data flow audits	Incorrect, incomplete, outdated information in the data sources. Incorrect, inconsistent, incomplete information records matching the destination sources.	8 out of 16
Classify information content and structure for assessment	Accuracy, timeliness, completeness, and consistency, bridging the interdependencies between data and business.	9 out of 16
Capture information at the source and make the source information responsible for changing the information	Inconsistency of information, enhancing information reliability	11 out of 16
Prioritize IQ dimensions for measurement	Concisely, accurately and consistently measure IQ across units, saving time and resources	10 out of 16
Standardize, promote, and train IQ metrics of measurement	All IQ- related problems	15 out of 16

Table 5-1. Suggestions for IQ and Information Assurance

Table 5-1 outlines five different suggestions for IQ assurance for information exchanges. Some conditions need to be changed to make these assessments work. Firstly, the business

processes need to be enhanced for information accuracy and consistency assurance. Secondly, the information manager should have knowledge (at least at a basic level) of the processes and information needs of the various organizations or units. Finally, measurement procedures and metrics should be standardized.

5.2 Principle Based Design

Using principles that have been suggested in the academic community by Albert Chern [200], it provides a consistent and focused guidance for the artifact design. Principles are particularly useful when it comes to solving 'complex' problems, which cannot be solved by known and feasible computational techniques [201]. These kinds of problems are complex because they often socio-technical in nature or because they occur in socio-technical systems [201]. For example, both humans and technology are needed to exist and function in information exchanges. In contrast to traditional computer-based systems, socio-technical systems include both human actors and software components, and normally are regulated and constrained by organizational rules, business processes, external regulations [202]. This implies that the technical and social aspects are interconnected, that neither should take logical precedence over the other, and that they should be designed together [200].

Principle-based design (PBD) can be viewed as a variation of the perspective design research paradigm that should result in "a prescriptive theory which integrated normative and descriptive theories into design paths intended to produce more effective information systems" [203]. Because principles are generic by nature and thus do not constrain designer creativity or possible solutions, they provide freedom in designing and using artifacts based on the needs of their research.

Because PBD focuses on goal attainment rather than compliance (in case of rules) and because the actors are free in implementing the principles, the expectation is that there will be more commitment and less resistance in multi-party involved information exchange environments. As such, PBD is especially suitable for designing the techniques that need to operate in task environments consisting of:

1. multi-participant organizational networks where each participant has different sets of goals, processes, supporting technology and systems, yet are mutually interdependent in terms of information sharing and decision-making;

2. the quality of information shared need to be assured according to the contextual factors and requirements in organizational regulations, technology efficiencies, and designed processes;
3. multi-audience environments (principles used by ICT-experts, managers and operators);
4. environments where the range of solutions and alternatives is heterogeneous and dynamic in nature.

Considering previous work of information sharing in public sector [3, 4, 104, 108], it is argued that information exchange quality assessment take place under the four characteristics listed above. Principles have been defined in various ways and they have been used interchangeably with other problem solving notions, including laws, patterns, rules and axioms [204]. Housel et al. [205], for example, define principles as "generic prescriptions for the design and implementation of information systems". From an engineering perspective, Gilb [206] defines principles as "rules of thumb that guide the choices and actions of engineers". From MIS perspective, Richardson and Jackson [207] define principles as "the organization's basic philosophies that guide the development of their architecture." In the area of information technology (IT), the Open Group have defined design principles as "general rules and guidelines, that are intended to be enduring and seldom amended, that inform and support the way in which an organization sets about fulfilling its mission" [208]. Thus far there is no uniform definition available; however, these definitions imply that principles are normative or prescriptive in nature, and that they are meant to give direction for the design, which is why this research considers principles as directive guidelines.

The use of principles determines the effectiveness of a design. As a result of their intrinsic non-contextual nature and general applicability, principles cannot provide readily available solutions to specific design problems [209]. Rather than being offered as finished products, their articulation helps clarify where some of the gaps in our knowledge exist [210]. Therefore, the use of principles is intended to select and apply the most appropriate knowledge for specific design and development tasks [51].

In specification of this research, it is found public administration researchers have highlighted the gaps that often exist between the way technique and technology is intended to be used by those who design it and the way it is actually implemented by its users. To ensure the quality of information in information exchanges, the designed QA.IE techniques should facilitate

capture of the dynamic intra or inter organizational information flow, and measure the static information elements within the involved contextual factors.

5.2.1 Synthesizing Design Principles

Drawing on the findings in Chapter 4 and the interviews, the synthesis of design principles that assist assurance of IQ during information exchanges is presented. Five experts from IT and IS are gathered as focus group for the design principles discussion. As discussed in Chapter 3, synthesis is a creative and interactive process. The IQ and information exchange issues we have encountered in the field study (Chapter 4) lead us to critical reflection on the pathways derived from literature and focus group. From the perspective of an information manager, the IQ dimensions are requirements and they need to be satisfied for information exchange quality assessment. The flowing table 5-2 provides an overview of the synthesized principles and the IQ and information exchange requirements.

Design Principles	**IQ dimensions**	**Information exchange requirements**
1) Allow trace and track IQ in information flows	Consistency, accuracy, accessibility, timeliness	IT capability, process workflow
2) Provide connections of information/data assessment to an abstraction level	Consistency, completeness, accuracy	Organizational policy and goals
3) Maintain a single connected information pool for assessment throughout all organizations/units.	Consistency, accuracy, completeness, accessibility	Policy, IT capability, ease of use
4) Standardize information structures and information exchange assessment across all organizations and units	Consistency, understandability, timeliness	Information exchange policy, process standardization, workflow
5) Enable feedback checks on quality of information flow	Accuracy, consistency	Process standardization
6) Minimize the number of measured items and metrics	Timeliness, accessibility, understandability	Easy of use, user acceptance

Table 5-2. Design principles for assessing IQ of information exchanges.

Table 5-2 provides an overview of the design principles drawn from literature and practice. In accordance with The Open Group Architecture Framework (TOGAF) prescriptions for communication principles [208], this section elaborates on the rationale underlying each design principle using findings from our field study and/or theoretical foundation. Discussion on the impact these principles will facilitate assessing specific IQ and information exchange requirements.

Principle 1. Allow trace and track IQ in information flows

Rationale. Information exchange occurs rapidly and it is important that the assessment can track to the point where information exchange occurs along the information flow. The case study in EMS case revealed that the information flow is not tractable, which causes difficulties to determine at which point the information become incorrect. As such, this study proposes that changes in information should be visible and traceable. This principle ensures the assessment is traceable for measurement and poor IQ causes in information exchanges. It also ensures the information exchange quality is accurate, consistent, timely, and can be accessed easily. In that sense, it gains trusts from the actors for the exchanged information.

This designed QA.IE assured IQ and information exchange requirements: IQ-Accuracy, consistency, timeliness, and accessibility; Information exchange – IT capability, process workflow.

Principle 2. Provide connections of information assessment to a an abstraction level

Rationale. This principle is synthesized from the core theories in parallel with the observations that information management is limited to the low data level and often not connected to the business level. Although business application data always exists within the context of business, such an understanding is still not aware in practice. This causes problems because the low data level does not capture the requisite semantics to accurately communicate information across business processes. As a result, most of the semantic data issue exist at the process and organizational boundaries. The top (business or enterprise) level is the focal point with the highest probability for discrepancy [15]. In EMS case for instance, the data being assessed in the physical data-storage layer rational databases. Although assessment carried out regularly, the organizations still experience symptom of poor

information control over the routine tasks. Often data can is validated within databases, where the higher level strategy and organizational goals are not considered for predefined the rules. It is found that their assessed accuracy rate is so high that data/information should be very trustable and support the operation. However, the fact is that IQ is not even measured regularly within the operational and business concerns, where other IQ criteria such as consistency, completeness, and timeliness reside within. That is also the reason that in public sector their information exchanges often encounter unsolved issues. Instead, efforts often focus on re-custom data structure or custom class. Accordingly, this principle suggests that IQ assessment focus on bridging data to the high business and enterprise contextual factors.

The designed QA.IE techniques assured IQ and information exchange requirements: IQ-Consistency, completeness, relevancy, information exchange- policy and goals.

Design Principle 3. Maintain a single connected information pool for assessment throughout all organizations/units.

Rationale. This principle is synthesized based on the system interoperability and observation where information exchange were often inconsistency and duplicated. The field study in EMS case showed that information managers generate several different systems and standards for information sharing and storing. It is noticed that in large public organizations, the units and workers generated and distributed information from inconsistent templates, creating some confusion from the interview findings. Early research by Stasser & Titus [211] shows that pooling information permits a group decision and better communication that is more informed than decisions of individuals. The use of a single, continuously IQ assessment system would minimize the lag between segmented information and consistent information. Accordingly, it is expected that this form of synchronous information assessment will lead to improved accuracy and timeliness.

The designed QA.IE techniques assured IQ and information exchange requirements: IQ-timeliness, completeness, consistency, and accessibility; Information exchange – policy, IT capability, ease of use.

Principle 4. Standardize information structures and information exchange assessment across all organizations and units

Rationale. It is observed that the information management team was often confused because of the different standards and requirements for their information in individual organization or units. That makes the information assurance team difficult to have a systematic and standardized regulation, especially to ensure the IQ when information is exchanged from place to place. The interviews revealed that most of the time information can be validated with a local scale but that causes problem for cross organizational services. No standardized measurement and assessment makes it difficult and extremely frustrating when comparing and integrating services at a large scale. The various standards make the information more difficult to intemperate and time costly. Therefore, this principle is to ensure the standards of information assessment for accurate information in a consistent level. Standardized information format and representation enhances understandability among different users.

The designed QA.IE techniques assured IQ and information exchange requirements: IQ-consistency, timeliness, understandability; Information exchange – policy, process standardization, and workflow.

Design Principle 5. Enable feedback checks on quality of information flow

Rationale. It is observed several situations that quality of information evaluated by authorities is lack of meta-information. Particularly, information assessed in individual organization does not connect or consider the information flow from end to end. For example, the same data source is measured as "100% accurate" stored unit/organization system A does not match the "100% accurate" data in unit/organization system B. This assessment results often overstate the quality of information and performance and cause false sense of "excellence". With increasing numbers of players and actors, centralizing the assessment tasks of validating information is useful, but concurrently limiting the tasks to small number of roles or experts will be very difficult. It will be helpful that in such networks, the tasks of monitoring the quality can be broken down to a two-step process. First, individual information sources (doctors, staff etc.) can provide feedback in the form of quality rating. Based on such these ratings, dedicated experts can further validate and rate the information. Accordingly, this study proposes that information providers and information users should at least indicate the level of reliability of information as part of the IQ measurement process.

This designed QA.IE assured IQ and information exchange requirements: IQ-accuracy, consistency, complete; Information exchange- process standardization.

Principle 6. Minimize the number of measured items and metrics

Rationale. When managers have too many items to measure and assess, it is very time consuming for collecting, enriching, measuring, validating, and analyzing the quality. Not only does the use of overloaded items exhaust the examiners but also the participants. For example, the current quality assessment program for Beaumont hospital is carried out quarterly, however due to the complicated measurement index the assessment approach is always scoped to the individual units and always overlooks some of the details. This principle enables the assessment functions and metrics scope to the core items that match the stakeholders' needs and the high performance of information exchange across organizations and units. This principle does not suggest limiting the assessment items or sacrificing the quality of outcomes. Identification and prioritization of the items are essential procedures. This principle also assures a better understanding on information by limiting the chance of confusing and complicated information pools. Meanwhile, it provides easier and quicker access to the information that needs to be assessed by limiting the items.

The designed QA.IE techniques assured IQ and information exchange requirements: IQ- Timeliness, accessibility, understandability, information exchange- Easy of use, user acceptance.

This section synthesized the design principles to ensure QA.IE techniques development is consistent and meets the requirements. These six design principles should empower the information management team in assuring IQ in information exchanges. Returning to the research question 3a), this section was set out for investigations (*Which design principles to follow to ensure the techniques meet the IQ and information exchange requirements*?): this section presents six design principles for assuring the techniques design to assess the required IQ criterion. The audiences for these principles include a range of stakeholders in the public domain. Firstly, the principles are meant to guide us in (re)designing assessment techniques towards the assurance of IQ in information exchanges. Information management authorities could also employ the principles provided in this research to their current practices even if the final techniques are not employed. Having presented the design principles, the next step in this study was to elaborate QA.IE techniques details.

5.2.3 Drawing on the Theoretical and Empirical Findings

QA.IE techniques are conceptualized as a three-stage process for IQ of information exchanges. The stages are following the findings from the literature and empirical data, where information flow, information structure, and information measures are focused. This section answers the research question 3b) 3c) and 3d) *What is a suitable description for information flow and information organization? How to connect the exchanged information to the related contextual factors? How to identify and prioritize IQ requirements and measure IQ?*

The previous sections explored in detail the introduction and explanation of principles for design. In line with the statement quoted above, this section presents a conceptual model of the QA.IE techniques. The artifact design is in line with the described principles and requirements derived from theoretic and empirical findings. “Conceptual modeling is the activity of formally describing some aspects of the physical and social world around us for the purpose of understanding and communication” [138]. A conceptual models primary objective is to convey the fundamental principles and basic functionality of the system in which it represents. In this thesis, the conceptual models are developed to demonstrate the techniques for assessing IQ of information exchanges. This also can facilitate further development as actual products for the users.

Stage One- Business Process Modeling

As observed in literature and in practice in Chapter 3 and Chapter 4, information exchange presented in a sequential process where resources and personnel need to be well-capable of acting on their own initiative in ways that are consistent with the organizational goals and information system capacities. Furthermore, as in section 5.1, interview findings suggest that business process presents the information flow and information exchanges. This results in the characteristic that the abstract level of business process is required for information exchange management.

Information exchange is the key concept in our research which involves the exchange processes and the information flow. Figure 5-4 illustrates the nature of information flow in business processes. The information flows between various organizations and the information elements can be visualized and analyzed. This model allows viewing the information exchange processes and the exchanged information elements. What is more, from the

information exchange processes, the contextual factors can be captured, for example, information of technology and application that facilitate information exchange, the structure of all types of exchanged information etc. The architecture here describe that the information contents and contextual factors captured from the processes should be organized, interlinked, and presented.

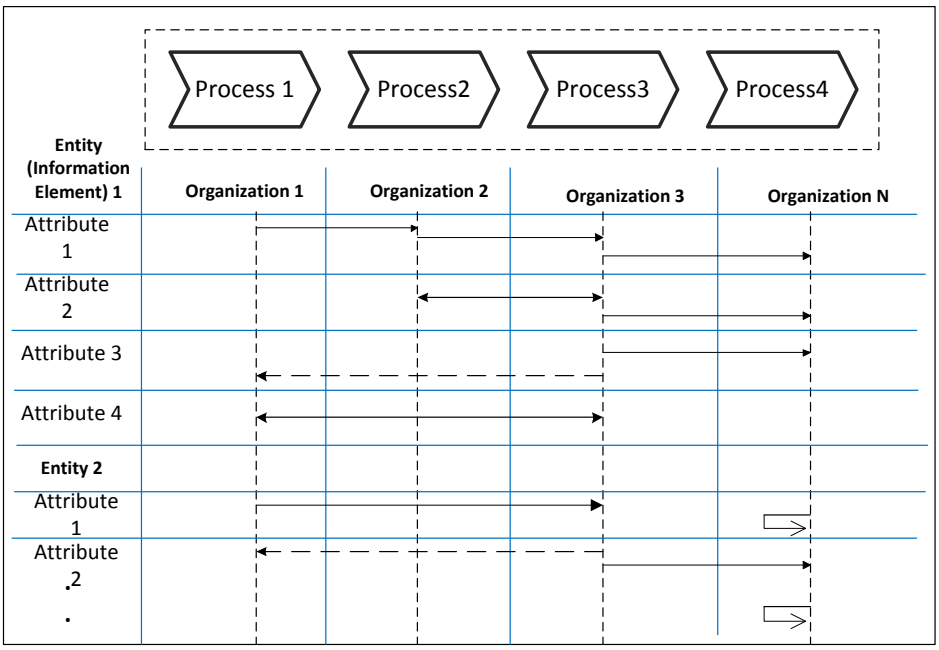


Figure 5-4. Conceptual model of the business process and information flow

Stage one followed and satisfied the first two design principles: 1) IQ and information flow can be traced and tracked, and 2) Provide connections of information assessment to an abstraction level.

Stage two-Information Profile

In order to assess the exchanged information, static information contents require to be organized. Whereas information architecture describes the information exchange, in this element I describe how business processes are used to extract important context characteristics. The business processes involve enterprise contextual factors that the most important contextual factors can be captured in the profile. This information profile will enable assess of the information that is based on contextual factors.

In section 3.3.1 I identified the most important contextual factors in the enterprise, and for this research purpose, the following characteristics are considered in the quality assessment: (i) Organization which includes the organizational participants that perform the processes, (ii) Information including the information types and attributes, and information format, (iii)

Technology that is used to facilitate the tasks, and (iv) Business Process including the steps executed in information exchange. Usually, a data model can be developed to assist the information structure and specification, but with DEMO approach, Objective Fact diagram is equivalent to data model, demonstrated in chapter 6. In table 5-3, the context information captured in business process model are classified as who, what, when, how, and information format. This allows IQ measurement based on the specified enterprise contextual factors.

What (Info Type)	Who (Organization)	When (Process)	How (Technology)

Table 5-3. Information profile frame for IQ assessment

Stage two followed and satisfied the design principles: 3) maintain a single connected information pool for assessment throughout all organizations/units, and 4) standardize information structures and information exchange assessment across all organizations and units.

Stage three-Information Quality Analysis

As reviewed in section 3.1.3, IQ measurement is the process of evaluating quality dimensions that are relevant to the information user in a particular context [86]. Usually assessment includes measures and such measurements are compared to reference values in order to enable a diagnosis of quality for improvement [19]. Prior to executing the measurement process, identification and prioritization of IQ dimensions is an important and challenging task [25, 28]. Measurement metrics rely on a set of quality indicators and calculate a score, a percentage, ratio, or scales from these indicators. Figure 5-5 provides an abstract view of measurement on the exchanged information. When the information exchange process occurs, the pieces of information provided and utilized can be measured. Literature describes mature IQ measurement methods and metrics, as shown in the figure below [20]. Leppänen [20] also suggest the use of a questionnaire to measure stakeholder perceptions of IQ dimensions lending further substance to this research's initial posit of the importance of an empirical approach. To generate the metadata, Eppler and Wittig [95] proposed a series of approaches such as user experience, spot checking, sampling etc.

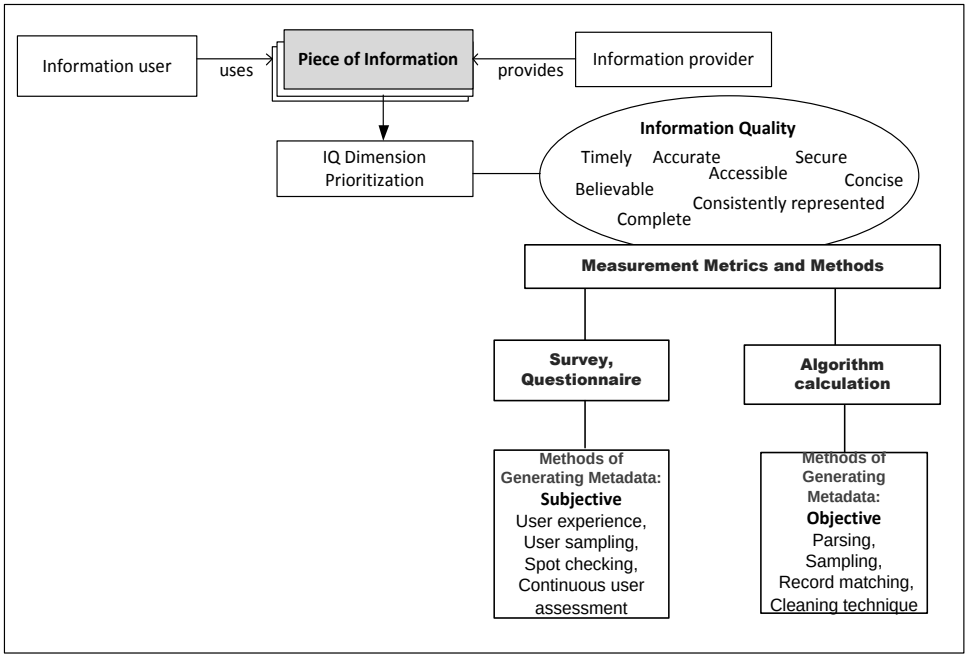


Figure 5-5. An abstract view of quality measurement on the exchanged information

A method for IQ identification and prioritization is derived based on this empirical EMS case, as described in Chapter 4. In relation to information exchange in public sector, IQ dimensions for measurement are *Timeliness, Accuracy, Completeness, Accessibility, Consistency,* and *Understandability.* Although IQ dimensions requirements may vary in different organizations, these six dimensions are considered essential in general public cases. More IQ dimensions can be added to the list for measurement to meet specific scenarios.

Methods and guidance for prioritizing IQ dimensions in each scenario is summarized and presented in figure 5-6 below. Review and tag, and domain investigation in public sector are complete. The adaptable phase remains to the *expletory and confirmatory interviews* for each specific case scenario. Chapter 6 demonstrated that each case requires and prioritize IQ dimensions differently.

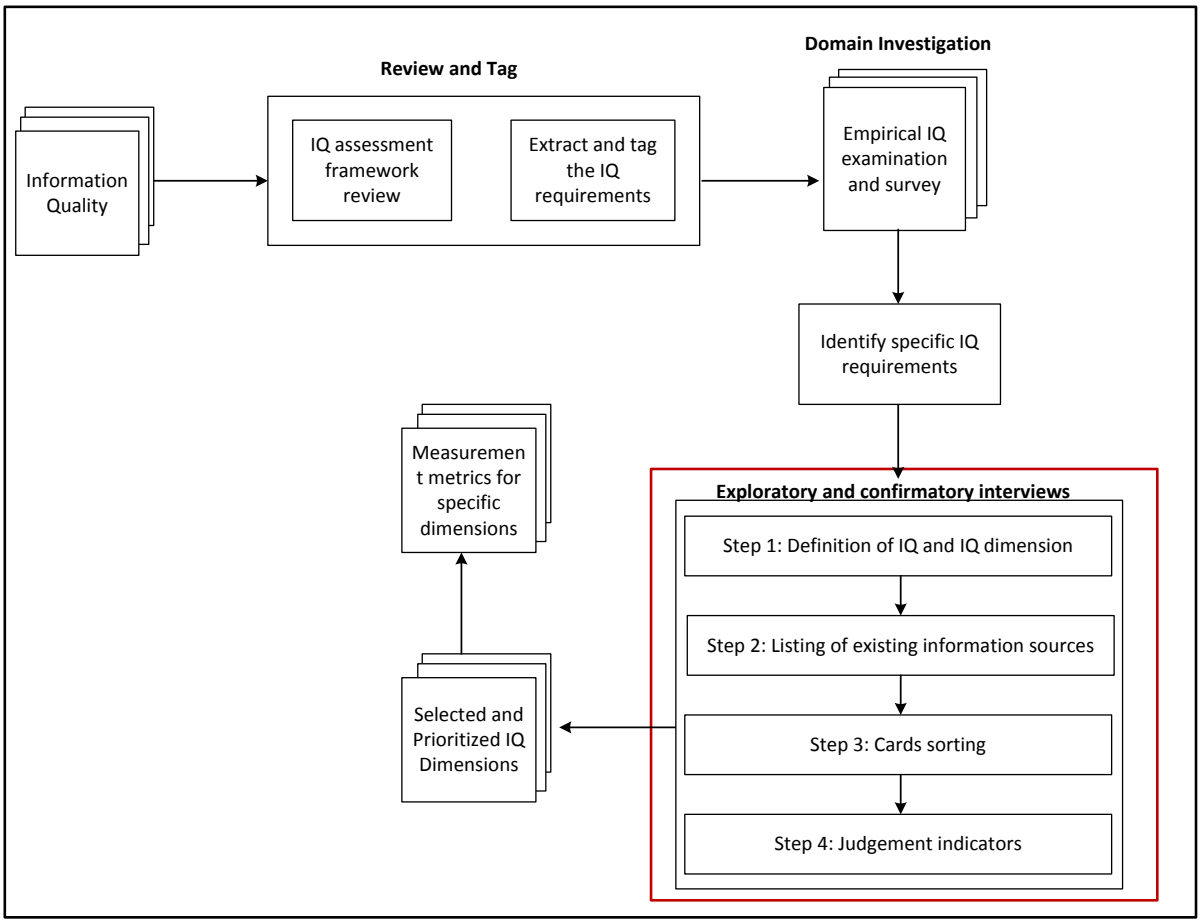


Figure 5-6. IQ dimension prioritization method

Once the information elements are analyzed and prioritized, identify and prioritize the IQ dimensions and the related metrics for quality measurement are followed. As identified in the previous section 5.1.1, six IQ dimensions are prioritized that are applicable to the public sector: Accuracy, Consistency, Completeness, Timeliness, Understandability, and Accessibility. As classified in table 5-4, IQ dimensions are prioritized according to the enterprise contextual factors. Accordingly the IQ measurement for the exchanged information is selected and carried out. A variety of techniques and approaches are developed for the IQ measurement in the existing research. In this study, subsequently the prescriptions of possible IQ measurement metrics are provided for the quality assessment, and the method of generating metadata for objective and/or subjective assessment. Summarized results of IQ metrics used in this case are displayed in Table 5-4.

Dimension	**Definitions and Metrics**	**Method of Generating Metadata**
Accuracy	Survey the degree of accurate information with which verbal	Spot checking

	communications is transferred.	
	Survey the degree of accuracy with which written information are satisfied by customer and user	Sampling, Spot checking
	Free-of-Error Rating = 1-,<*N/T*> Where *N* = Number of data units in error and *T* = Total number of data units.	Sampling, Cleaning technique
Consistency	Check the degree of information which is the same in different location. And/or information is being handled in the same procedure.	User experience Spot checking
	Check the degree of information which is presented in consistent formats.	Sampling
	Consistency of various sources Consistency Rating = 1-<*C/T*> Where *C* = Number of instances violating specific consistency type and *T* = Total number of consistency checks performed.	Record matching
Completeness	Check or survey of the information includes all necessary values.	User experience Sampling
	The degree that the attributes are assigned values in a data set. Completeness Rating = 1-<*Comp/T*> Where *Comp* = Number of incomplete items and *T* = Total number of items.	Sampling
Timeliness	Check the information is sufficiently ready for usage on the task on hand.	User experience
	Timeliness Rating = 1-<*Δ of expected and actual time of activities occurred/T of expected time of activities occurred*> Where Δ = value difference and T= Total number of items.	Sampling
Understandability	Check or survey if the representation of the information is understandable for the users.	Sampling, User experience
	Survey the degree of information exchange between actors can be understood.	User experience Spot checking
Accessibility	Survey the information is able to be transmitted/communicated when it is needed.	User experience Sample
	Check if the information is available when it is needed.	Spot checking

	The degree that data can be retrieved in a data set. Accessibility Rating = 1- <*A/T*> Where *A*= Number of inaccessible items and *T*= Total attempt access number	Sampling

Table 5-4. List of dimensions, measurement, methods

The method of generating metadata description details are listed as follows, adapted from [133].

- Cleaning techniques: The impact of data errors on data mining methods and data warehouse has given rise to data cleaning methods. The methods identify and eliminate a variety of data errors. The identification techniques can be used to count errors and this to assess IQ.
- Record matching- determines whether two records represent data on the same object
- Sampling: Sampling techniques choose a representative subset of the information and only consider those for quality assessment.
- Spot checking: An inspection or investigation that is carried out at random or limited to a few instances.
- User experience: For the user experience method, the users must apply their experience and knowledge about the sources. This may include hear-say, experiences with the source itself, reports, etc.

Summary

In depth discussion with the researchers formed the IQ assessment technique for information exchange, presented in figure 5-7. The designed technique adopted Business Process Models where rich enterprise context can be captured; designed an Information Profile where the information content is organized accordingly; and constructed an IQ Analysis Framework where IQ measurement and improvement is developed based on previous information. Business process model defines the exchanged information within an enterprise context because it overarches organization and application systems that interact with each other [36]. The Business Process Model then facilitates assess statically the "right piece of information from the right source and in the right format is at the right place at the right time" [13], which will be structured in the information profile in form of what, when, who, and how under the dynamic information exchange processes. And finally the IQ Analyzing provides concrete IQ measurement and assessment methods and metrics for the exchanged information.

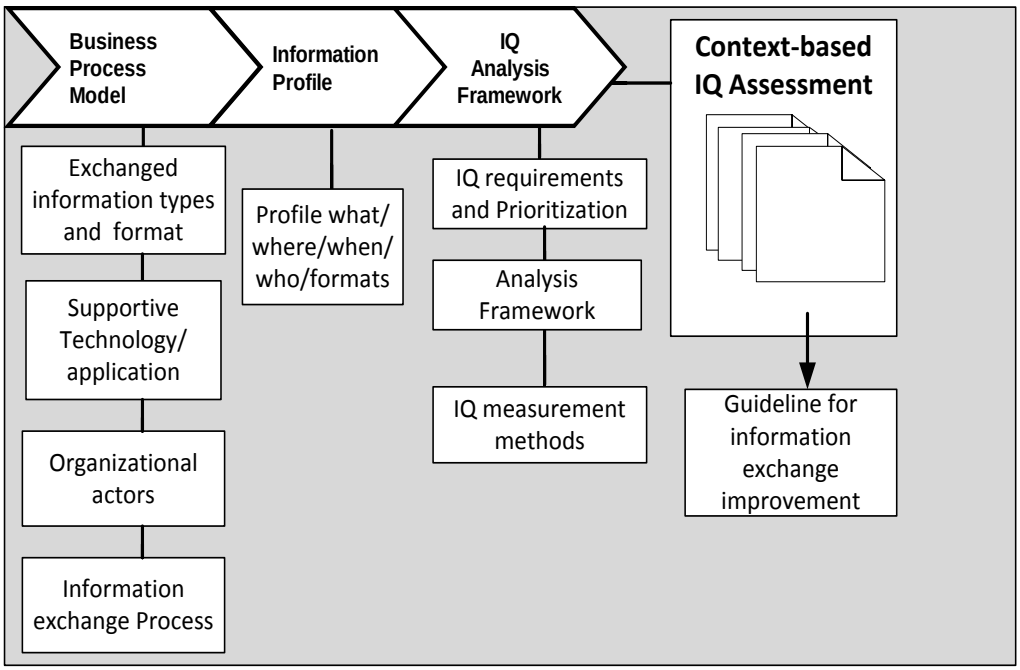


Figure 5-7. Overview of QA.IE techniques

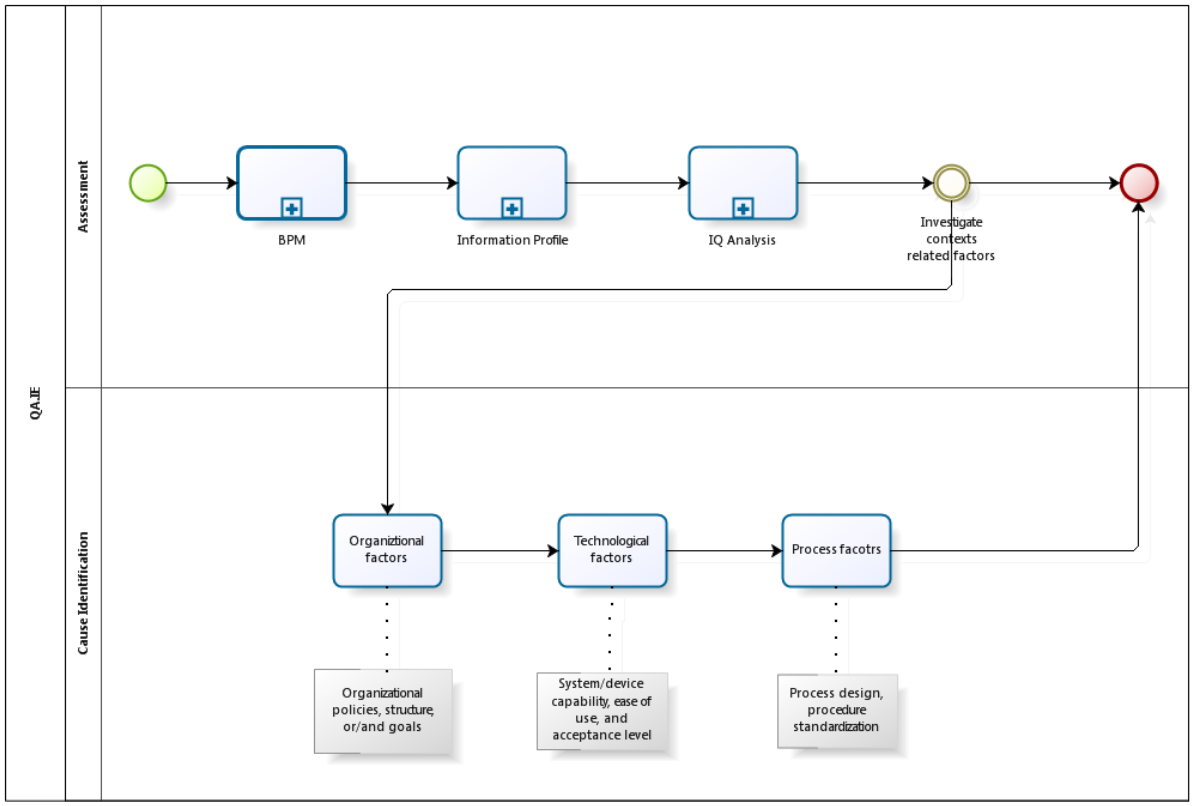
The QA.IE techniques design and development is based on theoretical and empirical foundation. In addition, the techniques meet design principles requirements. A summary is displayed in table 5-5 below.

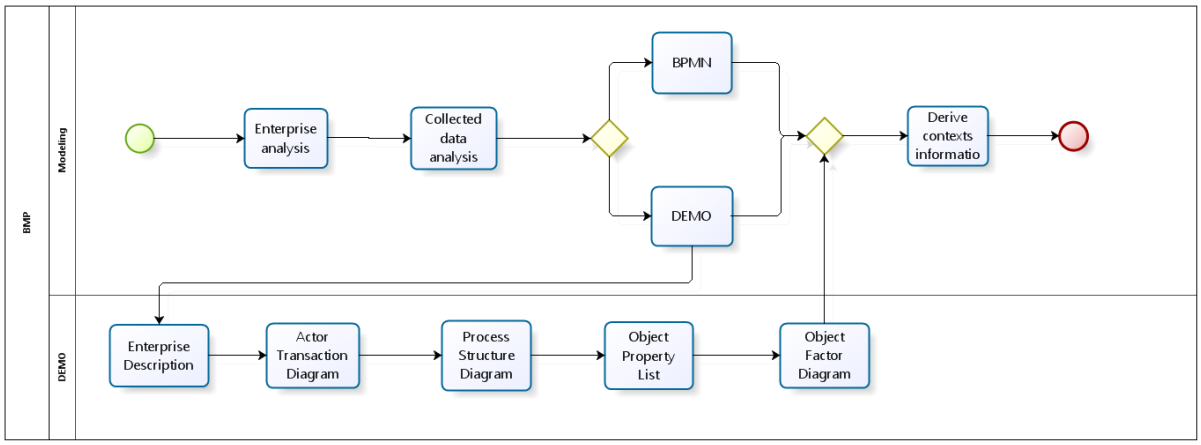
Stage	**Design Principle**	**Description**
One- Business Process Modeling	1, 2, 5	BPM provides an abstraction level view for information exchange, and allows traceable data
Two- Information Profile	3, 4, 5	Information being organized and classified according to the contextual factors. Standardize the structure and allow a single connected information pool, which enables feedback checks on IQ.
Three- Information Quality Analysis	6, 1	Minimize the number of measured items and metrics. Low IQ causes can be traced to abstraction level contextual factors.

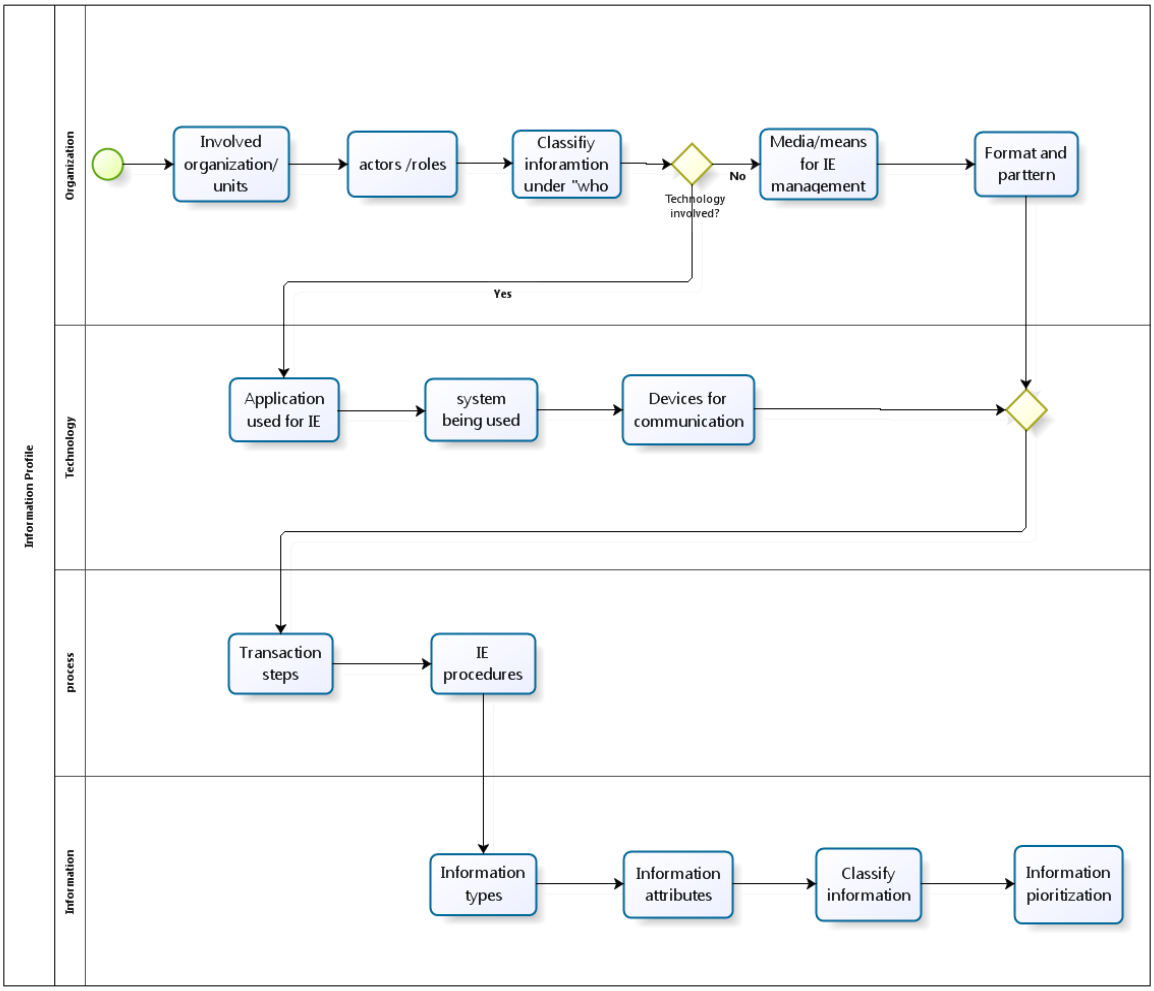
Table 5-5. IQ.IE techniques and design principles

5.3 Representation of the Designed Artifact – Models

The QA.IE techniques are represented as models to guide the implementation. Figure 5-8 illustrates the overall techniques and detailed three stage steps. These models provide detailed steps to carry out the techniques. The first layer states that three stages of BPM, Information Profile, and IQ analysis would facilitate identify the causes for poor information exchange quality. The causes are analyzed from organizational, technological, and process factors. THE second layer consists of the detailed procedures of each stage, for example, under BPM stage, enterprise analysis and information analysis regarding information exchange need to follow. Secondly the executor has to choose either BMPN or DEMO modeling tools to display the information exchange processes. If DEMO is chosen, enterprise description, ATD, PSD, Object Property List, and OFD are followed. Lastly, contextual factors are listed out. Subsequently, stage two and stage three are followed according to the models. In the Information Profiling stage, involved organization/unit and actors are extracted firstly. Then consider if technology is involved in the information exchange processes, if yes, then identify the information exchange used applications, systems, and devices for categorization. After organizations and technologies are identified, process steps need to be extracted. Exchanged information types and attributes, are subsequently classified for further analysis. The third stages of IQ Analyzing, as showed in the models, prioritize information type and IQ dimensions based on the contextual factors are the first two steps. Subsequently the IQ metrics and methods are selected from the provided table for IQ measurement. Based on the results, analysis for information exchange quality is carried out. These assessment processes allow identify the causes of low IQ in information exchange quality, based on the enterprise context factors. At this research stage, the QA.IE techniques are manually executed, automatic tool for implementing these techniques can be further developed in the future based on this conceptual level.


QA.IE
Assessment
Cause Identification
BPM
Information Profile
IQ Analysis
Investigate contexts related factors
Organizational factors
Technological factors
Process facotrs
Organizational policies, structure, or/and goals
System/device capability, ease of use, and acceptance level
Process design, procedure standardization


BMP
Modeling
DEMO
Enterprise analysis
Collected data analysis
BPMN
DEMO
Derive contexts informatio
Enterprise Description
Actor Transaction Diagram
Process Structure Diagram
Object Property List
Object Factor Diagram


Information Profile
Organization
Technology
process
Information
Involved organization/ units
actors /roles
Classifiy inforamtion under "who
Technology involved?
No
Yes
Media/means for IE management
Format and parttern
Application used for IE
system being used
Devices for communication
Transaction steps
IE procedures
Information types
Information attributes
Classify information
Information pioritization

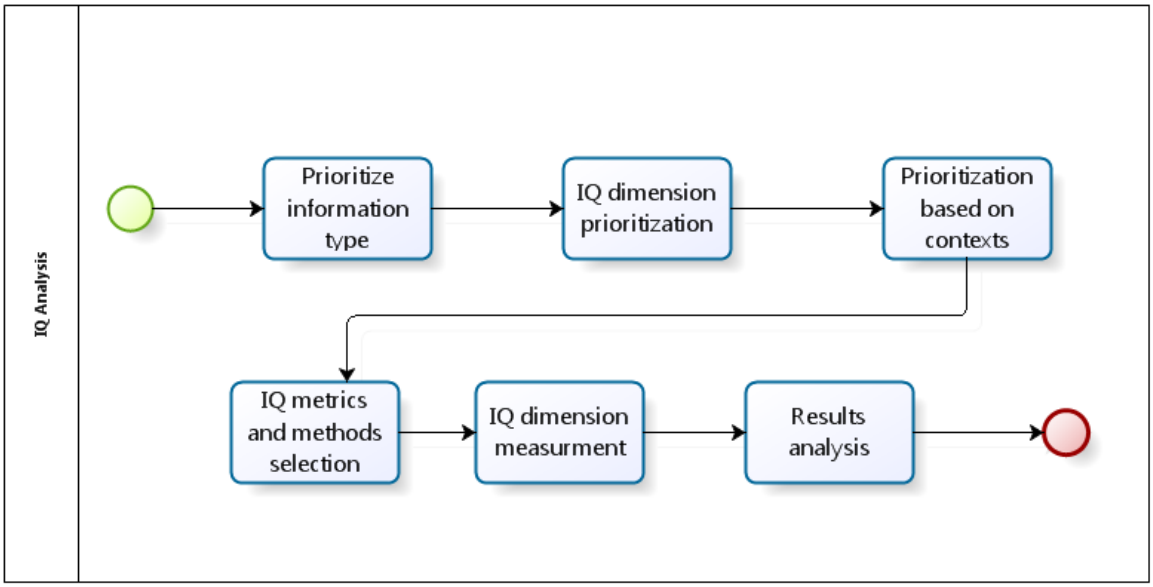


Figure 5-8. QA.IE models

6

ARTIFACT EVALUATION

6.1 INTRODUCTION

This chapter reports on the results of the case application of QA.IE techniques, as well as the interview and feedback on the evaluation framework. The assessment techniques are applied to assess the organization's information exchange quality and identify the causes. In return, the practitioners provided their professional insights to the assessment techniques based on the results. The main objective of this session with professionals was to evaluate the extent to which the proposed techniques could provide effective information exchange quality assessment.

Accordingly, this chapter is the main research methodology for investigating the final research question in this thesis. Firstly, case implementation to test its applicability and utility was carried out. From the case implementation, feedback from the experts and professional are collected to complete the developed evaluation framework. Three cases are chosen to examine the IQ and information exchange: case one is the inter-organizational EMS in Dublin, case two is intra-organizational level, and case three is inter-organizational level. Chapter 5 has already provided the detailed description of the QA.IE techniques and its components. The case implementation proceeds by the results gained from applying this artifact – QA.IE techniques.

6.1.1 Case Implementation Methods

Conducting the case studies, on- site observation is carried out to collect the data regarding the information exchange processes, roles, information requirements, involved ICT for communication and coordination. Overview of the research methods and instruments can be reviewed in section 2.5. To carry out the QA.IE techniques, the author observed together with one or two intern researchers as consultation. Observations were conducted using a predefined observation protocol (in Appendix–F) in order to follow the structure in observation notes and improve reliability through comparison inter-cases. Based on

observation, notes are taken and when possible, complemented these notes by consulting and confirming the notes from in-field experts.

To complement direct observation, methods such as interviews, documentation and records reviews are used to enhance the understanding of information exchange management and the effects of the interchanges on the quality of this information. Benbassat et al. [212] have stated that the goal of data collection from multiple sources is to obtain a rich set of data surrounding the specific research issue and to capture the contextual complexity. This form of strategy is usually described as triangulation [141]. The interviews lasted for approximately 10-20 minutes. The basic structure of the interview questions is shown in Appendix- G. Each interview session began with a short introduction of the research purpose. The observation and interview findings allow us carry out the first stage of QA.IE techniques – business process modeling by using DEMO.

Short introduction was presented to the interviewees for purpose of evaluating the research approach and results (see Appendix– B). Interviewee number varied, depending on each organization's complexity, structure and availability. Before, during, and after implementing the designed QA.IE techniques, explanations, application processes, and results are discussed and validated with key stakeholders.

Moody and Shank quality factors were introduced to the key stakeholders in a focus group setting. Focus group is especially useful when the subject under investigation is complex and concurrent use of additional data collection methods is required to ensure validity. This evaluation phase seeks for validation of the designed QA.IE techniques. Case implementation using field observation and interviews to ensure the implementation process is rigorous and relevant. Moody and Shank factors is selected to evaluate the artifact QA.IE techniques when applied to the cases. This focus group approach provides feedback that is discussed among experienced experts. Interview and focus group data are recorded and transcribed to readable and categorized texts. Moody and Shank quality factors were explained as rating criteria towards the implemented QA.IE techniques.

Finally, a group of relevant researchers is formed to evaluate whether the QA.IE techniques meet the requirements of derived six design principles. Discussion starts with a review of the six design principles selected for this research. Implementation results of the three cases are presented to the researchers. Agreed rating results are marked on the evaluation framework.

6.1.2 Validity of the Evaluation Framework

As for any type of academic research, validity of the research approach is a key issue. According to Hammersley [213]: "Validity is another word for truth and reliability refers to the degree of consistency with which instances are assigned to the same category by different observers or by the same observer on different occasions". It is particular important to pay attention to reliability and validity in order to evaluate the quality of the research, especially in case studies. According to Yin [214], reliability and validity have a number of dimensions: Construct validity, internal validity, and external validity.

Construct validity is the extent to which correct operational measures are established for the concepts being studied. Construct validity is achieved by using multiple sources of evidence [214, 215]. For this research, evaluation framework comprised of multiple sources of evidence for data collection to strengthen construct validity: case application, interviews, direct observations, and focus group. Deliberately seeking confirmation from multiple data sources leads to more reliable results.

Internal validity is the extent to which a causal relationship can be established, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships. In this research, validation and verification techniques were performed during the case study to validate the collected data from the interviews and observations with staff and related authorities. The analysis of the data has also been validated. Moreover, the resulted QA.IE techniques has been designed and validated qualitatively with decision makers. This is to ensure the internal validity.

External validity establishes the domain to which a study's findings can be generated. External validity or generalization refers to what extend the findings from this study can be generalized and transferred to other cases in other domains and settings. Cook and Campbell [216] define external validity as "approximate validity with which conclusions are drawn about the generalizability of a causal relationship to and across populations or persons, settings, and times". One can find several definitions and conceptions of generalizability in information systems research. Usually, generalization involves extrapolation into a domain or setting not represented in one's sample [53]. Such extrapolation is made by assuming one knows the relevant conditions. I did not attempt generalization by guessing at laws and checking out some of these generalizations in equally specific but different condition. In this

research, I collected empirical data from field studies and tested the designed artifact in another two different cases.

As elucidated by Lee and Baskerville [217], an increase in the sampling size is beneficial but the benefits take the form of improved reliability of the sampling procedure, rather than improved generalizability of a sample to its population. I therefore emphasize considerable weight on the reliability of the sampling procedure, which is explained in section 6.1.3. To respond one particular case study criticisms, that the designed results cannot be generated due to the specific situations, I implemented the designed results to their two different cases in public sector domain.

Regarding the validity of the research instrument, three types of validity need to be addressed: psychological, structural and process validity [67]. The psychological validity refers to the degree that QA.IE techniques are implemented in a natural situation where bias is not presented to the participants. In our session with professional workers, the participants were chosen on site across the organization. The feedback process is considered to be accurate by the original informants. This was apparent in meetings, conference, and focus groups that were arranged to present and based on original opinions with no incentive attempting to the answers.

Structural validity refers to the degree that the structure of the evaluation framework (the theory and assumptions on which it draws) was isomorphic to that of the reference. The modeling structure strictly follows the organization operation. Structure of our evaluation framework was in accordance with literature (i.e. Moody and Shank Framework introduced in this Chapter earlier). In addition, this evaluation structure dictates the way in which organization operated in fields, the practitioners' perspective, and the researcher's perspective.

Process validity refers to the degree that the processes observed in the evaluation procedures were isomorphic to those observed in the reference. The evaluation process of the present thesis was completed with a clear plan, and the process is claimed to have resulted in (i) a holistic view, (ii) a theoretical and methodological reference and (iii) application for practitioners. The interviews functioned as a kind of intervention, as the interviewees often indicated that they became conscious of phenomena (information management and other aspects in information exchanges) that they had not addressed before. During this process, on

the one hand, it may increase researcher effects, as the researcher potential has a stronger influence on the interviewee when introducing a new point of view. On the other hand, researcher effects may decreases, as attention is given to the new theme in the interviews, not so much to the researcher.

6.1.3 Reliability of the Evaluation Framework

Reliability refers to the extent to which the same or a different researcher can, at least in principle, reapply the same procedure when making another observation or measurement (e.g. observing the average of another random sample of the same size taken from the same population) and except it to lead to the same result as before. Fundamentally, this category considers whether the process of the study is consistent and reasonably stable over time as well as across researchers and methods.

As mentioned above, the process and structure of the evaluation is predefined for guiding consistency of case implementation. A high degree of stability indicates a high degree of reliability. In this research, the QA.IE techniques was implemented and evaluated with structured format, such as predefined interviews, observation protocols, and focus group structures. That provides the stable and consistent process and results.

6.2 Case Demonstration – Emergency Medical Service

6.2.1 Stage One- Business Process Modeling

The application starts with the technique of Business Process Modeling. Design and Engineering Methodology for Organization (DEMO) is adapted to study the information exchange process for quality assessment. As reviewed in section 3.3, DEMO is an enterprise context based concept that is considered the highest conceptual model and helps to ensure integrated enterprise [163]. To construct its diagrams, DEMO consists of a defined sequence of steps, beginning with a textual or process representation of an organization, and ending with a process structure diagram [67]. Subsequently the Information Profile and IQ Analyzing are carried out. From the DEMO aspect process models, these steps allow one to understand the enterprise based process and meaning of information, measure and quantify the identified dimensions, and finally, provide improvement recommendations.

Following DEMO, shown in figure 5-5 in chapter 5, observation and description of the EMS enterprise operation facilitate deriving transaction types and respective resulting types. Whether dependencies exist is checked between transaction types identified in the previous

step, which occur when the executor of a transaction is the initiator of another inner transaction. This step provides consistent and precise information concerning communication that occurred between actors.

After identifying transaction types and checking dependencies, the environment (i.e. contextual factors) is determined by mapping each transaction to a respective initiator and executor to create an Actor Transaction Diagram (ATD), illustrated in figure 6-1. In the ATD, a circumscribed diagram represents a transaction, and each transaction connects two boxed representing the initiator and the executor actor roles. The initiator connects to the transaction symbol with a solid line, and the executor connects to the transaction with a solid line ending in a black square. The grey boxes illustrate composite actor roles (i.e., elements whose structure is unknown). Grey boxes represents all environmental elements (i.e., elements outside the organization), so the organization with a grey box is presented when referring to the core of the organization, further specified using elementary actor roles represented with white boxes.

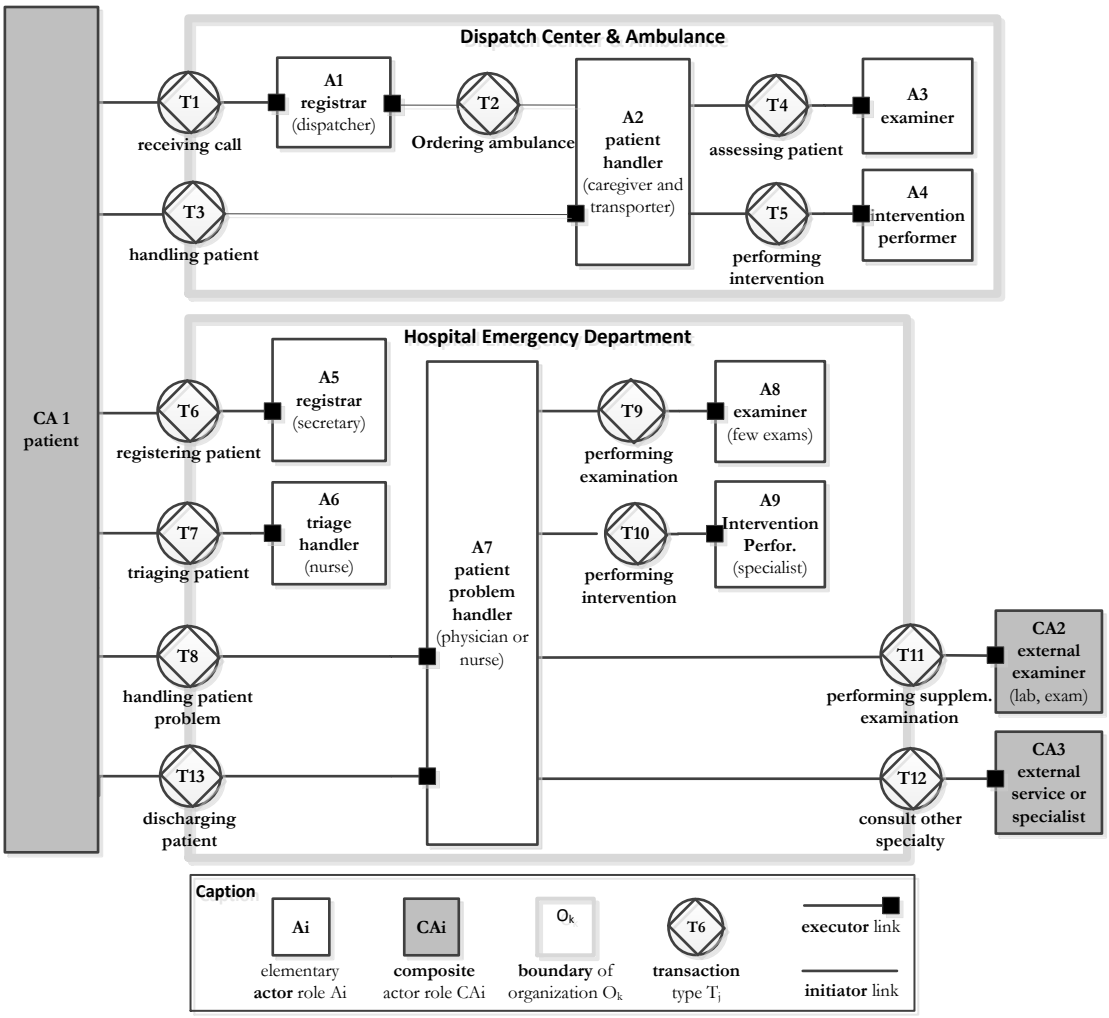


Figure 6-1. Actor transaction diagram (ATD) of EMS

The processes inherent to each transaction type are modelled, acknowledged in the ATD. Figure 6-2 and figure 6-3 shows the Process Structure Diagram (PSD), which depicts the procedure relationship between transaction types, highlighting communicative commitments between organizations for emergency delivery. This PSD allows capture of relevant and important information elements based on enterprise contextual factors of people, location, etc.

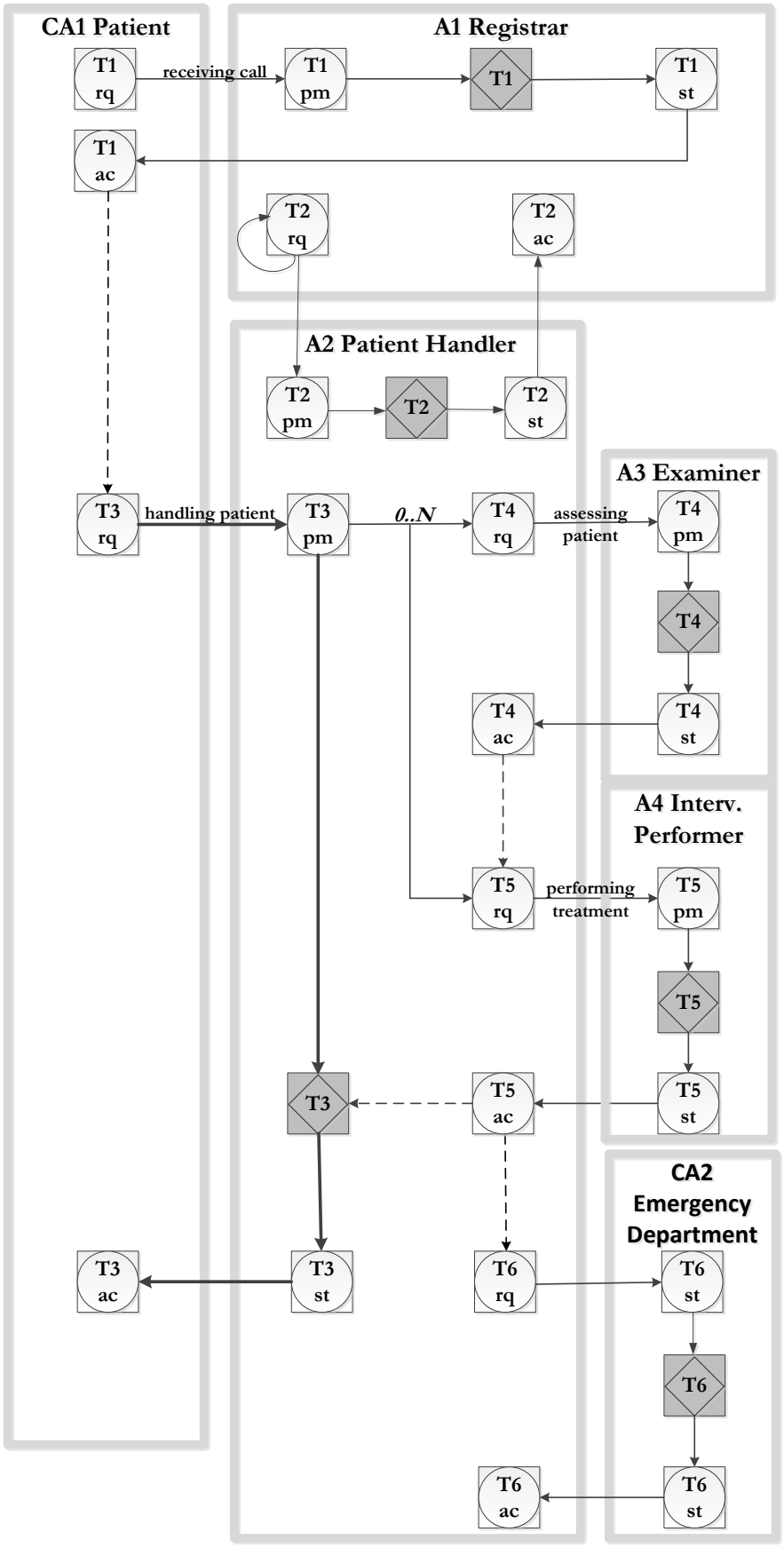


Figure 6-2. Process structure diagram (PSD) of EMS business process 1

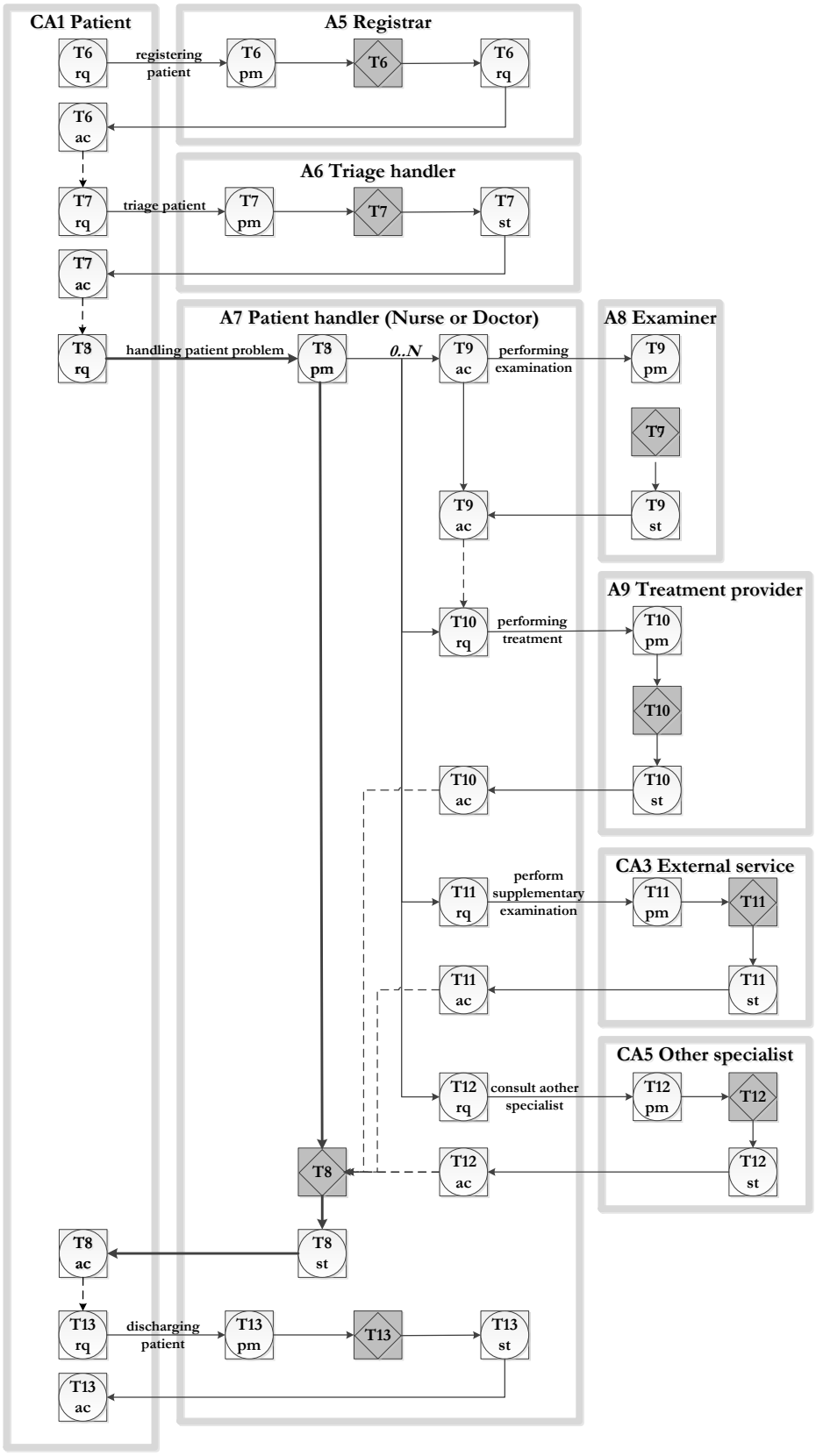


Figure 6-3. Process structure diagram (PSD) of EMS business process 2

Before evaluating the business process, a process is designed by following steps proposed in [67] to define the transactions, actors, and process structures. The results are presented below in the Process Structure Diagram (PSD). As depicted in figure 6-2 above, new patients may ask for an ambulance (T1), which assists and transports them (T2). The handling of patients' problems may lead to different actions: assessing the patients' problems (T3), performing some medical assistance (T4), and routing patient to an emergency department (T5). When patient arrives at the ED, they are registered to the hospital (T6); then they go through a triage process (T7); after that, patients' problems are handled (T8).

Subsequently, the exchanged information is derived. In order to analysis the information, a clear property type and object class are listed in table 6-1 below.

Property type (attribute)	**Object class (entity)**	**Property type (attribute)**	**Object class (entity)**
patient_address	EMERGENCY_REGISTER	illness_assessment	INTERVENTION_REPORT
patient_name,	EMERGENCY_REGISTER	prehospital_medication	INTERVENTION_REPORT
contact	EMERGENCY_REGISTER	prehospital_treatment	INTERVENTION_REPORT
illness_code	EMERGENCY_REGISTER	data_time	INTERVENTION_REPORT
station_leaving_ time	AMBULANCE_DISPATCH	injury_intent_code	TRIAGE
scene_arrival_ time	AMBULANCE_DISPATCH	provider_impression	TRIAGE
scene_levaing time	AMBULANCE_DISPATCH	level_of_ illness	TRIAGE
ed_arrival _time	AMBULANCE_DISPATCH	severe_ level	TRIAGE
ed_leaving time	AMBULANCE_DISPATCH	pcr_vitals	EXAMINATION
amubulance_code	AMBULANCE_DISPATCH	blood_ pressure,	EXAMINATION
station_code	AMBULANCE_DISPATCH	glasgow_ coma_score	EXAMINATION
injury_code	INJUR_ CASE	treatment	INTERVENTION
cause_of_injury	INJURY_CASE	medication	INTERVENTION
facility_needs	INJURY_CASE	further_care_indication	INTERVENTION
room_location	INJURY_CASE	treatment	INTERVENTION

Table 6-1. Object property list

In figure 6-4 I present the Object Fact Diagram (OFD), which contains the categories, object classes, fact types, and result types. From the OFD, it is able to identify the information types and information elements involved in the processes.

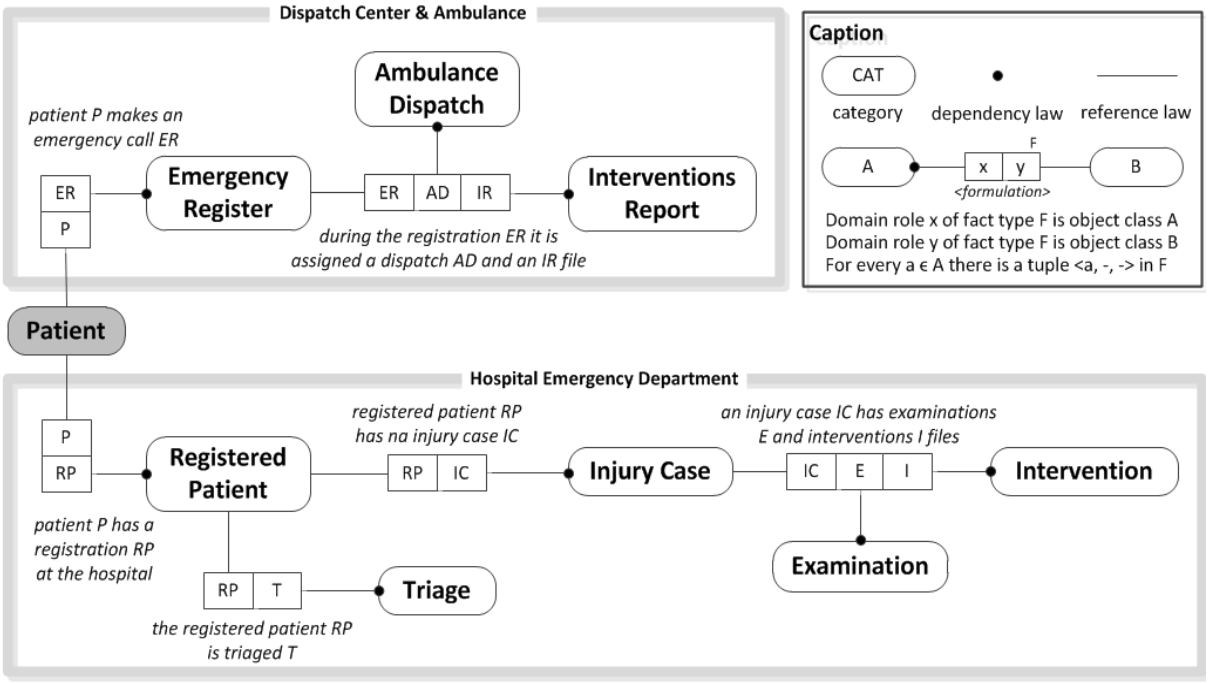


Figure 6-4. Object fact diagram (OFD) of EMS

6.2.2 Stage Two-Information Profile

From the Modeling Phase, visualize and identify the information exchange path is possible. Reports and documentation review allow us to identify the key information elements that are being exchanged and shared, such as patient information, injury information, treatment information, etc. In order to assess and measure the "right piece of information from the right source and in the right format is at the right place at the right time" [14], the information in the context of what, when, who, where, and information format is profiled, shown in table 6-2 below.

Where (Org)	**Dispatch Center & Ambulance**		**Emergency Department**	
What (Info)	Fact and Result Type	Object and Transaction	Fact and Result Type	Object and Transaction
	patient address, patient name, contact, illness	Emergency Registrar (T1)	Bio data, allergy, medical history name, medical card ID	Registered Patient (T6);

	leaving station time, arrival scene time, leaving scene time;	Ambulance Dispatch (T2, T5)	cause of injury, injury intent code, provider impression, level of illness, severe level, facility needs	Injury Case, Triage (T7, T8);
	illness assessment, medication provided, treatment, date/time	Intervention Report (T3, T4)	PCR vitals, blood pressure, Glasgow coma score	Examination (T9);
	Patient name; illness assessment, medication provided, treatment	Emergency Register; Intervention Report (T5)	treatment , medication, further care indication	Examination, Injury case, Intervention (T10)
Who (Org)	Registrar (Call taker, Dispatcher Officers) and Patient Handler (paramedics, ambulance crew, fire brigade)		Registrar (secretary), Triage Handler (nurse), Patient Problem Handler (physician or nurse), Examiner (technician, nurse or caregiver) and Intervention Performer (specialist or physician)	
When (Process)	Call received, Info received, Patient handled (T1-T5)		Patient on-way, Patient arrived, Patient handled (T6-T13)	
How (Tech)	CAD, Phone, Radio, Paper-PCR,		Paper-PCR, PHR, Pagers, in-person communication	

Table 6-2. Profile of the exchanged information

Based on the table above, the enterprise context was specified in the EMS case is composed of: (i) Organization of Call Center (CC), Ambulance, and Emergency Department (ED), and involved actors, which presented in the table as "Where" and "Who" (ii) Information contents of the information types, which is presented as "what" (iii) Process in terms of the critical process steps for information exchange and the service delivery, presented as "When" (iiii) Technology that IQ is influenced by technology involved or non-technology involved, which presented as "How".

6.2.3 Stage Three-Information Quality Analysis

While in general these are the agreed dimensions from the cross discipline users, further investigation on defined and selected IQ dimensions in section 5.2.3, table 5-4. IQ prioritization is necessary due to various contextual factors. For example, technology users

rank conciseness more important than completeness, whereas non-technology user regard completeness as more important [21].

Based on the information type (entity) and classified enterprise context in the information profile (table 6-2 and table 6-3), prioritizing the information elements and IQ dimensions is started. Because trade-offs of IQ criteria and different perceptions of IQ occurs due to the contextual factors [21], organizing and prioritizing the information and IQ dimensions according to contextual factors of organizations, technology, and process is subsequently carried out. Results are shown in table 6-3.

Organization	Registrar		Paramedics		Nurse/Doctor	
Technology	CAD		Radio, Paper-PCR		Paper-PCR, e-PHR Verbal communication	
Process	T1	T2	T5	T6	T6	T7
Information	Emergency Register	Emergency Register	Injury Case	Intervention Report	Intervention Report, Triage	Examination, Intervention
	Timeliness	Accuracy, Timeliness	Timeliness, accuracy, Completeness, Understandability, Consistency ,		Timeliness, accuracy, Completeness, Understandability, Consistency ,	

Table 6-3. Information and IQ dimensions prioritization based on contextual factors

The emergency service started when the emergency call is dialed, for the information exchange between the caller and the call taker (T1), information understandability and timeliness are the most important dimensions. Information exchange between the call center and the ambulance dispatch center (T2) reveals that *accuracy* and *timeliness* are the most critical dimensions for the ambulance reach to the right place at right time.

User experience was conducted to survey the IQ dimensions for T1 and T2. Since the information exchange/transferring between call take and ambulance crew is through an integrated CAD system, it is instant data transfer. To measure the accuracy and timeliness, 20 participants from call center and ambulance center were sampled respectively.

(1) How long do you think it takes you, on average to answer a 112/999 call? (i.e. the length of phone rings, before its answered)

☐ <5secons ☐ 6 to 10 seconds ☐ >10seconds

(2) How do you rate the information accuracy based on your experience?

☐ very satisfying ☐ satisfying ☐ unsatisfying ☐ very unsatisfying

Results shown are summarized in figures below. It is found between the caller and the call taker reveals good timely information exchange. The information accuracy between call center and ambulance crew showed 5% of unsatisfying, which are caused by the address inaccuracy.

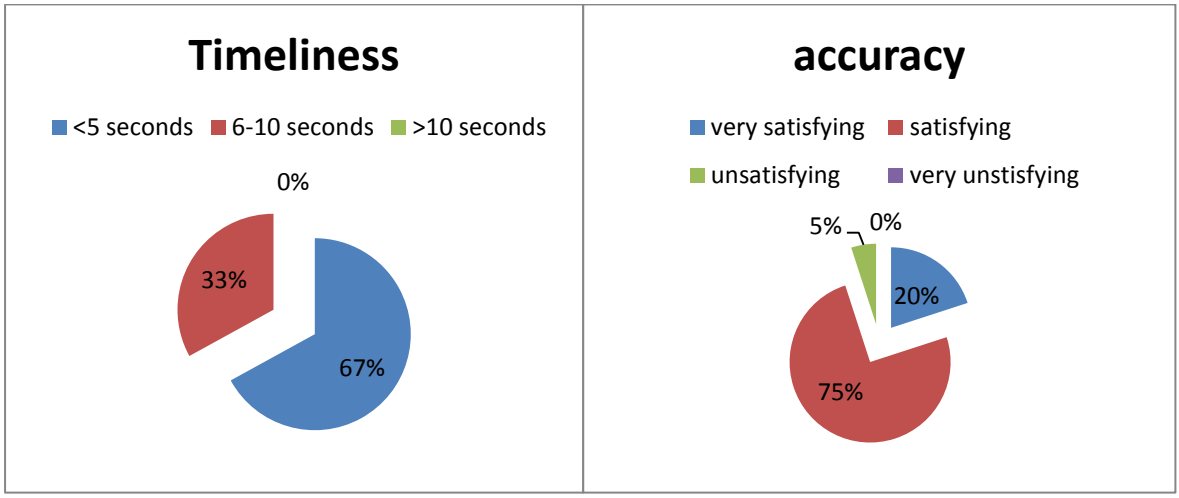


Figure. 6-5: Timeliness to answer a 999/112 call and accuracy of received information

In-depth observation shows that the lowest IQ occurs in processes T5 and T6, where information exchange between ambulance crews and ED staff members are the most problematic—both before and after arrival at the ED—causes low-quality information elements of pre-hospital intervention, including assessment and treatment given to a patient en route to the hospital. Face-to-face communication, paper PCR records, and manually re-entering patient records into the hospital patient health records (PHR) system facilitate this information exchange. Considering real-time information exchange occurs primarily through verbal communication, disparate approaches are designed. Non-digital information exchanges are assessed, including face-to-face communication and paper-based PCR records. **Spot checking** and **user experience** methods are used to generate metadata. Twenty consecutive emergency deliveries were conducted, and two ED staff members who had received a patient rated the information after initial patient management. The result was 40 interviews conducted regarding injury causes, pre-hospital interventions assessments, and pre-hospital treatments. Statistics associated with frequency distributions are used. Respondents rated how satisfied the information dimensions were from 1 (not satisfied at all) to 9 (extremely

satisfied), based on the verbal information exchange they experienced recently. This identified *Accuracy, Timeliness, Consistency, Understandability,* and *Completeness* of information provided from ambulance crews. Results are shown in table 6-4.

IQ Dimension	Mean	Min.	Max.	S.D.
Accuracy	6.06	1	9	1.092
Timeliness	4.78	1	9	1.427
Consistency	6.12	1	9	1.251
Understandability	4.98	1	9	1.827
Completeness	7.51	1	9	1.740

Table 6-4. Results for non-technology information exchange satisfaction

Items ranged from 1 to 9, with a mean higher than 7 taken to represent satisfaction. The standard deviation for each item was below 2. *Timeliness* and *Understandability* received low satisfactory ratings from ED staff regarding verbal communication or written messages. Overall, results suggest low quality of information exchange in this spot-checked sample.

Quality of exchanged information that occurred with technology involved is assessed, which in this case consisted of two-way radios and PHR. For critical patients in which injury cases and patient information needed to be communicated before the ambulance arrived at the ED, I measured quality of information exchange facilitated through radio systems. Mentioned in table 5-4, **sampling** was selected as a method. Timeliness in these circumstances means arrivals must have been preceded by pre-hospital communication. Seven of 13 critical patients' information was communicated prior to ED arrival. 7 recorded radio conversations that occurred within three months are selected. To measure the Accuracy, Completeness, Consistency, and Understandability based on the metrics in table 5-4, I compared recorded radio communications to the PHR system. It was considered accurate if the information recorded was the same as that entered into the system. Seventy-three counts of 98 (14 items times 7 cases) were correct, considered complete if all information in the PHR regarding an injury case was found in recorded radio conversations. Eighty counts of 98 items were complete. Consistency was assumed if those 7 records were presented in the same format, and only 5 of 7 were found consistent. For understandability, it is counted questions asked by a recipient, and 12 of 98 items were questioned in the 7 cases. Results are presented in figure 6-6 below.

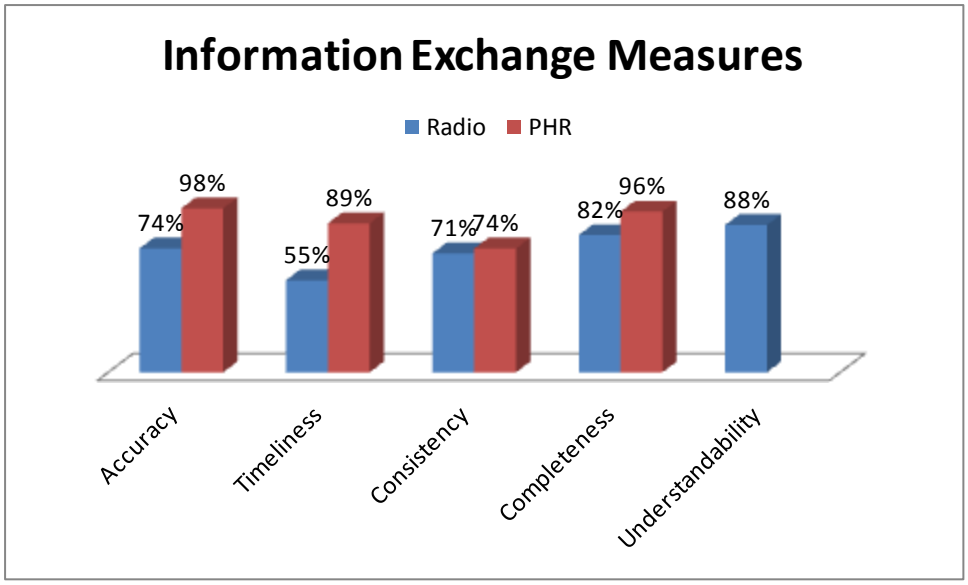


Figure. 6-6 IQ measures between ambulance and the ED staff with technology involved

For electronic information, 20 records between emergency documents in ambulance notes and PHRs are collected and compared. Results are shown in figure 6-6. Overall exchanged information was of higher quality when technology was involved, and above all, information exchange timeliness and consistency were of lowest quality. This case demonstration presented the applicability of the designed QA.IE techniques. The results allow identification and examination of the causes of the low IQ in information exchanges, which is the objective of the designed artifact presented in this thesis. The improvement recommendations outlined based on the contextual factors that are derived in this research. Summary is shown in table 6-5 below.

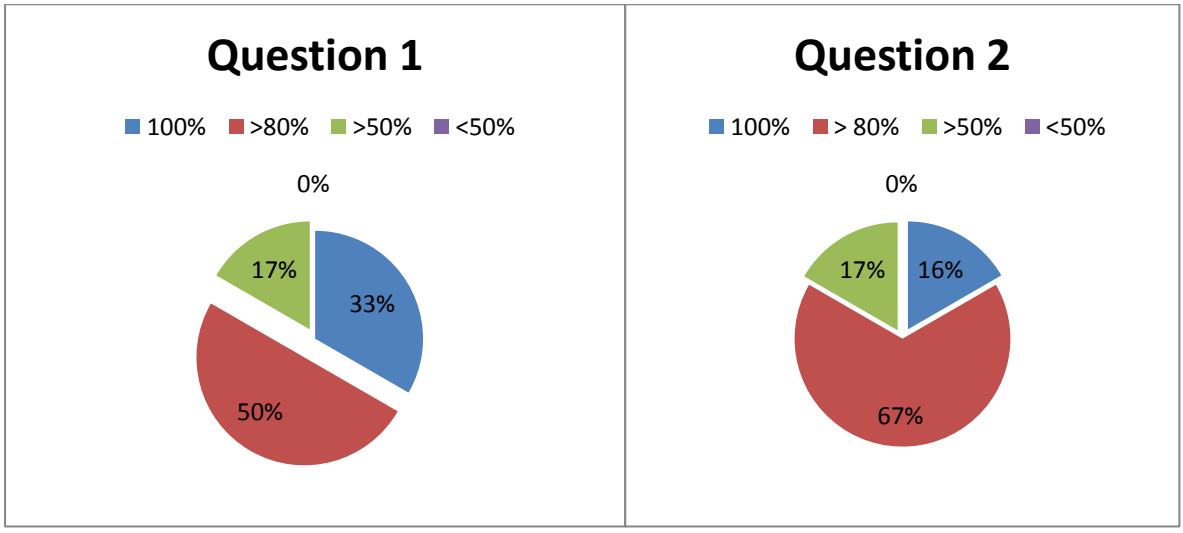
Who	**What**		**When**	**How**
Ambulance; ED staff	Injury case (injury cause location); pre-hospital intervention (assessment and treatment)		T5, T6	Radio communication; paper-based PCR
Recommendation one	Technology (capability, ease of use, acceptance)	Integrate EMS system (such as CAD) from ambulance centre to hospital; automate information exchange; increase user friendly devices for communication; incentives or motivation for using new adapted systems.		
Recommendation two	Process (standardization, workflow)	Standardize Paper-PCR structure and writing; standardize verbal communication between paramedics and ED staff, both face-to-face and remote verbal information exchange. Standardization matches business activities and		

		workflow.
Recommendation three	Organization (policy, goals)	Ambulance centers and hospital ED integrate the authorities and share the same goals for patient care. Policy making considers these two organizations as one regarding emergency delivery and care providing.

Table 6-5. Identification of causes and recommendation

6.2.4 Evaluate the QA.IE techniques based on EMS case implementation

As mentioned in section 6.1.1, a focus group of six experienced authorities were selected for a two-hour evaluation discussion. According to the previously described evaluation framework in section 2.1.4, a group of four researchers is gathered to discuss whether the QA.IE techniques met the pre-defined design principles detailed in section 5.2.1. Six interviews with information manager and executive level managers are conducted. Interviews results are shown in figure 6-7.



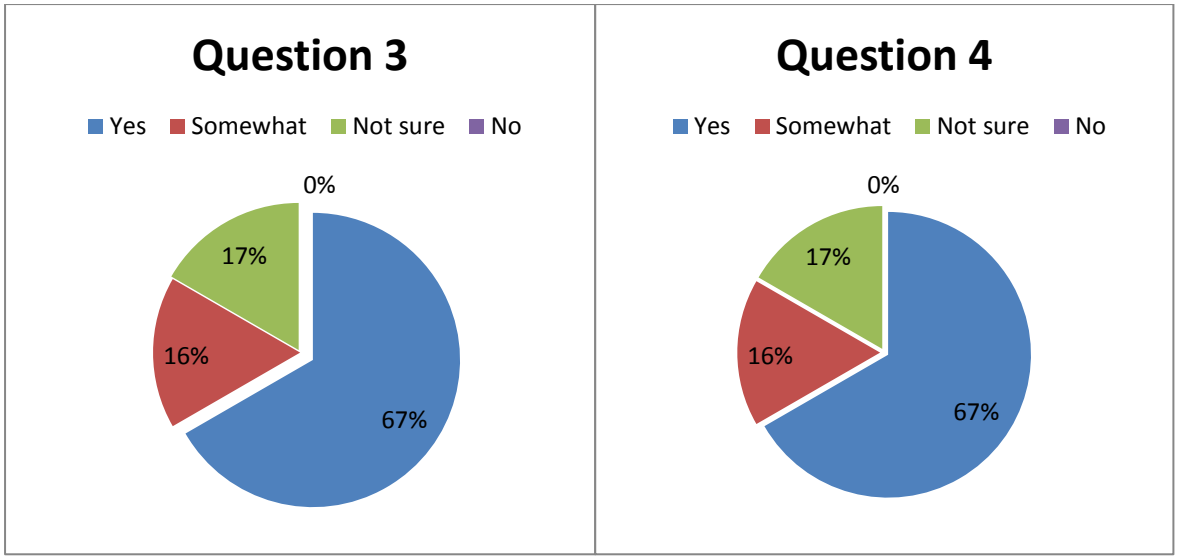


Figure 6-7. Interview results of the EMS case

From the interview results above, it is concluded that the designed QA.IE techniques receive positive feedback regarding the importance in its approach for identifying the problem and improvement in information exchange quality.

Finally, the Moody and Shank quality framework is presented, introduced, and explained to the group. Combined with QA.IE techniques case implementation process and results, this case seeks thorough group discussions according to the rating criteria. The rating is according to the definition of each Moody and Shanks Factor that described in section 2.4 (page 32). If the proposed output meets the defined criteria then it is accomplished. If the participates still not sure about the results, it will be marked as partially accomplished. If the participates do not agree with the results, then is not accomplished. If the results cannot been seen, that means results in progress and further testing is needed. Eventually a combined objective rating from the group was conducted. Evaluation results are shown in table 6-6 below. From the results below, it is concluded that the outputs of QA.IE techniques are promising and sound. Although completeness and simplicity can be improved, overall they meet the Moody and Shanks Factors.

Proposal main outputs \ Evaluation criteria		Demonstration of the artifact	Design principles	Interviews with practitioners	Moody and Shanks Factors							
					Completeness	Integrity	Flexibility	Understandability	Correctness	Simplicity	Integration	Implementability
BPM	Construction Model (ATD)	✓		✓	✓	✓	✓	✓	✓	◔	✓	✓
	Process Model (PSD)	✓	✓	✓	◔	✓	✓	✓	✓	✓	✓	✓
	State Model (OFD)	✓		✓	◔	✓	✓	✓	✓	✓	✓	✓
Information Profile	Context Information Organization	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Context information Prioritization	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
IQ Analysis	IQ Metrics	✓		✓	◔	✓	✓	✓	✓	◔	✓	✓
	IQ Measurement	✓	✓	✓	✓	✓	✓	✓	✓	◔	✓	✓
	Improvement Identification and Recommendation	✓		✓	✓	✓	✓	✓	✓	✓	✓	?

Caption: ✓for accomplishment;◔ or partial accomplishment; ✗ for not accomplished; ? for results in progress; <empty space> stands for not applicable.

Table 6-6. Evaluation framework completed in case one

6.3 Case Demonstration – Hospital Operating Room in Ireland

Dynamic settings process complex information, which require attention in order to be managed effectively. In hospitals, the multi-faceted information exchanges are essential for healthcare delivery to the patients. The operating room (OR) especially requires the coordination and communication of human and material resources to support the efficient surgical performances. A large hospital in Dublin was selected for this study purpose. Hospital A is a country-owned, tertiary care, academic hospital that consists of 11 ORs. To apply the designed QA.IE techniques, the stages and the presented models (section 5.3) are followed.

6.3.1 Enterprise Description

The local demand for surgery services has increased over the last two decades. The capacity of the ORs at the complex has reached demanding levels of utilization. Surgical cases are conventionally classified into elective and emergency. An elective case is one whereby the patient can wait at least three days without sustaining morbidity or mortality.

Observations of the information flow within one suite of six ORs were performed. The patient admission may be scheduled via several routes or emergent. The OR staff is comprised of registered nurses, nursing assistants, scrub technicians and unit secretaries, all supervised by an OR charge nurse. The charge nurse collaborates with the OR staff, surgeons, anesthesia care providers, facilitates personnel and outside equipment suppliers in order to facilitate patient movement within the OR suite.

6.3.2 Stage One- Business Process Modeling

To be consistent with the case demonstration and preference in this study, DEMO is selected. Observations among and between the OR personnel and other hospital departments were performed at the apparent hub of the information exchanges. A total of 27 cases were observed from pre-surgery area to post-surgery care providing ward. The communication pattern is observed and noted down on the three day observation of 27 cases in total.

When there is a surgery scheduled for a patient, regardless of whether it is an emergency or elective surgery, the patient is registered for the OR unit. The patient is transported to the pre-surgery room for check-up and get ready by the OR charge nurse. Anesthetists and surgeons are then confirmed for the operation. Once the operation is complete, post-surgery care for the patient is provided. In the meantime, the surgeon is required to update his schedule to the OR secretary and complete a report. After identifying transaction types and checking dependencies, the environment (i.e. contextual factors) is determined by mapping each transaction to a respective initiator and executor to create an Actor Transaction Diagram (ATD), illustrated in figure 6-8. In the ATD, a circumscribed diagram represents a transaction, and each transaction connects two boxed representing the initiator and the executor actor roles.

In the case of both elective and emergency surgeries, the patient is firstly registered for surgery. When OR and doctor availability is confirmed, patient transportation will be arranged. Before the operation, OR charge nurse needs to confirm the patient condition and record examination record before the confirmation with anesthetist and the surgeon. The operation starts when the patient is set up in the OR after anesthetization. Surgeons, anesthetist, and the nurses usually are the main actors. During the operation, information regarding treatment, medication, patient condition etc. is recorded to the system by the nurse. After surgery, the patient is transferred to the assigned ward and post care is provided.

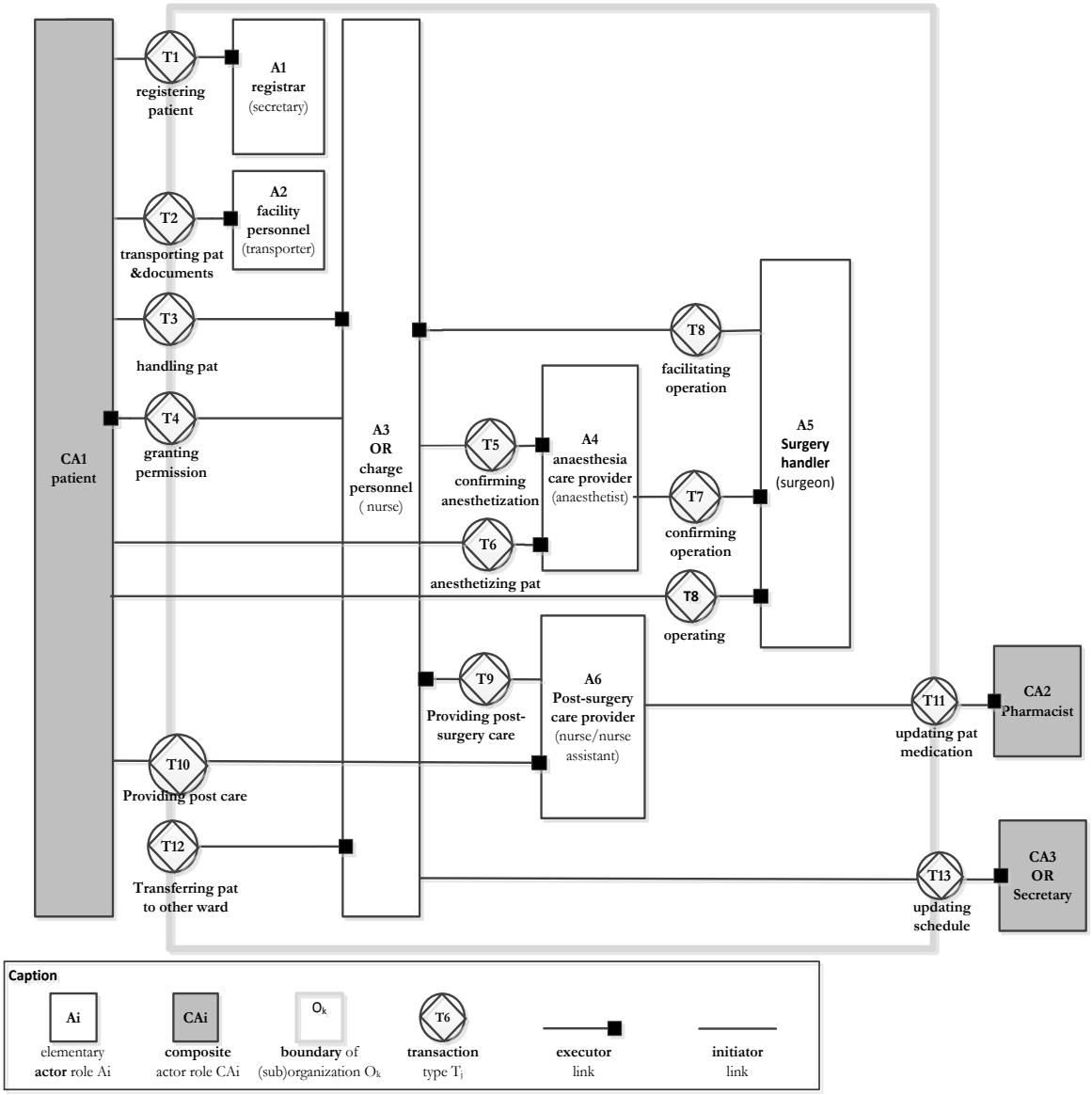


Figure 6-8. ATD diagram in hospital OR

Consistent with the ATD, a detailed process structure diagram (PSD) is modeled rigorously. Figure 6-9 below shows the initiator and executor on each process. Information regarding the involved organization/actors, information technologies, business processes, and exchanged data can be extracted strictly.

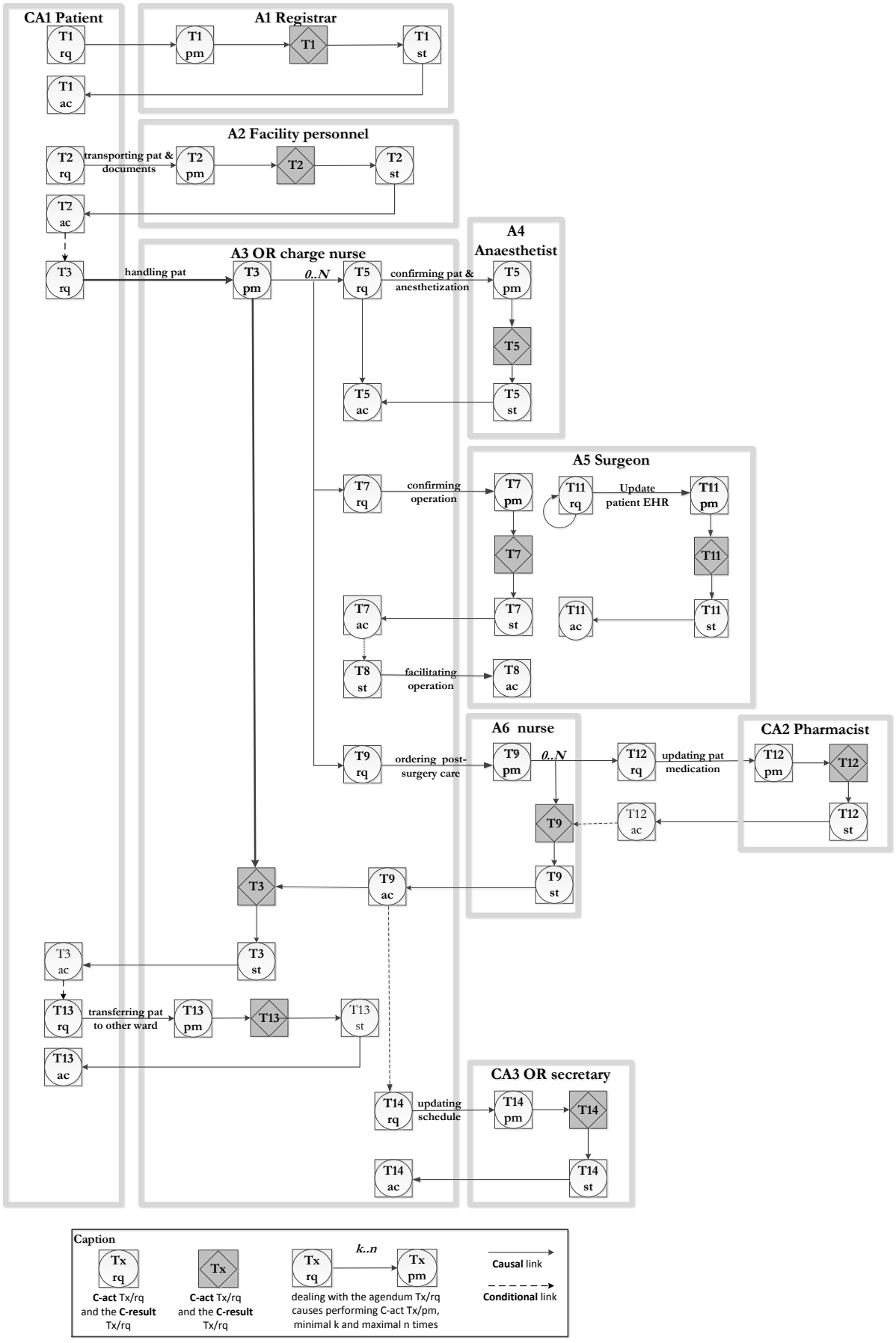

CA1 Patient
A1 Registrar
A2 Facility personnel
A3 OR charge nurse
A4 Anaesthetist
A5 Surgeon
A6 nurse
CA2 Pharmacist
CA3 OR secretary
transporting pat & documents
handling pat
0..N
confirming pat & anesthetization
confirming operation
Update patient EHR
facilitating operation
ordering post-surgery care
updating pat medication
transferring pat to other ward
updating schedule
Caption
C-act Tx/rq and the C-result Tx/rq
C-act Tx/rq and the C-result Tx/rq
k..n
dealing with the agendum Tx/rq causes performing C-act Tx/pm, minimal k and maximal n times
Causal link
Conditional link

Figure 6-9. PSD diagram in hospital OR

As depicted in figure 6-9 above, the patients may ask for registration with the OR sectary (T1). Facility personnel assist and transport the patient to pre-surgery room (T2), where the OR charge nurse will handling the patient through a series of actions (T3). The handling of patients' problems leads to different actions: assessing the patients and confirming anesthetization with the anesthetist (T5), confirming the operation with the surgeon (T7), facilitating the surgery during operation (T8), and coordinating post-surgery care after the operation (T9). Medication updates are sent to the pharmacist for patient post-surgery care (T11). When the patient is transferred to the post-care, the OR charge nurse needs to post the OR room updates (T13). Modeling of the processes is inherent to each transaction type acknowledged in the ATD. This SPD notation is based on the Transaction Axiom, and it also includes the precedence relationships, both causally and conditionally between transaction types, which are used to highlight the communicative commitments.

Further to detail the information exchanged in these processes, the State Model is presented as instructed in DEMO. Table 6-7 presents the object property types, which depicts data types and attributes.

Property type (attribute)	**Object class (entity)**	**Property type (attribute)**	**Object class (entity)**
patient_id	PATIENT_RECORD	intervention	SURGICAL_TREATMENT
treatment_history	PATIENT_RECORD	vital signs	SURGICAL_TREATMENT
intervention_history	PATIENT_RECORD	monitor_feeds	SURGICAL_TREATMENT
medication-history	PATIENT_RECORD	time	SURGICAL_TREATMENT
bill_history	PATIENT_RECORD	anesthetization	SURGICAL_TREATMENT
patient_name	REGISTRATION	anesthetist_status	STAFF
date_of_birth	REGISTRATION	surgeon_status	STAFF
age	REGISTRATION	room_staff_status	STAFF
address	REGISTRATION	scheduled_surgery	OPERTATING_ROOM
contact	REGISTRATION	equipment	OPERTATING_ROOM
allergy	REGISTRATION	room_readiness	OPERTATING_ROOM
cause	INJURY_ CASE	pending_changes	OPERTATING_ROOM
illiness	INJURY_CASE	prescription	ADDITIONAL_MEDICATION
severe_level	INJURY_CASE	medicine_updates	ADDITIONAL_MEDICATION
room_location	INJURY_CASE	date_time	OPERATION_SCHEDULE
patient_status	EXAMINATION	chief_surgeon_name	OPERATION_SCHEDULE

condition	EXAMINATION	anesthetist_name	OPERATION_SCHEDULE
special_potision_needs	EXAMINATION	OR_code	OPERATION_SCHEDULE
equipment_needs	EXAMINATION		

Table 6-7. Object property list

Object fact diagram is presented follow by the models and the table 6-6. Figure 6-10 below shows the information items that are relevant to the operation of the organization, including categories, object classes, fact types, and result types.

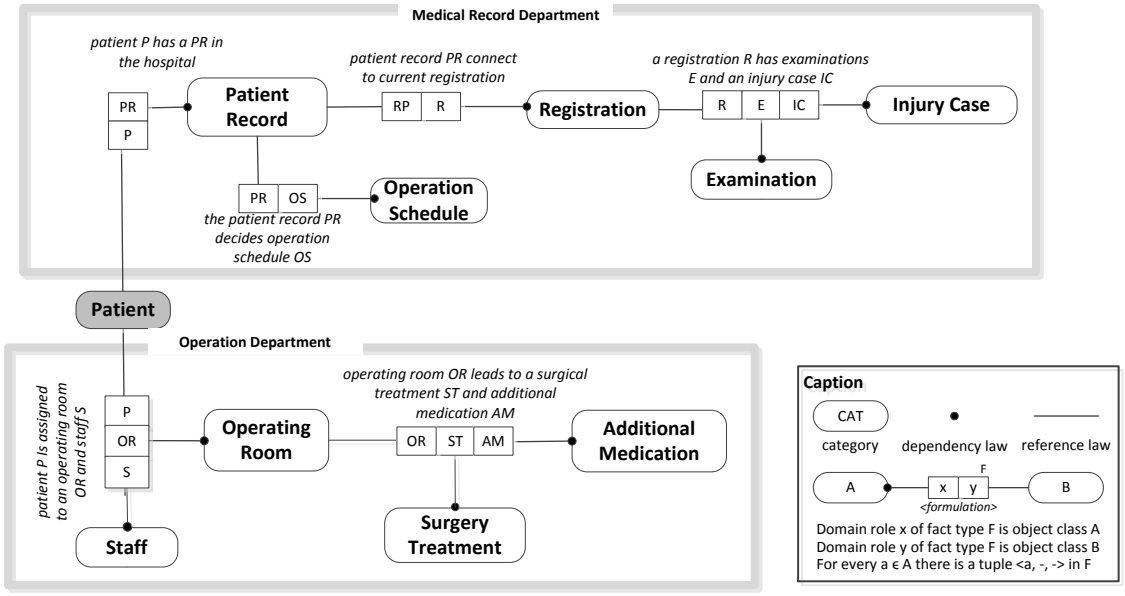


Figure 6-10. Object property list

From the models, context information of technology, organization, process, and exchanged data can be structured and profiled.

6.3.2 Stage Two- Information Profiling

To measure the quality of the information, prioritization of information elements is necessary. Table 6-8 below summarizes the information that is structured according to the contextual factors, and information elements are prioritized according to the contextual factors.

	Pre-surgery units		**Operating Room**		**Post-surgery units**	
What (Info)	Fact and Result Type	Object and Transaction	Fact and Result Type	Object and Transaction	Fact and Result Type	Object and Transaction

	patient ID, medication history, patient name, address allergy	Patient records, Registration(T1)	vital signs, monitor feeds, time, anesthetic status, intervention	Surgical Treatment (T8)	Patient-name, medication, room location, illness, patient status	Injury case (T10)
	patient name, room location , OR room code, surgery date time, surgeon name	Registration Injury Case, Operating Room, Surgery Schedule (T2);	patient status, equipment needs, medication, room location	Examination , Injury case (T9)	scheduled surgery, pending changes, room readiness	Operating Room (T11)
	patient name, treatment history, intervention history, medication history; patient status, condition, special positioning needs, equipment needs; anesthetist status, surgeon availability, room staff status	Patient Records, Examination , Staff (T3, T5, T7)			prescription updates, medication history	Additional Medication (T13)
Who (Org)	Registrar (admission clerk, secretary) and Patient Handler (Facility personnel, OR charge nurse, anesthetist)		Patient Handler (nurse), Anesthetic staff (anesthetist), Examiner (nurse) and Intervention Performer (Surgeon)		Post-surgery caregiver (floor nurse or nurse), pharmacist	
When (Process)	Patient is admitted for emergency or elective surgery (T1-T7)		Patient transferred to OR, Patient in operation (T8-T9)		Operation is finished, patient is transferred out OR	
How (Tech)	Whiteboard, pagers, HER, phones		PHR, Pagers, in-person communication		in-person communication, EHR	

Table 6-8. Information profiling

Table 6-8 above provides structured information based on the contextual factors. To analyze and measure the information quality while the information is exchanged between the actors, stage three is followed.

6.3.3 Stage Three-Information Quality Analysis

Further information elements and IQ dimension prioritization is followed. Following the method developed in figure 5-6 (section 5.2.3), this case resulted in prioritization of *Accuracy, Completeness, Timeliness,* and *Accessibility* for IQ analysis. Information again is further profiled and organized according to the contextual factors of organization, technology, information/data, and process. In this case, focus is intra-organizational information exchange, and involved actors are the key roles representing the organization factors. For technology, it again is divided into non-digital and digital information exchange, shown in table 6-9 below.

Organization	OR register, OR charge nurse, equipment personnel, floor nurse, anaesthetist, surgeon, and pharmacist		
Technology	**Non-digital:** Paper sheets, pagers, whiteboard, in-person communication	Injury case, Examination, Staff , Operating Room, Operation Schedule	T2, T3, T5, T7, T9, T12
	Digital: Electronic Patient Records (EHR)	Basic data, Pre-surgical Examination, Surgical Treatment, Additional Medication	T1, T11, T13

Table 6-9. Information and IQ dimensions prioritization based on contextual factors

Perform measurement of the information elements and dimensions, metrics and methods are selected based on table 5-4 in chapter 5.

Firstly, for non-digital information exchange, observation on oral communication among the OR charge nurse, the equipment personnel, floor nurse, anesthetist, and surgeon is conducted. **Spot-checking** and **sampling** methods are selected to generate metadata. Following these 27 surgery cases I observed, two OR charge nurses who is the key role in coordinating OR room and surgery arrangement, two animists, two surgeons, three facility personnel, OR staff, and floor nurses are interviewed. Three days were randomly selected, and towards the end of each day, interviews regarding their satisfaction of information exchange were conducted. In total, 45 interviews in three days were carried out. With consistency among all the cases, I again used statistics associated with frequency distributions. Respondents rated how satisfied the information dimensions were from 1 (not important at all) to 5 (extremely important), based on the verbal information exchange they experienced recently. This identified *Accuracy, Timeliness, Completeness,* and *Accessibility* of information are rated by the interviewees. *Accuracy* is defined as correct information. *Completeness is descripted as* complete information that is structured or non-structured. *Timeliness* means updated information in

consent form, whiteboard, and surgery preference sheet. *Accessibility* defined as 'information that is easy to obtain when needed' in table 5-4. Information type of Injury Case, Examination, Staff, Operation Schedule, and Operating Room are measured. Attributes of each information type are listed and presented to the interviewees as reference (Table 6-6). Results are shown in table 6-10.

IQ Dimension	Information Type	Mean	Min.	Max.	S.D.
Accuracy	Injury Case	3.02	1	5	1.932
	Examination	3.61	1	5	1.823
	Staff	2.05	1	5	1.967
	Operating Room	2.32	1	5	1.087
Completeness	Injury Case	3.98	1	5	1.323
	Examination	3.06	1	5	1.565
	Staff	2.67	1	5	0.971
	Operating Room	2.88	1	5	0.832
Timeliness	Injury Case	3.79	1	5	1.041
	Examination	3.54	1	5	1.931
	Staff	3.25	1	5	1.221
	Operating Room	2.70	1	5	0.864
Accessibility	Injury Case	3.81	1	5	1.954
	Examination	3.04	1	5	1.103
	Staff	2.41	1	5	0.850
	Operating Room	2.12	1	5	0.896

Table 6-10. Results for non-digital information exchange satisfaction

Items are ranged from 1 to 5, with a mean higher than 3 were taken to represent satisfaction. Information on staff received low satisfaction ratings from regarding verbal or written communication. Overall, results suggest low quality of information exchange in this spot-checked sample, particularly the information type and attributes on staff and operating room.

For the digital information exchange, the observed 27 surgical cases records in the hospital EHR system are accessed again by the researcher. According to table 6-9, archived information types in the patient record including the patient basic data, pre-surgery examination, surgical treatment, and medication in EHR are measured. From the measurement results of basic data, pre-surgery examination, surgical treatment, and medication, it reflects the information enter, transfer, and retrieval quality of the registrar, the

OR charge nurse, and the surgeon. According to table 5-4, the metrics and methods are extracted to suit this case.

Accuracy	Free-of-Error Rating = 1-,<*N/T*> Where *N* = Number of data units in error and *T* = Total number of data units.
Completeness	The degree that the attributes are assigned values in a data set. Completeness Rating = 1-<*C/T*> Where *C* = Number of incomplete items and *T* = Total number of items.
Timeliness	Timeliness Rating = 1-<*Δ of expected and actual time of activities occurred/T of expected time of activities occurred*> Where Δ = value difference and T= Total number of items.
Accessibility	The degree that data can be retrieved in a data set. Accessibility Rating = 1- <*A/T*> Where *A*= Number of inaccessible items and *T*= Total attempt access number

The approach for accuracy measuring in the following way: (1) basic data from each case from, the patient when the patient has recovered physically is selected to confirm whether they match the data in the records; (2) pre-surgery examination data and (3) for surgical treatment data I compare the paper records that are written by the OR charge nurse to the stored data in the system; (4) for medication data the system recorded data with the surgeon or the nurse is checked. To conduct the measurement metrics to this specific case, the following data resource and procedures are used.

For completeness measuring, all these four types of data directly calculate the value being entered in the structured and unstructured free text.

For timeliness measuring, the entering time stamps of all these four types of data are recorded, comparing with the required time buffer.

For accessibility measuring, times of not being to successfully access to the needed information are marked down by the research during the case observations. Results are presented in figure 6-11 below.

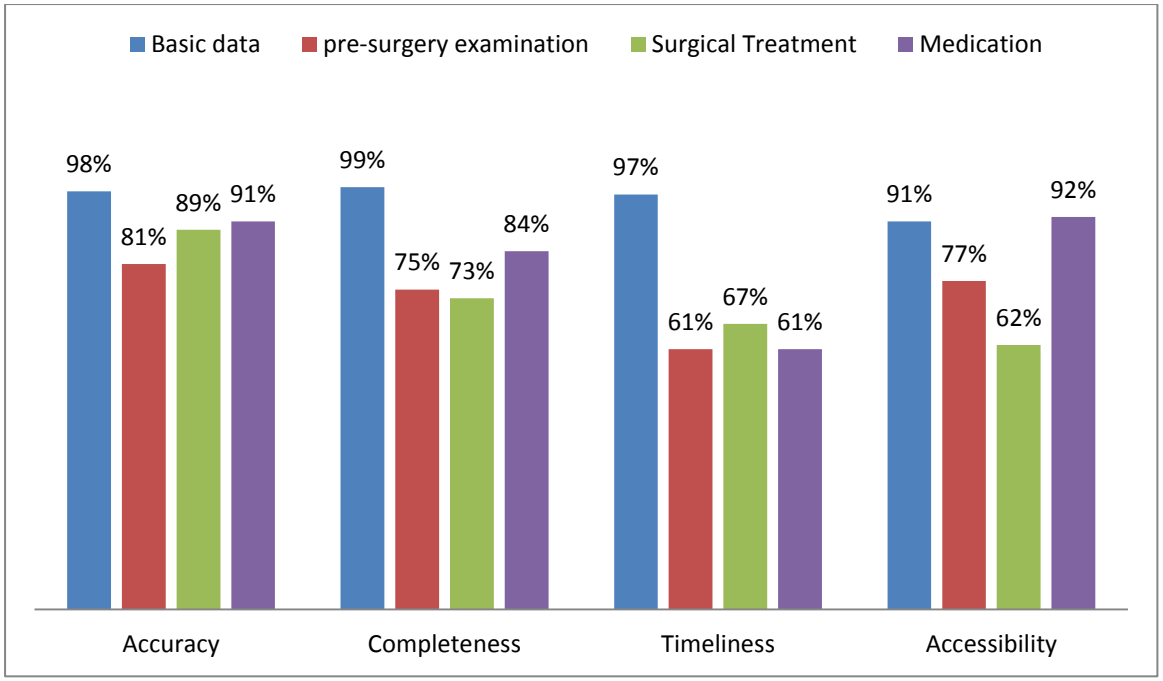


Figure 6-11. Digital information exchange results

The measurement results show that the patient basic data reveals the best quality of all. Medication data is followed. The very low quality of surgical treatment data and medication data is shown as well. According to Irish HIQA authority, requirements for patient records, good and satisfactory quality data is required to be higher than 98% in average. In this sense, it is concluded that the sampled results are far below the standard in this investigated setting, and IQ degrades as multiple entering and editing by various actors. Analysis combined with both digital and non-digital IQ results measured above. The causes relating to the contextual factors of technology, organization, and business processes can be examined. The improvement recommendations are proposed accordingly based on the contextual factors. Table 6-11 summarizes the findings and future directions for improvement.

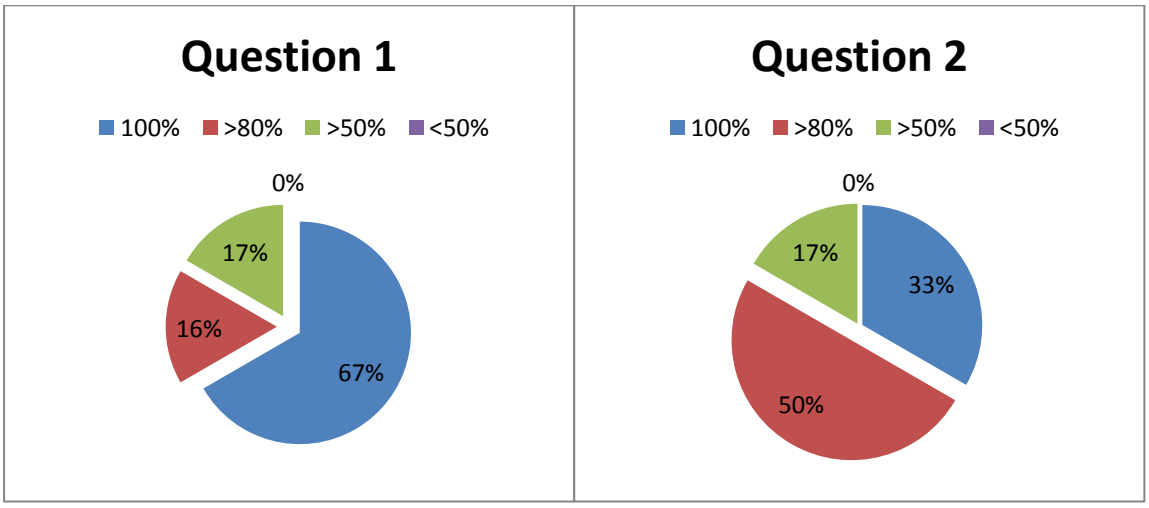
Who	What	When	How	Why
OR charge nurses	Staff (availability and readiness for operation), operating room, surgery schedule	T3, T5, T7	EHR, phone, pagers, printed documents	Too many different formats for communication and information exchange; No single procedure standards
Surgeons	Staff (Surgeon availability, schedule cooperate with other staff), Surgical treatment	T8, T11	in-person communication, EHR	No digital record pre-during, and post- surgery
Floor nurse	Medication, surgical treatment	T10, T14	pagers, in-person communication, paper sheets,	No integrated system for surgeries and EHR system

			EHR	
Rec. one	Technology (capability, ease of use, acceptance)	Digitalize information entering and exchange for surgery scheduling and staffing. Introducing integrated mobile device recording operation regarding surgical treatment. Automatic extraction from free-text field to structured field can be adopted to reduce missing data.		
Rec. two	Process (standardization, workflow)	Standardize procedures for preparing surgeries among the actors. Identify the critical process steps for improvement.		
Rec. three	Organization (structure, policy, goals)	Enhance information exchange and IQ for OR setting, achieving the ultimate goals for patient cares. Define policies that stress regular trainings. Develop structured team for surgery delivery.		

Table 6-11. Identification of causes and recommendations

6.3.4 Evaluate the QA.IE techniques based on OR case implementation

Based on the proposed evaluation framework, interviews with six practitioners are conducted, who held managerial potions in the hospital. One nurse manager, two information system administrator, the IT director, operational manager, and the OR charge nurse. The same interview questions were asked, and the results show in figure 6-12. Results showed very positive attitudes towards our approach and proposal overall.



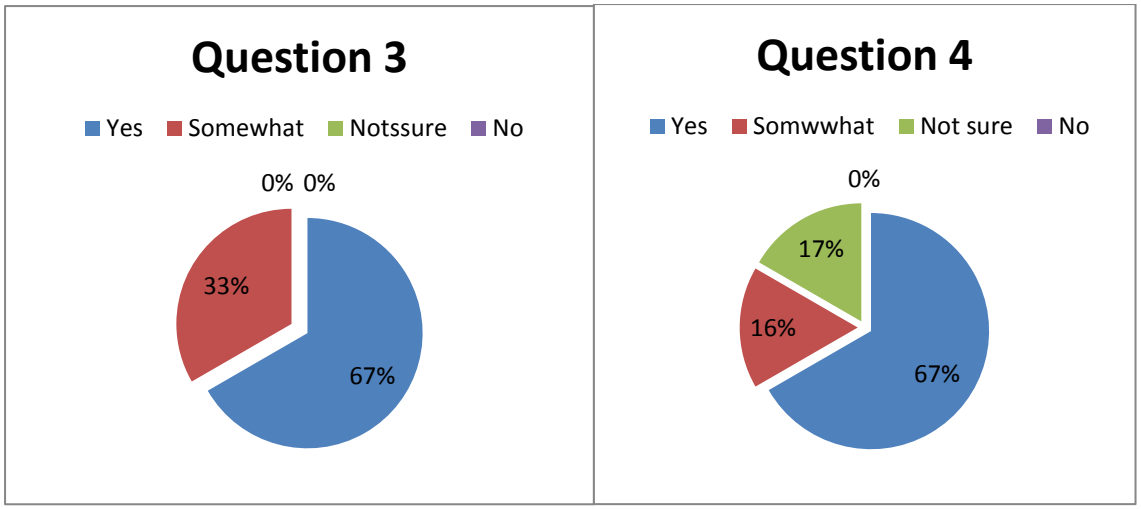


Figure 6-12. Interview Results of the OR case

The same instrument focus group with on-site practitioners is followed to evaluate the QA.IE techniques based on Moody and Shanks factors. Focus group composed of six stakeholders, the overall rating is very promising and positive. Although improvement on simplicity and flexibility can be further examined, the QA.IE techniques indeed bring context based measurement on IQ and information exchange. Overall results are summarized in table 6-12 below.

Proposal main outputs \ Evaluation criteria		Demonstration of the artifact	Design principles	Interviews with practitioners	Moody and Shanks Factors							
					Completeness	Integrity	Flexibility	Understandability	Correctness	Simplicity	Integration	Implementability
BPM	Construction Model (ATD)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process Model (PSD)	✓	✓	✓	✓	◌	✓	✓	✓	◌	✓	✓
	State Model (OFD)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Information Profile	Context Information Organization	✓	✓	✓	◌	✓	◌	✓	✓	✓	✓	✓
	Context information Prioritization	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
IQ Analysis	IQ Metrics	✓		✓	✓	✓	✓	✓	✓	✓	◌	✓
	IQ Measurement	✓	✓	✓	✓	✓	◌	✓	✓	✓	✓	✓
	Improvement Identification and Recommendation	✓		✓	◌	✓	✓	✓	✓	◌	✓	?

Caption: ✓for accomplishment; ◔or partial accomplishment; ✗ for not accomplished; ? for results in progress; <empty space> stands for not applicable.

Table 6-12. Evaluation framework completed in case two

6.4 Case Demonstration – Balcao Perdi a Carteira (BPC) for Citizen Identity Service

E-government for citizens is an essential topic for information sharing and information exchange. Portugal has been on the leading trend since 2007 with various digitalized services provided to the citizens. System integration of the public administration entities project was completed in 2011. The authorized officer from any office location is able to access and share citizen information for completion of a citizen's request. For example, when a citizen requests the insurance of an e-citizen card, the office is able to access the social security data from Ministry of Justice and the citizen's healthcare plan and code from Department of Healthcare to complete the application. The 'Balcao Perdi a Carteira' (BPC) office on their information exchange systems from the front end to the back end is investigated.

6.4.1 Enterprise Description

The 'Balcao Perdi a Carteira' (BPC) is a service provided to all the Portuguese citizens, who live in Portuguese territory, which aims to facilitate reissuing a set of citizen identification documents (i.e. citizen card, driving license, pensioner card) in the presence of several Entities, including personal data changing, lost or stolen. Information exchange occurs between the citizen and the BPC officer, as well as the officers and other public entities such as Ministry of Justice in case of citizen card reissuance. All the procedures are complete by the integrated electronic information systems. This is an inter-organizational information exchange setting, and the QA.IE techniques are carried out to this public domain.

6.4.2 Stage One- Business Process Modeling

Generally speaking, the procedure for a request in the BPC is divided into three main phases: an initial screening procedure; the citizen service on confirmation of the request is able to advance; the citizen post-service, the procedures performed followed by the first contact with the citizen, who may or may not has received the requested documents. All procedures are developed on the support of an integrated computer system where all the necessary operations for reissuing are performed.

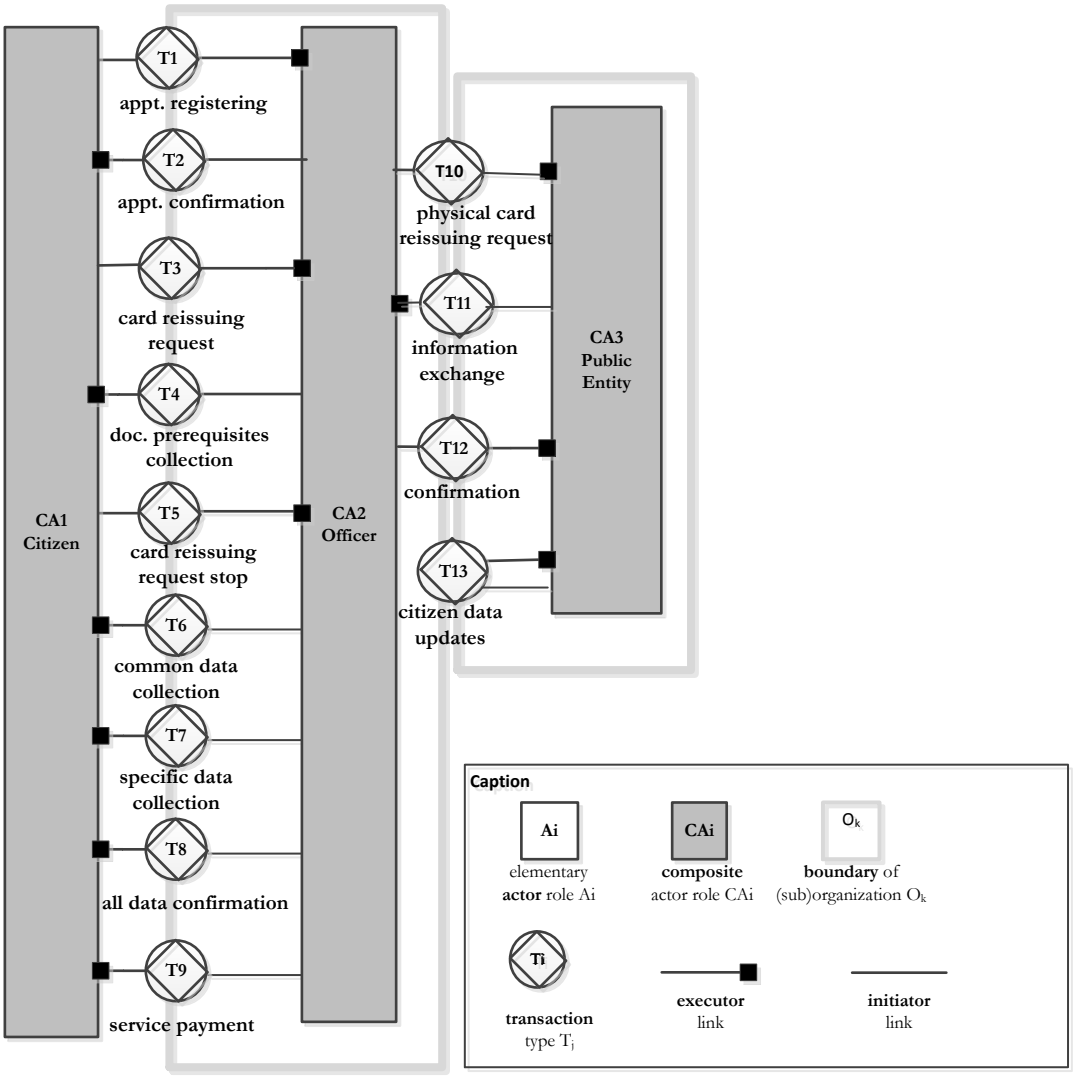


Figure 6-13. ATD model of Balcao Perdi a Carteira' (BPC) identification card reissuing

The ATD is modeled on the basis of observation, material reviews, and interactions with in-field staff. The ATD diagram is shown in figure 6-13. If a citizen needs to have any identity card(s)/document(s) reissued, he/she can file an online registration form to make an appointment for reissuing through the open portal on BPC website (T1). After the appointment is confirmed through email (T2), the citizen goes to BPC to precede card issuing request (T3). The officer subsequently responds to the request and collects the prerequisite documents to process the request (T4). If the citizen cannot provide enough data as requested prior to arrival arranged via email appointment confirmation, then he/she has to stop the procedure (T5). If/When the prerequisite documentation collection is complete, the officer checks the common data (what kind of cards are requested for reissuing/replacing, i.e. citizen card, driving license, pensioner card) (T6). Once the common data is complete as required on the form, then the officer checks the specific data (i.e. address, card number) (T7). On the

confirmation of all the data (T8), a payment is required (T9). Subsequently, the officer requests a physical card to be reissued from the relevant entities through Agency for the Modernization of the Public Administration (AMA) platform (T10). Information exchange occurs between the entity and the officer regarding the request (T11). Once everything is confirmed (T12), the entity updates the citizen data and reissues the card or document (T13).

Consistent with the ATD model, a SPD model is followed to entail the transaction between the initiator and executor, shown in figure 6-14 below. Since all the processes are facilitated by the web portal IAP (interoperability for public administration), exchanged information is sent, transferred, and received in a digital form. The oral communication between citizens and the BPC officers is very limited.

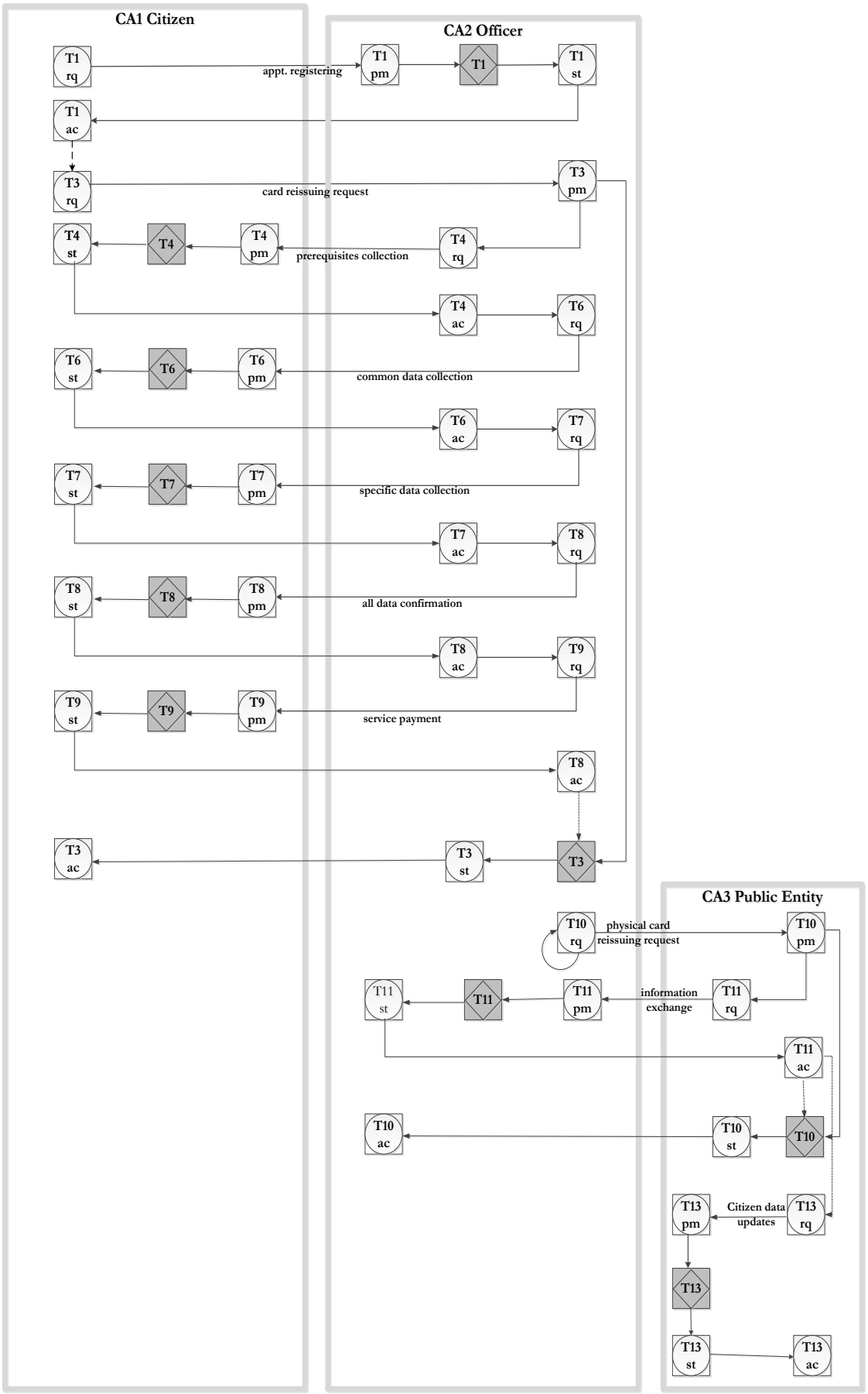

CA1 Citizen
CA2 Officer
CA3 Public Entity
T1 rq
appt. registering
T1 pm
T1
T1 st
T1 ac
T3 rq
card reissuing request
T3 pm
T4 st
T4
T4 pm
prerequisites collection
T4 rq
T4 ac
T6 rq
T6 st
T6
T6 pm
common data collection
T6 ac
T7 rq
T7 st
T7
T7 pm
specific data collection
T7 ac
T8 rq
T8 st
T8
T8 pm
all data confirmation
T8 ac
T9 rq
T9 st
T9
T9 pm
service payment
T8 ac
T3 ac
T3 st
T3
T10 rq
physical card reissuing request
T10 pm
T11 st
T11
T11 pm
information exchange
T11 rq
T11 ac
T10 ac
T10 st
T10
T13 pm
Citizen data updates
T13 rq
T13
T13 st
T13 ac

Figure 6-14. SPD model of Balcao Perdi a Carteira' (BPC) identification card reissuing

Subsequently, object property list is followed, presented in table 6-13. From the descriptions, the ATD model, and SPD model, information entity and attributes can organized in object property list, followed by the OFD model. Figure 6-15 depicts the relationship between the object facts.

Property type (attribute)	**Object class (entity)**	**Property type (attribute)**	**Object class (entity)**
photo	PREREQUISTES	request_number	REQUEST
citizen_card	PREREQUISTES	type	REQUEST
driving_license	PREREQUISTES	payment_value	REQUEST
parish_council_proof	PREREQUISTES	stop_motive	REQUEST
tax_id	PREREQUISTES	auth_paticipation	COMMON_DATA
single_vehicle_doc	PREREQUISTES	dl_state	COMMON_DATA
citizen_address	SPCIFIC_DATA	svd_form	COMMON_DATA
doc_number	SPCIFIC_DATA	name	ENTITY
citizen category	SPCIFIC_DATA	doc_code	ENTITY
actual_doc_issuer	SPCIFIC_DATA	info_code	ENTITY
alternative_address	SPCIFIC_DATA		
fiscal_allocation	SPCIFIC_DATA		
social_security_number	SPCIFIC_DATA		

Table 6-13. Object property list of BPC case

Table 6-13 shows the extracted property type and object class from the PSD model. The prerequisites, common data, and specific data are dependent on the request. For example, For the Driving License (DL) it is required for the citizen to present a photograph and their Identity Card/Citizen Card or request the Citizen Card (CC); Regarding the Single Vehicle Document (SDV), it is required the presentation of Citizen Card or Passport or request the Citizen Card (in this case the SVD remains dependent of the CC issuance) as well as the indication of his Tax Identification Number (TIN).

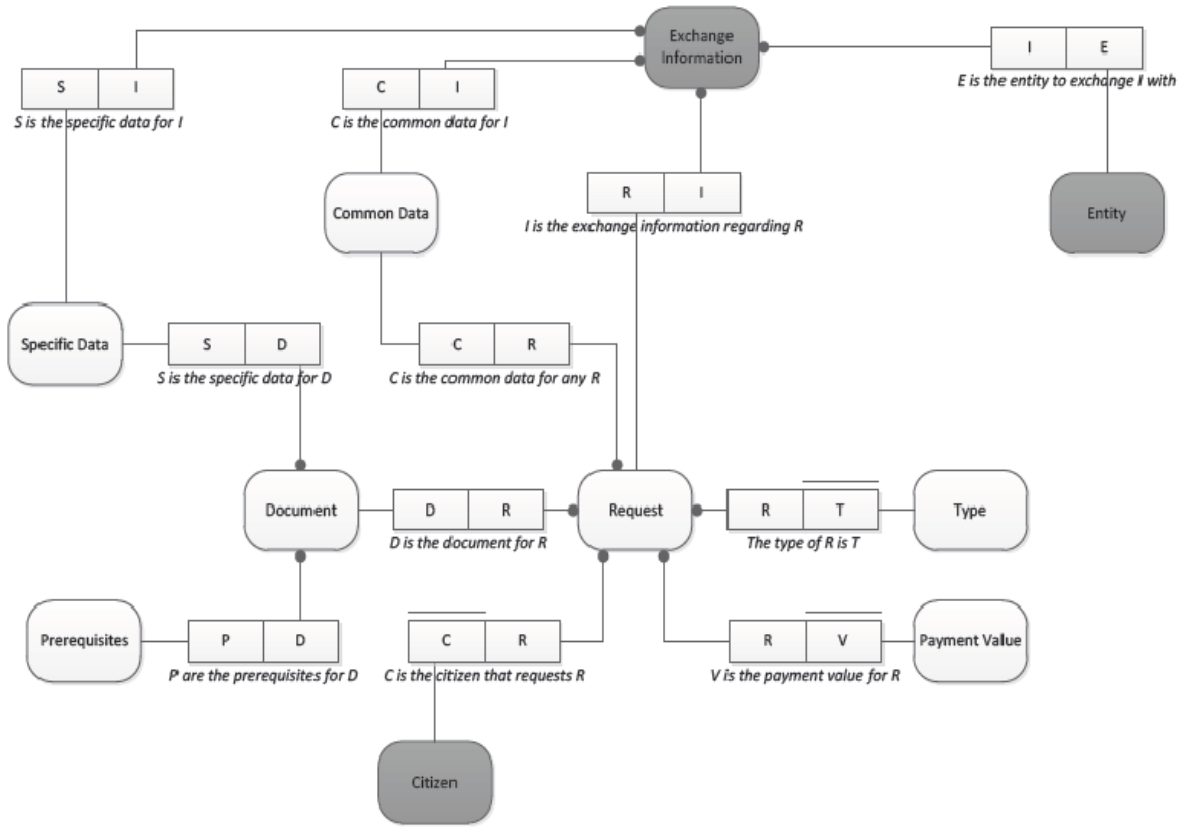


Figure 6-15. OFD model of Balcao Perdi a Carteira' (BPC) identification card reissuing

6.3.2 Stage Two- Information Profiling

On basis of the first BPM stage of QA.IE techniques, the second stage of Information Profiling in table 6-14 is followed. Exchanged information is categorized to who (actors of citizen, BPC officer, and public entity), what (object fact), when (transaction step), and how (digital and non-digital).

Who (org)	**Citizen**		**BPC Officer**		**Public Entity**	
What (Info)	Fact and Result Type	Object and Transaction	Fact and Result Type	Object and Transaction	Fact and Result Type	Object and Transaction

	type, citizen address, actual document issuer, alternative address, tax ID, social security number	Request, Specific Data(T1)	all data, entity name, entity code, info code	Prerequisites, Request, Common Data, Specific Data, Entity (T8)	Type, authentic participation, citizen address, doc number, alternative address, tax id, social security	Request, Common Data, Specific Data (T11, T13)
When (Process)	Citizen is applying an identification reissuing (T1)		Officer confirm all the data (T8)		Request physical card reissuing and information exchange (T10, T11)	
How (Tech)	BPC web portal		in-person communication, IAP Platform		IAP Platform	

Table 6-14. Information profiling

All the information is profiled and categorized according to the contextual factors, which provides a structured path to measure the information elements and chase the low quality causes.

6.3.3 Stage Three-Information Quality Analysis

Following 5.2.3, table 5-4, I firstly prioritize the IQ dimensions for the involved organizations/actors. In this case, IQ requirements are focused on the information on the web portal. Results showed that *Understandability, Completeness, Timeliness, Consistency,* and *Accuracy* are the most important concern criteria.

To measure the IQ dimension of the information exchange, subjective measurement method is selected to survey the **user experience.** A short electronic surveys were sent out to the citizens who had experienced the identify documents request. The citizen was simply asked to rate the IQ dimensions from information exchange perspective based on their experience with the web portal and the in the office. Again, 5-Likert Scale is used to be consistent with the previous case studies. 1 (not satisfied at all) to 5 (extremely satisfied). 19 citizens returned the survey with ratings. Results are presented in table 6-15 below.

IQ Dimension	Mean	Min.	Max.	S.D.
Understandability	4.46	1	5	1.130
Timeliness	3.88	1	5	1.240
Completeness	4.50	1	5	1.151
Consistency	3.98	1	5	1.027
Accuracy	4.71	1	5	0.940

Table 6-15. Results of the IQ satisfactions on information exchange from the citizens

Overall, it showed a good satisfactory score, which indicates that the information presented on the web portal prior the actual appointment is in good quality in general (T1). This leads to good information exchange processes in the BPC office, because the information provided on the website is understandable, up-to-date, complete, fairly consistent, and accurate. Although timeliness and consistency can be further improved, overall the quality is good.

For measurement of the information exchange between the BPC officer and various public entities regarding the requested identity card reissuing, 4 officers from the potentially involved entities (depends the document request from the citizen) are selected – Ministry of Justice, Ministry of Foreign Affair, City Council, and Regional Police Administration. In total, 14 surveys were received from the participants from those entities to rate their satisfaction level towards the IQ of information exchange with BPC. *Completeness, Accuracy, Security, Timeliness,* and *Accessibility* are identified as the most important dimensions.

IQ Dimension	Mean	Min.	Max.	S.D.
Completeness	4.06	1	5	1.030
Accuracy	3.98	1	5	1.140
Security	4.29	1	5	0.151
Timeliness	3.02	1	5	0.927
Accessibility	4.12	1	5	1.240

Table 6-16. Results of IQ satisfactions on information exchange from the entities.

From the measurement results, it shows the transferred data from BPC present decent quality. Compare to table 6-15, indication of IQ degrading is also presented as the information transferring from the citizen to the BPC and onto another involved entity. Subsequently, the cause identification and recommendation is filed based on the contextual factors and assessment results, shown in table 6-17 below.

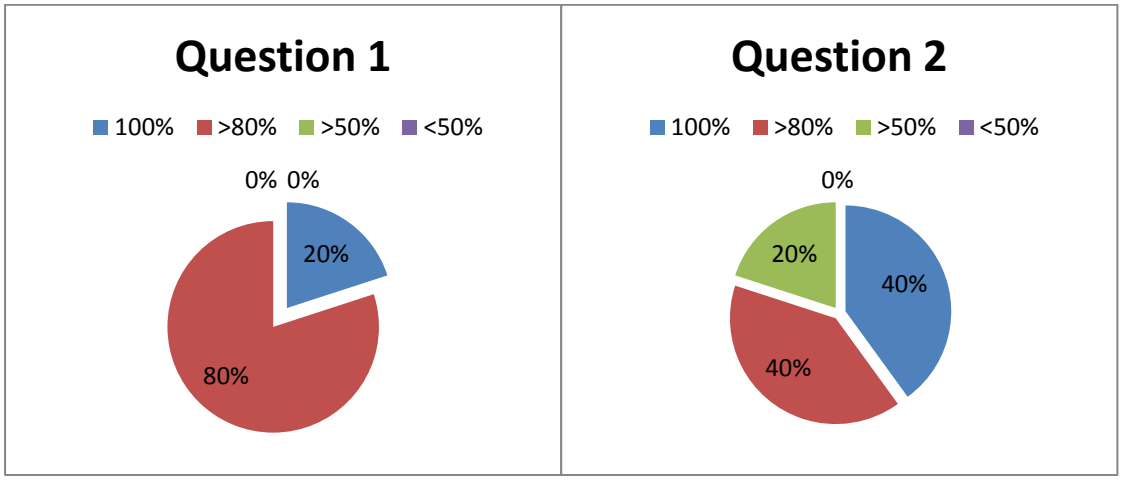
Who	What	When	How	Why
Citizen	Information timeliness and consistency regarding Prerequisites and Request data	T1	BPC web portal	Information is not updated timely enough; BPC officers do not check the portal frequently to ensure the information provided to the citizen prior arrival is consistent with the in-office

				procedure.
BPC Officer	Information accuracy and timeliness regarding Request, Common Data and Specific Data	T10, T11	IAP platform	Quality degraded as the information transferring
Rec. one	Technology (capability, ease of use, acceptance)	(1) Instead using IAP platform to transfer information, authentication to BPC for direct reissue the identity cards and documents. (2) Automatic quality detect tool to alert overdue data transferring or incorrect information from the original source.		
Rec. two	Process (standardization, workflow)	Standardize procedures on evaluating the web portals. Workflow between public entities needs to be identified to improve the information exchange.		
Rec. three	Organization (policy, goals)	Providing citizen service time and information efficiency is the goal for all the public entities. Policy made by involving the stakeholders from each entity and the citizens.		

Table 6-17. Identification of causes and recommendations

6.3.4 Evaluate the QA.IE Techniques based on BPC Case

Following the same instruments, interviews with five practitioners who held managerial positions in the organization were carried out. The results are shown in figure 6-16.



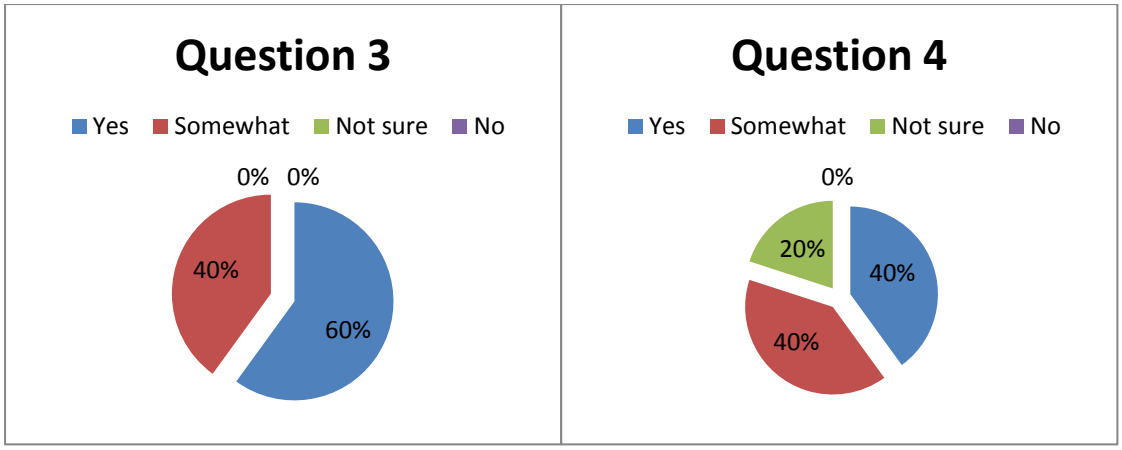


Figure 6-16. Interview results of BPC Case

Subsequently, a focus group with on-site practitioners and an evaluation framework is presented to discuss the designed QA.IE techniques. Based on the proposed evaluation framework, the results are shown in table 6-18 below.

A focus group composed of five stakeholders for discussion, and the results showed positive feedback on overall ratings. Although some of the criterion can be further utilized according to the practitioners' experience, overall the QA.IE techniques demonstrate the novel approach to connect data to the business level.

Proposal main outputs \ **Evaluation criteria**		**Demonstration of the artifact**	**Design principles**	**Interviews with practitioners**	**Moody and Shanks Factors**							
					Completeness	Integrity	Flexibility	Understandability	Correctness	Simplicity	Integration	Implementability
BPM	Construction Model (ATD)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process Model (PSD)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	◯
	State Model (OFD)	✓		✓	✓	✓	✓	◯	✓	◯	✓	✓
Information Profile	Context Information Organization	✓	✓	✓	✓	✓	◯	✓	✓	✓	✓	✓
	Context information Prioritization	✓		✓	✓	✓	◯	✓	✓	✓	✓	✓
IQ Analysis	IQ Metrics	✓		✓	✓	✓	✓	✓	✓	✓	◯	✓
	IQ Measurement	✓	✓	◯	✓	✓	◯	✓	✓	✓	✓	✓
	Improvement Identification and Recommendation	✓		✓	◯	✓	✓	✓	✓	✓	◯	?

Caption: ✓for accomplishment; ◔ or partial accomplishment; ✗ for not accomplished; ? for results in progress; <empty space> stands for not applicable.

Table 6-18. Evaluation framework completed in case three

6.5 SUMMARY

This chapter demonstrated and discussed the results of the designed QA.IE techniques in three cases. Our goal was to evaluate the extent to which the business model oriented approach behind inter or intra organizational information exchange would assure higher level of IQ. For this purpose, the designed QA.IE techniques are implemented in three different cases, and practitioners engaged evaluation framework was carried out as well. Data collection and analysis is carried out via both qualitative and quantitative analysis.

In the first case, the QA.IE techniques were carried out in an inter-organizational public case. Information exchanges were closely modeled, profiled, and measured. Results showed that the QA.IE techniques provide structured assessment of the exchanged information, relating the cause identification and solution proposal to technology, organizational and business process contextual factors. In this scenario, due to the complex of various information exchange format, cross discipline professionals, and rather unpredictable business processes because of the nature of the emergency, this QA.IE techniques showed advantages of providing an assessment approach in a systematic and structured pathway. The evaluation framework on this case implementation revealed positive feedback by the practitioners.

Similarly, in the second case, the QA.IE techniques were demonstrated in an intra-organizational case. This case is a typical area that communication and information exchange is essential but mostly practiced in a traditional way – oral communication takes up the majority of the processes. The techniques and evaluated by the practitioners are applied, the results showed good feedback because of the technology independent feature. The evaluation feedback suggested that digitalization of the information exchange processes will yield positive improvement. If technology is not available, improvement can also be enhanced from organizational and business process perspectives.

The last case implementation was carried out in a fully digitalized environment for inter-organizational information exchanges. BPC – office for citizen identification reissuing services was selected considering the e-government transformation project in Portugal in the past 5 years. QA.IE techniques evaluation framework results again suggested valuable output.

The assessment findings implied that even though digitalized information exchange was fully applied, further improvement can be enhanced by business process redesign and organizational structure enhancement.

7

CONCLUSION

This thesis presents QA.IE techniques for assessing information exchange quality in public sector. The societal driver for conducting this research is rooted in the many reports that reveal problems regarding IQ during information exchanges, particular in public sector. In particular, the public organization of EMS where information and time is critical is investigated. Problems and challenges were revealed regarding IQ and information exchange, including the disconnection of IQ assurance and business level related factors. From societal perspective, this research was required not only because stakeholders were previously left unguided in finding solutions for IQ issues across all the involved organizations.

The theoretical diver for this research stems from the lack of studies bridging the low data level to abstract business level when solving IQ problems, especially to information exchange topics. In addition, insights into the information exchange and sharing management, the quality of the information content is not addressed adequately. Theories in IQ and information sharing provide pathways for this research. This research is grounded in the literature and theoretic foundations, enabling one to bridge the gap and providing pathways to enrich the relevant work.

The QA.IE techniques is designed and evaluated with relevance and rigor. Three stages are composed – Business Process Modeling enables connection of the enterprise level contextual factors to the data level, Information Profiling facilitates structurally categorize information content, and IQ Analyzing quantifies the IQ measurement for identification of low quality causes relating to the contextual factors. Evaluation framework gathers experts in practice in research for feedback collection. Overall, a positive and promising outlook presented towards these QA.IE techniques.

7.1 Research Question 1: Establishing the Knowledge Base

In accordance with the research objective stated earlier, establishing two foundations in our knowledge base is needed. The first foundation is on defining and measuring IQ and information exchange related factors. Studies that have investigated in IQ studies mention

several examples of poor IQ and current solutions are not entirely sufficient. Information exchanges in public sector became an essential topic and increasingly gain attention. Studies have analyzed the challenges and factors associated with information sharing, yet the information itself is not addressed adequately. To connect IQ to the information exchange related factors, the first question of *what criteria are related to IQ assessment for information exchange* is formulated. In order to determine the answers sub-questions relating (1a) and (1b) contextual factors that influences information exchange, and which are the most important ones in the public domain, and (1c) IQ assessment approaches are employed currently.

By means of literature research, it is found a considerable number of publications on defining and identifying information exchange influential factors in pubic organizations, as well as the definition and measurement of IQ. Increasing attention of information exchange is shown in literature due to the expanding network and collaboration. Research on information sharing in public sector, combined with enterprise IA literature, provides this research a foundation to seek answers to sub questions (1a) and (1b). Organizational, technological, information, power, and trust are found in literature where the relevant contextual factors for intra-organizational and inter-organizational information exchange. Learning from the general information management literature, enterprise IA is selected. Enterprise IA is one of the successful approaches that connect information with other enterprise components. Information, technology, organization, business, business process are identified as the mostly mentioned contextual factors in an enterprise. These allow us initially conclude that information, organization, information, and business process are the most important contextual factors. This knowledge base gives an approach to understand information and information exchange at an enterprise level.

The construct of the quality has come a long way since first coined by Frederick Taylor [218]. Since then, the quality construct has expanded from a technical focused construct to human centered construct. With the rise of information as a ‘resource’ and IT, it was only natural that the quality of information becomes a subject of scientific interest. Consequently, there are several perspectives, frameworks and approaches of IQ. Literature is used to search answers for the third sub question selecting assessment instruments in developing QA.IE techniques. IQ is multi-dimensional and entails dozens of variables, not all of them being mutually exclusive. This IQ construct entails a mix of objective and subject scale, some of

which can be assessment only by information users. This emphasized the need to collect empirical data (on IQ issues) directly on site. It is also meant that our evaluation cycle would demand the incorporation of real mangers, as opposed to artificial. Despite numerous IQ studies in the literature, remarkably, scholars study IQ limited to the data level such as databases in individual information systems. None of these provide an approach to connect information to higher enterprise contextual factors. The proposed techniques comprise of IQ dimensions and assessment instruments, which were tested in other studies. This brought to the answer for sub research question (1c). Note that the aim was not to contribute to the definition and measurement of IQ, especially since there are already several contributions that have focused on this. Instead, it is in search of a set of techniques that allows us to connect information issues to the enterprise level.

The second foundation needed is to establish in our knowledge base was on theories that supported our claim. WST was chosen, as WST states that during the information exchange processes, other elements such as technology, participants are involved. To ensure the quality of information, the other elements should also be considered. Through an extensive literature review, it is found that coordination theory is a well-studied and applied theory information system and other domains. Acknowledging that several constructions and operationalization of coordination theory exist in the literature, the most common construction in the information system field is the management of interdependencies between actors, goal, and processes by means of various mechanism [183]. This theory did help us to understand how information can be coordinated to other enterprise interdependencies that IQ can be managed. These are the two core theory supports for our research approach and the research questions formulation.

7.2 Research Question 2: Enrich Empirical Foundation from EMS Case

A considerable part of this research project took place with practitioners on site. It is considered as necessary because of the ‘mystification’ of information and information exchange management in public organizations. While the majority of literature underlines the complexity of information sharing, the process and systems, compounded by the complicated organizational relationships, literature provides some descriptions and indications. In this sense, field study is the suitable approach. Chapter 2 presents three other reasons for choosing field studies over other data collection methods. The field studies included observation of the EMS exercises and surveying participating authorities. In addition, capitalizing on the

information and information management of the authorities by means of interviews are conducted. I designed the field studies to answer three sub-questions.

The first sub-question (2a) asked *how does public EMS agency in practice manage information between organizations and information sharing*? Answering this question required us to study various approaches currently in use. Answers are sought for by triangulating observational data, informal talks with the participants during their daily exercises and discussions with the managers. It is found that information exchange is process focused and heavily engaged with technological and organizational elements. Surprisingly, information exchange management barely existed in EMS domain. For information management focus on databases in individual information systems, method such as data cleaning and linkage match are employed.

The second sub questions (2b) and (2c) are formulated as *considering the various contextual factors involved in an emergency response, how would the enterprise contextual factors affect IQ for all level of involved organizations*? *And what are the existing requirements regarding IQ dimensions and measurement in the EMS case*? These questions are asked because the practitioners would be the best judges of the answers that derived from literature. This question was investigated by using semi-structured interviews with experienced managers and participants.

Based on the EMS field study, full engagement with the EMS daily activities are carried out. The field study findings reflected well to the literature. The current information management is mainly focused on information system check, including database cleaning, data mining, automate data extraction etc. Regarding information that is not shared in digital format, not much standard management procedures presented. Also, information management is separated from organization to organization. Integrated management approach is very limited.

Information shared vertically and horizontally within and between organizations. Various applications and systems are used to assist information exchanges, and such technological support is essential to ensure the quality of information. The technology capability and user acceptance determine the information flow format (verbal communication, paper documents, or digital texts). Organizational structure and organizational goals formed the information exchange and sharing pattern. The quality of information criteria is defined by their organizational goals. The process for the information exchange is highly reflected to their

business processes for EMS delivery, the procedures are formed according to their business processes. That said, business process effectiveness heavily affects the quality of information and information exchange.

Our field investigation classified *accuracy, completeness, consistency, timeliness, accessibility,* and *understandability are the criteria required for EMS practice and public organizations in general*. The measurement approach depends on the information format and representation.

This empirical investigation provided the design foundation of the QA.IE techniques. This public EMS case showed the current problems in information management. Contextual factors of organization, technology, and business process are essentially connected to information exchange and IQ. However, in practice this concept is not transferred to practice. The important IQ dimensions and IQ measurement approaches are also identified through this case study, with extended higher public authorities' involvement. To conclude, the reported field studies constitute a crucial part of this research by equipping us with knowledge on IQ and information management in current practice. The knowledge gained in this cycle was a prerequisite for starting the third cycle of this research that is reflected on next.

7.3 Research Question 3: Business Process Model Oriented Artifact Design

Equipped with the knowledge gained from theory and practice, the design cycle of this research is entered. The first sub question (3a) I addressed in this cycle asked *which design principles to follow to ensure the techniques meet the IQ and information exchange requirements*. It is in this phase that is aimed to synthesize design principles for assessing the quality of information exchanges. Based on our interviews with the practitioner from public sector, the insights are gained – a set of techniques are valuable by connecting information exchange involved contextual factors to the information assessment. Establish the capacity to connect the exchanged information dimensions assessment to the enterprise contextual factors is needed. As such, it is necessary to deduce detailed capabilities that would function as stepping-stones towards the induction of more generic principles. Here, capabilities refer to the quality assessment competencies of connecting information to the enterprise contextual factors – the IQ measurement items are assessed and analyzed based on the information exchange related context factors.

In the process of capability construction, structuring and dynamic adjustment is necessary. Capabilities under structuring category promote the empowerment of information managers through information pooling, information structure standardization, assessment items and process constructing. On the other hand, capabilities under the dynamic structuring category promote enterprise contextual factors awareness and IQ feedback by means of tracking information flow and the measurement results. To ensure QA.IE techniques capabilities, the set of six principles in conjunction with the IQ dimensions are presented in section 5.2.1.

To address the sub question 3b) *what is a suitable description for information flow and information organization?* Based on the literature and empirical foundation, IA concept was employed to bridge gap between information and enterprise contextual factors. Reasoning and description of enterprise IA is entailed in section 3.3. IA suggests that managing information in an enterprise level business process modeling is an efficient approach.

To assess and analyze the information based on context factor of organizational, categorizing all information content for measurement is necessary. Therefore, information profiling is chosen to address the sub question 3c) *how to connect the exchanged information to the related contextual factors*?

Lastly, to enable the IQ measurement, a pool of IQ dimension assessment metrics and methods is formulated according to literature and the characteristics of public sector information sharing. That answered the sub question 3d) *how to identify and priorities IQ requirements and measure IQ?*

Subsequently, three stages are formed for the QA.IE techniques. These are Business Process Modeling, Information Profiling, and IQ analyzing respectively with descriptions of each detailed in section 5.2.2. Lastly, the designed set of techniques is presented in a detailed model describing the processes for QA.IE techniques implementation.

This designed artifact – QA.IE techniques are very much empirically driven, and the insights are consistent with the literature and are supported by theoretical foundation. From this QA.IE techniques model (see section 5.3), information can be measured based on enterprise contextual factors, the causes of poor IQ can be traced based on enterprise contextual factors, and the improvement strategies can be proposed based on the enterprise contextual factors.

7.4 Research Question 4: Evaluation Framework Reveal Positive Feedback

"The proof of the pudding is in the eating." As DS researchers, it is believed in this adage. Accordingly, the final cycle in the DSR was the evaluation of the proposed QA.IE techniques. The question leading this phase asked *how the designed artifact meets the criteria that are pre-defined for its research purpose*. Efficient quality assessments for information exchange criteria are concluded based on the rigor and relevance cycles. As descripted in section 2.1.4, firstly, the designed artifact is applicable and can be demonstrated and applied in real cases. Secondly, the business-oriented QA.IE techniques should meet the six design principles requirement, which were defined from the empirical case and design literature – 1) allow trace and track IQ and information flow, 2) provide connections of information, 3) maintain a single connected information pool for assessment throughout all organizations/units. 4) standardize information structures and information exchange assessment across all organizations and units, 5) enable feedback checks on quality of information flow assessment to an abstraction level, and 6) minimize the number of measured items and metrics .Thirdly, interviews with practitioners provide their practical feedback on a) the importance of the research problem, b) the approach acceptance, c) the artifact achieved its purpose, and d) the artifact brings improvement. Last, derived from literature, Moody and Shanks factors are chosen to evaluate *completeness, integrity, flexibility, understandability, correctness, simplicity, integration,* and *Implementability*. Through this rigor and relevant evaluation approach, the designed QA.IE techniques are the proof of importance and applicability.

The second sub question asked was *would this designed artifact fit in related body of knowledge*? The answer is positive. While applauding the steady increase of research on information sharing for public organizations, the quality study of the shared information itself were lacking in previous research. Research in this area has been focused on political, technological, social and economic perspectives, which do not provide enough guidance for information exchange quality. This research fits in the knowledge of information sharing and exchange: quality of shared information should be assessed, combined with the emphasis of organizational, technological and business process perspectives.

This research also fits in the body knowledge of IQ studies. As reviewed, very limited research investigates the information from information exchange perspective, even if there is, the focus is often on the databases – from technical and statistic calculation viewpoint. This

research extends existing knowledge and makes important contribution to IQ studies by providing a set of techniques to investigate IQ issues in information exchanges, from a business process perspective to connect information to an enterprise level.

The last sub question engaged applicability and usefulness in practice of these proposed techniques. In this evaluation cycle, demonstration and implementation were clearly showed that the QA.IE techniques in three different public organizations, which showed the applicability. The evaluation framework resulted in positive answer to the usefulness of the designed QA.IE techniques.

7.5 EPILOGUE

In this final section, what this research actually implies and contributes to science and society are analyzed first. Secondly, the strengths and limitations of this research are reflected. Finally, the role of IT and human factor and conclude with avenues for future work is revisited.

7.5.1 Implications of QA.IE Techniques

Following a series of steps (i.e. empirical analysis, design and evaluation) and employing a combination of research instruments (i.e. observations, questionnaires and quantitative analysis) this thesis presents three major assessment stages that have proven to provide quality information and information exchange management, particularly in public organizations. QA.IE is a response to the observation that existing information exchange and IQ approach do not satisfy the quality requirement. Growth of digital business expands the need for information exchange, which also reveals the weakness of the information quality assurance. As learned from the case investigation, current approaches in public organizations do not adequately address IQ of information exchange, which has caused many problems. For example, timeliness information transferred and the solution is often focused on changing business intelligence. As suggested by Work System Theory, Coordination Theory, and Social Exchange Theory, information issues should be connected to other elements in the organization.

This research implies that a business process oriented approach for information management is essential. Business processes not only facilitate activities redesign, but more important to the scope of this research, connect and integrate information flow to other enterprise context factors, such as actors, IT applications, organizational goals, and business activities. For

successful information exchange quality assurance, the role of information managers need to be aware of the context factors to solve information related issues. On a technical level, IA architects need to consider move away from the traditional database focused approach, such relational database, to a business rule based approach. On a societal level, communication and training need to be frequent, educating the importance of IQ and information exchange and the guidance to achieve the goals.

7.5.2 Scientific and Social Contributions

This research is primarily to explore the literature of IQ and information exchange in public organizations. To bridge the gap in literature, theoretical supports for the proposed approach is also important. In line with the classification of theoretical contribution provided by Gregor [139]. Our theoretical contribution is type 5 – design and action theory. This type of theory says how to do something and gives explicit prescriptions (e.g. methods, techniques, principles of form and function) for constructing an artifact needed for achieving specified goals. In light of our theoretical contribution, three contributions can be considered in this regard.

First, regarding theories in IQ, one of the most important paper is the IS success theory proposed by Delone and Mclean [219]. Their work was important since it was the first to illuminate the importance of IQ and IS. While these authors have made a significant contribution on understanding the factors that make an IS successful within an organization, they do not address the dynamic information flow quality within cross-boundary organizations. This research, particularly the business process oriented approach, can be regarded as additional information of the IS success theory by Delone and Mclean [219].

The second contribution that needs to address is the work on organizations by March and Simon [173]. Their work was a cradle for many theories in the management and organization sciences. Nevertheless, their work only focused on coordinating interactions within a single organization and did not prescribe IQ assurance in cross boundary organizations. By extending the concepts of advance structuring and dynamic adjustment from March and Simon [173], it enables shaping and categorizing the information in information exchanges. Via QA.IE assessment techniques, this research demonstrates how there concepts can be implemented as means for IQ issues in cross-boundary organizations setting.

The third contribution, information sharing, is a concept that cannot be attributed to a single group of authors. In information system research, increasing attention on information sharing has been demonstrated due to the expanding networks. In public organizations, attention often landed on social and political factors that affect information sharing. Due to the spotlight of digital business, studies on information technology implementation became a popular topic for information sharing in public organizations. Quality of shared information, however, is still not addressed. This research extended to a degree that technological and organizational perspectives should be considered together with information exchange processes to ensure the quality of information sharing.

For societal contributions, the question of who is waiting for this thesis should be asked, and what does it do for the practitioners?

In this research, it is expected that the information managers would benefit from the QA.IE techniques to assess and improve the information exchange quality. These techniques serve the IS/IT managers in information management as a useful guide to understand the information exchange activities and improvement efforts. This study is a reminder of the importance of IQ and helpful in obtaining a better understanding of IQ from business processes and enterprise contextual factors. General managers could also use our observation protocol and survey to expand their evaluation instruments beyond individuals and team performance measurement.

Information architects can also benefit from the QA.IE techniques from technical design point of view. Firstly, stage of Information Profiling can be adapted for information modeling and structuring. In that sense, more environment contextual factors awareness can be added to information modeling. Secondly, the IS architecture designers could, for instance, employ and adapt the design principles provided in this thesis in their current practices and systematically reflect on their practices using the IQ dimensions.

Another audience can be the software vendors and IT consultants. Throughout field studies and interviews, an increasing number of software vendors and IT consultancy firms are trying to establish a market in public organizations is noted. In many cases, software products developed for different business domains are advertised, to date success is limited due to the unique organizational and political complications in public domains. Accordingly, software

vendors and IT consultancy firms could employ the empirical foundation of this thesis for a better understanding of information management.

7.5.3 Reflection on Our Research Strategy

The methodological approach chosen in this research project is DSR methodology. The benefits of this research approach are apparent; in the meantime some suggestions for DS researchers for further development of this methodology can be also provided.

DSR approach has come a long way since first coined by Herber Simon in "Sciences of the Artifact" in 1969 [44]. Simon discussed DS in the contexts of economics, psychology of cognition, and planning and engineering design. It took some time before Simon's ideas filtered through to ISs community. It was Hevner et al 's approach [46] that brought DCR to the ISs community, but it is still a relatively young discipline. While some proponents of this approach consider it a complete paradigm when it comes to conducting research, this research strategy can be more mature through two aspects: 1) ironing out the relationships between theoretical knowledge and empirical findings and 2) more specific methods and processes guidance for conducting this research methodology.

Since DSR emphasizes the need for constructing solutions to complex socio-technical problems, it can be argued that this approach allows scholars to make a more equally balanced contribution to science and society. However, balancing rigor and relevance is one of the tensions inherent in DSR. Sometimes this gives a false dichotomy and the two are not mutually exclusive. It is important in a thesis to carry out rigorous systematic research underpinned by appropriate theories. That does not mean the proportion has to be weighed equally. That was the issue when this project started, a similar relationship to match each theory and literature was tried to reach the suggested balance. In retrospect, it is realized empirical findings can also be less or unequal to the theoretical findings.

Because DS allows researchers to collect both qualitative and quantitative data using a combination of research instruments, another issue was uncovered. It is difficult to determine how to select the methods to fit the DCR and which specific process to follow. For example, a profile of methods/techniques/instruments for the design and evaluation cycles would have been very useful to guide the research conducting.

7.5.4 Future Work

This research developed a set of business process oriented quality assessment techniques for information exchanges. To date, the techniques are on a conceptual level that can be presented as models. Although positive and promising feedback received, there are limitations and further work is necessary in order to address the limitations.

Three limitations are highlighted in this section. The first limitation is rooted in our field study approach for the artifact design. Data collected from one single public sector – EMS case is draw heavily. While it is a complicated and typical information critical case that can be a representative for public sector, the different factors and characteristic of other public organizations cannot be ruled out. The fact that an artifact is in-depth developed based on a specific case may not be suitable for other cases in this public domain. While the other two case demonstration and implementation provided us the evidence of the artifact applicability, our sample cases are representative for all of the existing public organizations cannot be concluded. Moreover, the case selection might also be biased due to the researchers' desires.

The second limitation is that the research output is presented on the conceptual model level. The feedback from practitioners reveals the difficulty in understanding and using the techniques. This is rooted in the high requirements for applying the techniques – the users need to have a broad knowledge background such business process modeling, IQ metrics etc. The practitioner suggested that the techniques can be used more directly in a simpler form.

The third limitation revealed on our evaluation for the techniques generalization. Due to time and resource limit only three case applications are carried out. In order to generalize the feasibility and applicability in the entire domain (public organizations), more cases in a broader discipline are necessary. However the three stages of the presented techniques are designed in a broad and flexible format, which should be able to be adapted to other specific cases.

The future work will address the limitations mentioned above. Accordingly, three areas should be focused in further developing the proposed QA.IE techniques. First set of work is revisiting the design scenarios which can be beneficial for added value. Gathering practitioners from various fields in public sector in format of workshops to discuss the information and information exchange related problems and challenges. Investigation on enterprise contexts and IQ measurement approach that affect information exchange in their

current practice. These data analysis and findings can be added to revise the QA.IE techniques for precise.

Second set of work is to explore software that is "enterprise contexts aware" in IQ an information exchange. A software tool that highlights various contextual factors in the enterprise/organizations with specific functions is a significant development that offers potential for IQ assessment. The conceptual level design demonstrates IQ in information exchange setting allows effective assessment and improvement strategies with the enterprise contexts awareness. The development of application tools will make it simpler for implementation in practice. Figure 7.1 illustrates a possible configuration for an enterprise context aware application for cross-boundary information exchange in public organizations. The data can be taken from the existing data sources, including databases, mainframes, files, and spreadsheets. A data engine can be developed to process data, which works with any IQ applications, and which uses custom-built business rules developed according to prebuilt templates. Measurement metrics and cause tracking items are stored as data model for retrievals. Lastly, reports can be generated and pushed out using business intelligence or reporting tool for the information managers.

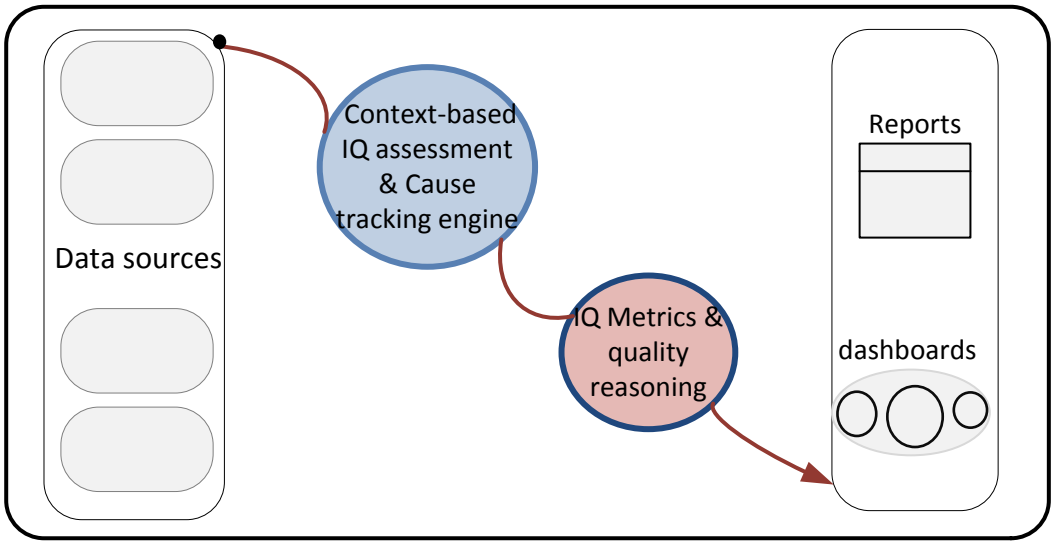


Figure 7-1. Work wechanism for context aware IQ assessment application

For a more detailed assessment process for the information managers, Wizard can be deployed for the application development. This facilitates guidance of the user in a step by step process to complete the assessment. Several interfaces will be designed and prebuilt in the application.

(1) Contextual factors: the information manager has choices of which context to investigate the IQ, choosing from the prebuilt factors to get further assessment on the data. For example, if the manager is interested in checking quality level under the technology context, he/she would chose "Technology" tab, and further information of the formats such as written, digital, verbal will pop up for choice.

(2) Information: on choices of the context, data file form the organization can be accessed or uploaded for IQ assessment. IQ metrics and methods are stored in the databases. Execution is activated to measure the quality of the data.

(3) Cause identification: based on the results report, the manager is able to click cause tracking. Prebuilt reasoning items on basis of contextual factors are stored, upon predefined reasoning items; the manager is able to retrieve the possible causes for low quality.

The more refined model is described in figure 7-2.

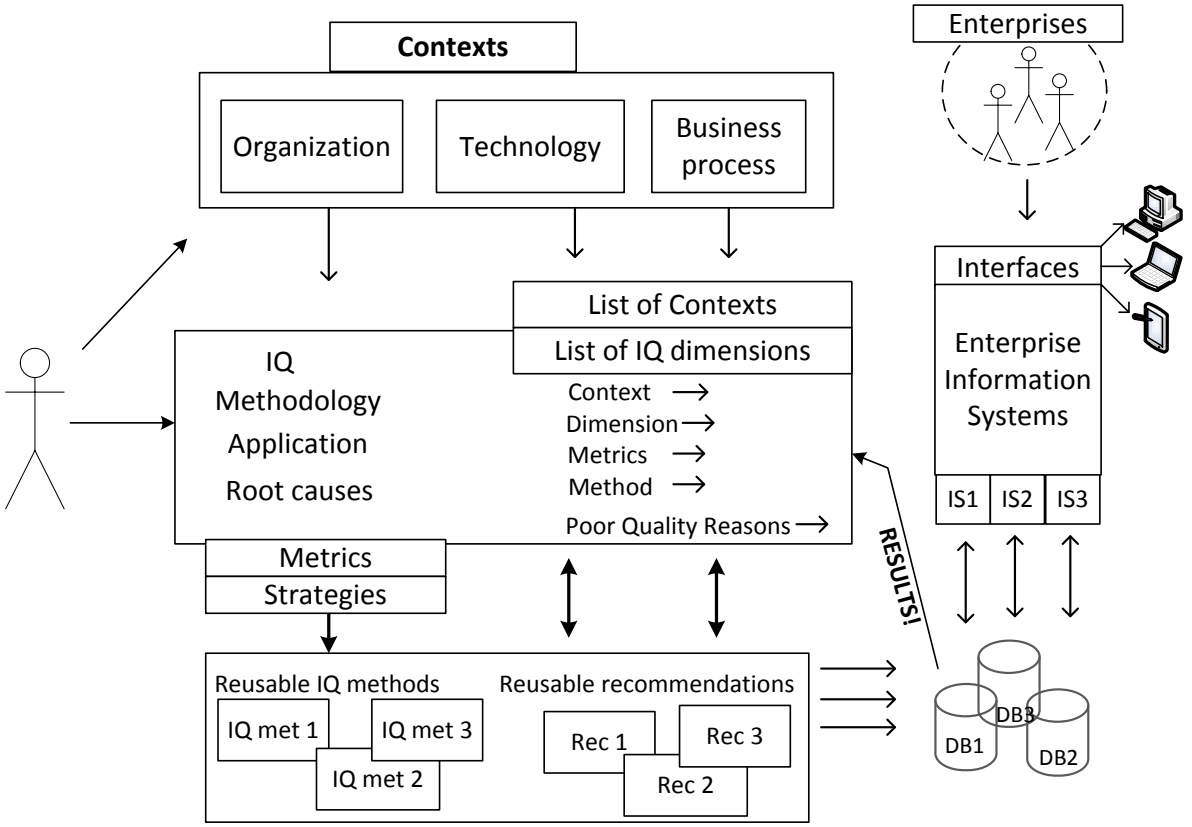


Figure 7-2. Description of potential enterprise context aware application

This software development is based on the current designed conceptual models, which addresses the limitation of ease of use for the end users.

The third set of future work is to expand the case implementation for evaluation and validation purpose. Investigations of the typical cases that represent the public organizations, including both inter-organizational or intra organizational services were conducted. The redesigned QA.IE techniques as a prototypical software can be further evaluated through case execution and test run.

In summary, the future work would address the limitations in current work, as well as the extension of this project – from conceptual level to physical level. All in all, this research approach is to prove that IQ in information exchange issues requires the enterprise and business level awareness. Commentary to current database level approach revealed both in literature and in practice, the research brings value to the existing knowledge.

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APPENDICES

Appendix– A: List of Abbreviations

ATD	Actor Transaction Diagram
BPC	Balcao Perdi a Carteira
BPM	Business Process Model
CAD	Computer Aided Dispatch
CC	Citizen Card
CLI	Caller Line Identification
DEMO	Design and Engineering Methodology for Organizations
DL	Driving License
DS	Design Science
DSR	Design Science Research
EA	Enterprise Architecture
ED	Emergency Department
EMS	Emergency Medical Service
EMT	Emergency Medical Technician
EO	Enterprise Ontology
HIQA	Health Information Quality Authority
IA	Information Architecture
IAP	Interoperability for Public Administration
ICT	Information and Communication Technology
INCI	Institute of Construction and Real Estate
IQ	Information Quality
IS	Information System
IT	Information Technology
OFD	Object Fact Diagram
OR	Operation Room
PBD	Principle Based Design
PCR	Patient Care Record
PHECC	Pre-hospital Emergency Care Council
PHR	Patient Health Record
PSD	Process Structure Diagram
QA.IE	Quality Assessment for Information Exchange
RQ	Research Question
SD	Standard Deviation
SVD	Single Vehicle Document
TCIS	Time Critical Information Service
TIN	Tax Identification Number
TOGAF	The Open Group Architecture Framework
WST	Work System Theory

Appendix – B: Evaluation Interview Question

Interviewee profile			
ID	Respondent	Organization	Background/expertise

Question 1:
To what degree do you think the research problem is important for investigation?
a) 100% b)>80% c) >50% d) <50%

Question 2:
To what degree do you agree to our proposed approach?
a) 100% b)>80% c) >50% d) <50%

Question 3:
Do you think the QA.IE techniques allow you find the causes of poor information exchange quality?
a) Yes b) Somewhat c) Maybe d) No

Question 4:
Do you think QA.IE techniques facilitate effective information exchange?
a) Yes b) Somewhat c) Maybe d) No

Appendix – C: Summarized IQ Dimensions and Descriptions

Dimension	Description
Access Security	Access to data must be restricted, and hence, kept secure.
Accessibility	Data must be available or easily and quickly retrievable.
Accuracy	Data must be correct, reliable, and certified free of error.
Appropriate Amount of Data	The quantity or volume of available data must be appropriate.
Believability	Data must be accepted or regarded as true, real, and credible.
Completeness	Data must be of sufficient breadth, depth, and scope for the task at hand.
Concise Representation	Data must be compactly represented without being overwhelming.
Ease of Understanding	Data must be clear, without ambiguity, and easily understood
Interpretability	Data must be in appropriate language. Units and definitions must be clear
Objectivity	Data must be unbiased (unprejudiced) and impartial
Relevancy	Data must be applicable and helpful for the task at hand
Representational Consistency	Data must be presented in the same format as previous data
Reputation	Data must be trusted and highly regarded by source and content
Timeliness	The age of the data must be appropriate for the task at hand.
Value-Added	Data must be useful and provide advantages from their use.

Appendix - D: Popular Methodologies for IQ Management

Dimensions	Name	Metrics Definition
Accuracy	Acc1	Syntactic accuracy: it is measured as the distance between the value stored in the database and the correct one Syntactic Accuracy=Number of correct values/number of total values
	Acc2	Number of delivered accurate tuples
	Acc3	User Survey - Questionnaire
Completeness	Compl1	Completeness = Number of not null values/total number of values
	Compl2	Completeness = Number of tuples delivered/Expected number
	Compl3	Completeness of Web data = $(T_{max} - T_{current})^*$ ($Completeness_{Max}$ - $Completeness_{Current}$)/2
	Compl4	User Survey - Questionnaire
Consistency	Cons1	Consistency = Number of consistent values/number of total values
	Cons2	Number of tuples violating constraints, number of coding differences
	Cons3	Number of pages with style guide deviation
	Cons4	User Survey - Questionnaire
Timeliness	Time1	Timeliness = $(\max(0; 1\text{-Currency/Volatility}))^s$
	Time2	Percentage of process executions able to be performed within the required time frame
	Time3	User Survey - Questionnaire
Currency	Curr1	Currency = Time in which data are stored in the system - time in which data are updated in the real world
	Curr2	Time of last update
	Curr3	Currency = Request time- last update
	Curr4	Currency = Age + (Delivery time- Input time)
	Curr5	User Survey - Questionnaire
Volatility	Vol1	Time length for which data remain valid
Uniqueness	Uni1	Number of duplicates
Appropriate amount of data	Appr1	Appropriate Amount of data = Min ((Number of data units provided/Number of data units needed); (Number of data units needed/Number of data units provided))
	Appr2	User Survey - Questionnaire
Accessibility	Access1	Accessibility = max (0; 1-(Delivery time - Request time)/(Deadline time - Request time))
	Access2	Number of broken links - Number of broken anchors
	Access3	User Survey - Questionnaire
Credibility	Cred1	Number of tuples with default values
	Cred2	User Survey - Questionnaire
Interpretability	Inter1	Number of tuples with interpretable data, documentation for key values
	Inter2	User Survey - Questionnaire
Usability	Usa1	User Survey - Questionnaire
Derivation Integrity	Integr1	Percentage of correct calculations of derived data according to the derivation formula or calculation definition
Conciseness	Conc1	Number of deep (highly hierarchic) pages
	Conc2	User Survey - Questionnaire
Maintainability	Main1	Number of pages with missing meta-information
Applicability	App1	Number of orphaned pages
	App2	User Survey - Questionnaire
Convenience	Conv1	Difficult navigation paths: number of lost/interrupted navigation trails
Speed	Speed1	Server and network response time
Comprehensiveness	Comp1	User Survey - Questionnaire
Clarity	Clar1	User Survey - Questionnaire
Traceability	Trac1	Number of pages without author or source
Security	Sec1	Number of weak log-ins
	Sec2	User Survey - Questionnaire
Correctness	Corr1	User Survey - Questionnaire
Objectivity	Obj1	User Survey - Questionnaire
Relevancy	Rel1	User Survey - Questionnaire
Reputation	Rep1	User Survey - Questionnaire
Ease of operation	Ease1	User Survey - Questionnaire
Interactivity	Interact1	Number of forms - Number of personalizable pages

Appendix -E: Survey on IQ and Information Exchange (IE)

Survey on Information Quality (IQ) and Information Exchange (IE)
Contact: Shuyan Xie, shuyanxie@computing.dcu.ie

All feedback and information will be treated as confidential

Section I: Respondent Information
Background: _____
Expertise: _____
Years of experience in public sector:_____

Section II: Circle the sub elements that affect information exchange
Organizational: (a) goals, (b) culture, (c) policy and rules
Technological: (a) capability (b) acceptance (c) ease of use
Business process: (a) workflow (b) process standardization (c) BP management

Section III: How much are the context factors connected to IE quality in your practice?

(a)Organizational goals are considered when measuring IE quality?
1 2 3 4 5 6 7
(b) Technology capability is included in IE quality assessment?
1 2 3 4 5 6 7
(c) Workflow is considered for IE quality improvement?
1 2 3 4 5 6 7
(d) Organizational culture is included for IE improvement?
1 2 3 4 5 6 7
(e) Ease of technology use made IE more efficient?
1 2 3 4 5 6 7
(f) Process standardization took place in IE and communication management?
1 2 3 4 5 6 7
(g) Organizational policies and rules are used to ensure IE quality?
1 2 3 4 5 6 7
(h) Technology acceptance is considered to improve IE?
1 2 3 4 5 6 7
(i) Business process management strategies include IE quality?
1 2 3 4 5 6 7

Section IIII: survey on IQ satisfaction.

	Totally Agree						Totally Disagree
(a) Exchanged information is up-to-date <Time. 1>	1	2	3	4	5	6	7
(b) Information received is correct <Corr. 1>	1	2	3	4	5	6	7
(c) All needed information is exchanged <Comp. 1 >	1	2	3	4	5	6	7
(d) Information is accessible when needed <Acce.1>	1	2	3	4	5	6	7
(e) Same information presented in different location<Consis.1>	1	2	3	4	5	6	7
(f) Exchanged information is easy to understand<Under. 1>	1	2	3	4	5	6	7
(a) IE in a timely manner <Time. 2>	1	2	3	4	5	6	7
(b) Information does not contains error <Corr. 2>	1	2	3	4	5	6	7
(c) Information content is complete <Comp. 2>	1	2	3	4	5	6	7

(d) easy to obtain the information <Acce.2>	1	2	3	4	5	6	7
(e) Consistent presentation in IE content <Consis.2>	1	2	3	4	5	6	7
(f) contains no difficulty in understanding <Under. 2>	1	2	3	4	5	6	7
(a) Information communicated within required time <Time. 3>	1	2	3	4	5	6	7
(b) Information is interpreted correctly <Corr. 3>	1	2	3	4	5	6	7
(c) Complete information is received, sent, and stored <Comp. 3>	1	2	3	4	5	6	7
(d) Accessible resource for information retrieval <Acce.3>	1	2	3	4	5	6	7
(e) Consistent standards and procedures for IE <Consis.3>	1	2	3	4	5	6	7
(f) Information is understandable via any media<Under. 3>	1	2	3	4	5	6	7

Appendix – F: Field Study Protocol

Name of the observer:

Case location:

Observed team:

Number of participants observed:

General	**Description**
Information management roles, tasks and responsibilities	(describe the roles, tasks and responsibilities regarding information management)
Information exchange structure	(describe the authorities and information exchange within and between organizations and departments process)
Information needs	(describe the information types and attributes that are exchanged between actors)
Information flows	(describe which roles and organizations exchange information the direction of information flows)
Information technology	(describe the software applications, functionalities, systems, hardware devices etc.)
Information ownership	(describe the information objects the different organization and teams possess)
Information Quality	**Description**
Accuracy	(count and note the times of wrong info is passed onto, i.e. wrong location or number)
Completeness	(count and note the times of missing info was entered and transferred)
Timeliness	(count the numbers of delayed info entering, i.e. later than the predefined and requested time for registration)
Consistency	(count the numbers of different info about the same event)
Accessibility	(count the numbers when actors have difficulty to retrieve needed info)
Understandability	(count the numbers of ambiguous or unreadable or unclear info passed from one party to another)

Appendix –G Interview Structure

Background of interviewee:

- Profession, tasks, workplace
- Connection to public services (experiences, views)?
- Which activities do you do at work?

Questions regarding information exchange and information quality:

- How the service is arranged (process for service delivery)? Are there several systems in operation? What applications/devices/systems are used to complete service?
- Role in information transfer processes: what kind of information do you get, from whom, where do you transfer information, what do you transfer, what is missing, what would you need additionally/less from information systems/other co-workers?
- What type of information do you think is important to complete the process? If have to prioritize the information type, which are the prioritized ones?
- With whom do you collaborate? Are they municipal employees/others?
- What format of communication do you use? Technical appliance or applications or other traditional communication methods? What kinds of problems do you possibly cause?
- Take an example of an information flow and discuss the quality of information in it
- How would you assess information flows between service providers?
- Do you mind take a short survey to rate the importance of the IQ dimensions based on your experience?
- Do you measure IQ? If you do, how?