AN ARCHITECTURAL APPROACH TO ANALYZE INFORMATION QUALITY FOR INTER-ORGANIZATIONAL SERVICE

Shuyan Xie
School of Computing, Dublin City University,Glasnevin, Dublin 9, Dublin, Ireland

Markus Helfert
School of Computing, Dublin City University,Glasnevin, Dublin 9, Dublin, Ireland

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Abstract: In inter-organizational service (IOS) system, the quality of information exchanged and shared by involved organizations is important. Although information quality (IQ) has been emphasized for decades, IQ problems still widely exist. For a significant class of information related to semantic issues, it is necessary to improve information quality not just by working on the information/data itself. However, this is not commonly understood and often leaves little doubt about the effectiveness of the current approach. We consequently propose an architectural approach to enhance IQ for IOS: enterprise-level information architecture allows a rich contextual environment to guarantee IQ, and provides a traceable path to measure IQ across organizations. It is demonstrated in an emergency medical service enterprise.

1 INTRODUCTION

In the class of applications that heavily depends on information quality (IQ), a typical approach to solve the IQ problem usually starts and ends with the activities scoped to the physical data storage level (Wang et al., 1995). But most of the efforts have only been successful to a certain degree (Drake et al., 2004). Given that in business applications information exists within the context of business processes, the attempts to solve IQ problems at the purely physical information level are not effective (Drake et al., 2004). The physical level does not capture the requisite semantics to accurately communicate information across processes. As a result, most of the semantic information issues exist at the exchange processes and organizational boundaries. For inter-organizational service (IOS)—we see it embedded in one enterprise—the top (enterprise) level is the focal point with the highest probability for data discrepancy (Eden and Kazman, 2003). Enterprise level information models are practically absent in current organizations, and therefore lacks of effective communication for the information across enterprise wide, organization or service boundaries.

This paper proposes to extend the information centric approach and focuses on creating an enterprise architectural view to analyze information. The reminder of the paper is structured as follows: Section 2 outlines the research methodology. Background is discussed in section 3. Section 4 presents our information architecture model, which is embedded in an Emergency medical service (EMS) case. We conclude our paper in section 5 by summarizing the main contributions together with some remarks for further research.

2 RESEARCH METHODOLOGY

This research is mainly concerned with theory building and thus it can be classified as being interpretive in nature. Interpretative research does not predefine dependent and independent variables, but focuses on the full complexity of human sense making as the situation emerges (Anderson et al., 2005). The architectural approach for IQ analysis

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presented in this paper has been illustrated by reviewing existing relevant literature in the domain of data, information quality, architecture, enterprise architecture (EA) and IA. The theoretical proposal presented in this paper consists of concepts and their relationships, as identified from literature, which have been further demonstrated in real case study. Thus, this research can be described as being interpretive and grounded in literature.

3 BACKGROUND

3.1 Information Quality

Information is difficult to manage from business standpoint. More specifically, it is not the information itself that is difficult, the problems lie with the people and processes using that information. So, in order to improve IQ under sharing environment across organizations, we must focus from dynamic perspective: the process of distributing information. Common definition of IQ is “fitness for use”. Information are high quality if they are fit for their intended uses in operations, decision making, and planning (Wang, 1998). In this sense, when information shared and exchanged among the parties are deemed of high quality if free of defects and process desired features. It point to the notion that IQ needs to be measurable and being measured appropriately while they are shared by multiple organizations.

Data is produced by measurements or observation (Drake et al., 2004), which brings to an important concept—a notion of data context or metadata—that is critical to the success of IQ improvement efforts. One of the causes for poor IQ problems is the lack of sufficient information context. To solve the poor IQ problem, information context should be defined and well understood (Drake et al., 2004, Eden and Kazman, 2003).

3.2 Architecture Approach

The word architecture is used whenever a high-level overview of interrelated components wanted to be defined, and when the relationships among them are complex and difficult to understand. Architecture is generally can be captured as a set of abstractions about the system that provides enough essential information to form base for communication, analysis, and decision making. (Foegen and Battenfeld, 2001, IEEE, 2000, Kazman et al., 1996, Kruchten et al., 2006, Rechtin, 1992). This points to the notion that architecture allows better understanding on the components and their relationships. In-depth discussion of various architectures is out of scope for this paper. We focus on EA to analyze enterprise-level IA.

Various EA frameworks define several views that focus on specific aspects such as business, technology, information, and so on, to reduce the complexity. IA has been indicated as one important component for EA (IEEE, 2000, Laudon and Laudon, 2002). 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. In doing so, all other EA components must be included. These relationships characterize how and by whom data is used and where it flows. The IA is used for understanding the information needed and used by people in performing tasks and business processes. Information is created by processes and tasks and is shared with other processes and tasks (Rood, 1994).

Figure 1 presents an understanding on the trend and focus of IA based on the timeline. IA is originated with static structure for information management. Researchers initially identify and employ the need for flexible IA in considering of the dynamic information environment. With the increasing dynamic requirements, researchers begin to focus on IA framework to demands under different situations (Campbell and Hummel, 1998, Duncan and Holliday, 2008, Ray et al., 2003, Riva and Rodriguez, 2002). From the time trend, it shows increasing attention on dynamic aspects in terms of the changeable and situational environment, as for example the structure or design of the environment with the data collection, data exchange. As dynamic concept is developing, such concept is applied back to and strengthened the context of static IA (Sherman, 2002).

Definition of architecture has been discussed by the researchers and practitioners, but there are no single defined concept is accepted. In general, there are two basic approaches that can be noticed regarding these definitions, one sees architecture as a descriptive concept (show as close circle in Figure 1) that factually describes the characteristics of existing artifacts, whereas the other sees architecture as prescriptive concept (show as open circle in Figure 1) that defines how artifact should be realized. It indicates that the former approach allows information elements exchanged and shared to be described and mapped for IQ assessment and measurement; the later approach indicates that from design point of view, enterprise-level IA allows a contextual environment to design to guard the IQ.

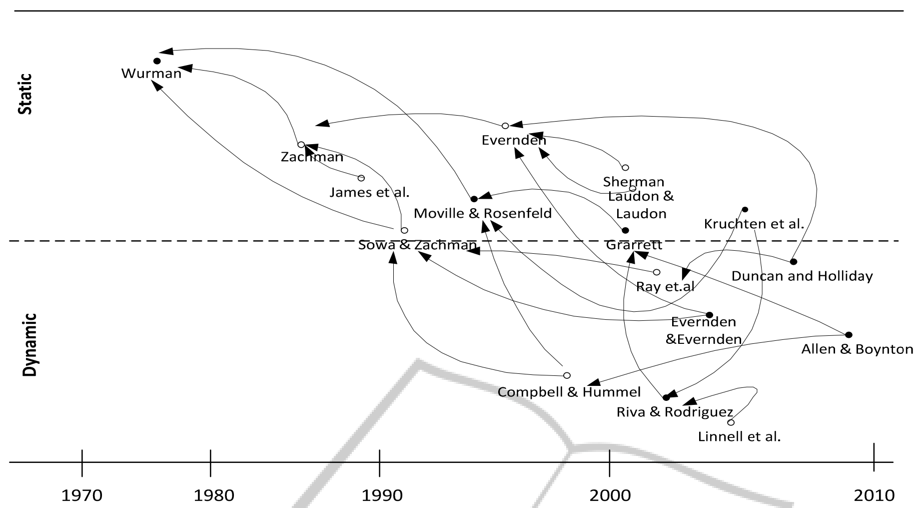

Figure 1: Information Architecture Research.

From the discussion and analysis, we describe that enterprise-level IA as a set of different information elements so connected or related as to perform a unique function, which is not performable by the elements alone. All indicate that the enterprise-level IA contains data definitions of the enterprise constituencies as well as the relationships among these constituencies. This again point to the notion that architecture provides a consistent contextual environment. We define that IA represents/defines the structure of information, including static aspects as a mapping showing the information elements, the interfaces and relationships between the various information elements (IEs), and dynamic aspect that the relationship of how the information shared and used across organizations. Thus, it allows a path for better IQ measurement by tracing the process.

4 ARCHITECTURAL ANALYSIS FOR IQ

4.1 Architecture as Metadata Source

Architecture can be seen as metadata source. A rich contextual environment (metadata) needs to exist, and a comprehensive set of models is needed to produce these models. The EA modeling efforts can produce these models (Fuller and Morgan, 2006). Time-critical services such as EMS introduce complexities to multi-organizational information sharing, including the need for timely information in a form that can be trusted and used by emergency responders (Dawes and Prefontaine, 2003, Horan and Schooley, 2007). IQ problems exists in EMS (Fisher and Kingma, 2001), however they often find it difficult to assess their current IQ. As mentioned previously, a notion of information context is absolutely critical to the success of any IQ improvement effort. This notion is at the crux of the poor information quality problem—insufficient information context (metadata).

A comprehensive set of models is necessary to produce this desired metadata. To work with such architectural complexity, some decomposition method s needed. One such method is the layered model. The information layer is where elements concerning information and data are captured and managed. We introduce the layered model and give an overview of the main constructs available for modeling IA. A possible layering can constitute a conceptual layer at the top, the logical layer in the middle, and the physical layer on the bottom (Bruel et al., 2002). This model assumes an information-centered approach. Adapted from National Intelligent Transportation System (ITS) Architecture "provides a common structure for the design of intelligent transportation systems" and prescribes a general model that supports the development of many different designs (2003). A simplified three-layered model is shown in figure 2. As with the other layers of the core meta model, it is split into the following views:

Conceptual—where defines the 'what'. Information terms this means 'what' information concepts are required within each domain.

Logical— where defines the 'how'. In information terms this is the next level of abstraction down, where defines 'how' the information concept are used. In this layer, it presents a functional view

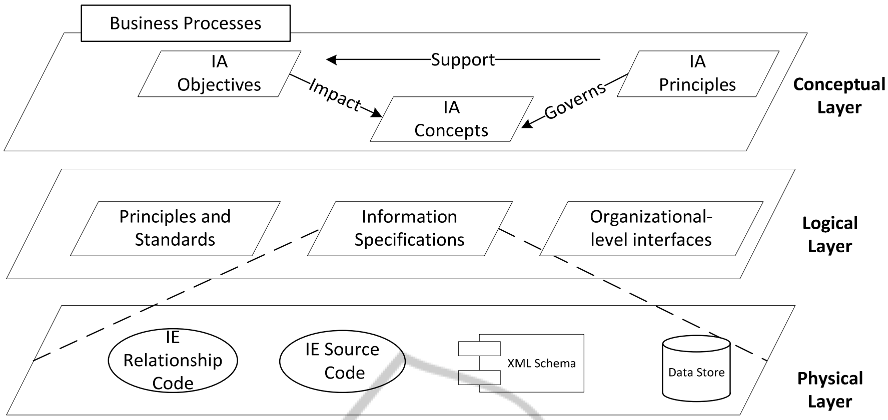

Figure 2: Enterprise-level Information Architecture Three-layered Model.

that consists of specifications that are used to perform user services. In this view, the functions are represented in a set of data flow diagrams.

Physical – The physical information view captures a particular view of information managed. It is a physical representation of important interfaces and components, and it divides the logical architecture functions into a number of high level classes.

The model shows that enterprise information models lie in both the conceptual and in the logical layers, and provide the foundation for consistent interaction between these layers.

Reflection to the National ITS Architecture (2003), this IA framework is developed along two dimensions: horizontal and vertical. Traceability along both dimensions is necessary for the vertical (between conceptual, logical, and physical) and horizontally within each layer but across the organizational boundaries. It is important to emphasize the business process is needed to be involved as the foundation for this IA model.

In the proposed three layered view of the IA, the conceptual layer includes the highest possible level of abstraction and therefore it captures the foundational components and their relationships. Thus, the top layer model is very stable and is not subject to change unless the most essential underlying structures change. The information elements that are defined at this level are cross referenced among the layers. Every element has at least one conceptual definition that references it. The reverse is also true: there is no information element presented that does not exist in the conceptual layer.

In the EMS case, where EMS is seen as a single enterprise that consists of multiple organizations, each individual organization will need to have its own three-layered organization-level IA model, where top-level organizational information concepts and the corresponding information elements will be mapped unambiguously to the enterprise-level model concepts. In this sense, only the elements that have their counterparts at the enterprise level can be possibly mapped. By relating each organizational level definition to the common enterprise level equivalents, we are eliminating semantic mismatch between different organizations. Since the information elements are cross-referenced with the process specification, there is enough contextual information to correlate information elements at the enterprise and individual organizational levels.

The logical layer of this enterprise focused IA model emphasizes information-related considerations and defines specifications for enterprise-level information. There are data/information that needs to be constructed to support the business processes defined at the top layer of the model. By defining information requirements in terms of the business processes, another major cause of low data quality is eliminated: the disconnect between the business and information view (Mukhopadhyay et al., 1995). Under EMS case which is also known as a multi-organizational enterprise, it is quite common for more than one system to be operating on information elements from objects defined at the top conceptual layer. Under this model, each system specification will define its own unique information attribute, but all these attributes are in turn mapped to the one element at the top layer. This top-down decomposition helps to alleviate a problem that is similar to “departmental information silo” (McGuffog, 1997).

Such proposed model for IA is necessary for IQ analysis and improvement, especially for a complex socio-technical enterprise like EMS enterprise that involves a strong dynamic aspect of the information elements.

4.2 Architecture Provides Dynamic IQ Measurement

In our description of information architecture, IA indicates: (1) Information elements (IEs), (2) Structure of IEs in an enterprise, (3) Information relationship/flow/exchange among all the involved organizations. We envision the structural architecture from static and dynamic aspects for EMS case. As showed in Figure 3, IEs (incident information, patient information etc.) can be presented as one way sequence, end-to-end sequence, or two-way sequence while shared across Organizations (components). By mapping the structure in a static view and the information flow process, it enables the dynamic consideration to monitor information/data that is generally isolated within each of the individual organizational environment. It allows to detect the information quality gap (accuracy, relevance, completeness etc.). Figure 3 shows a high-level overview information transmitted across organizations in emergency case. As knowing the static information structure and the dynamic information flow, we can systematically analyze and measure the IEs in each process. The way how information evolves and is connected provides a path to trace complex information relationship. We can trace the changes within and across the data stores—Computer Aided Dispatch (CAD), Patient care records (PCR), and Hospital Information system (HIS)—that allows us to measure the data quality from end-to-end, following the concept of information manufacturing systems that produces information products of which quality can be measured (Pham Thi and Helfert, 2007).

5 CONCLUSIONS

The main contribution of this paper is proposing an approach to describing enterprise-level IA and using these descriptions to indicate that IQ can be improved if architectural concept is enhanced. Enterprise-level IA can be rich metadata source to guard IQ as the information definition is traceable across organizations vertically and horizontally; Descriptive IA mapping allows IQ assessing and measuring both statically and dynamically. A robust traceability mechanism is necessary for high-quality information. The architectural models provide a foundation for the information traceability and thus quality information. We demonstrate it within the EMS case. This paper further confirmed the project idea of that information focused architecture provides a tool for information assessing and measuring, and therefore improve the quality.

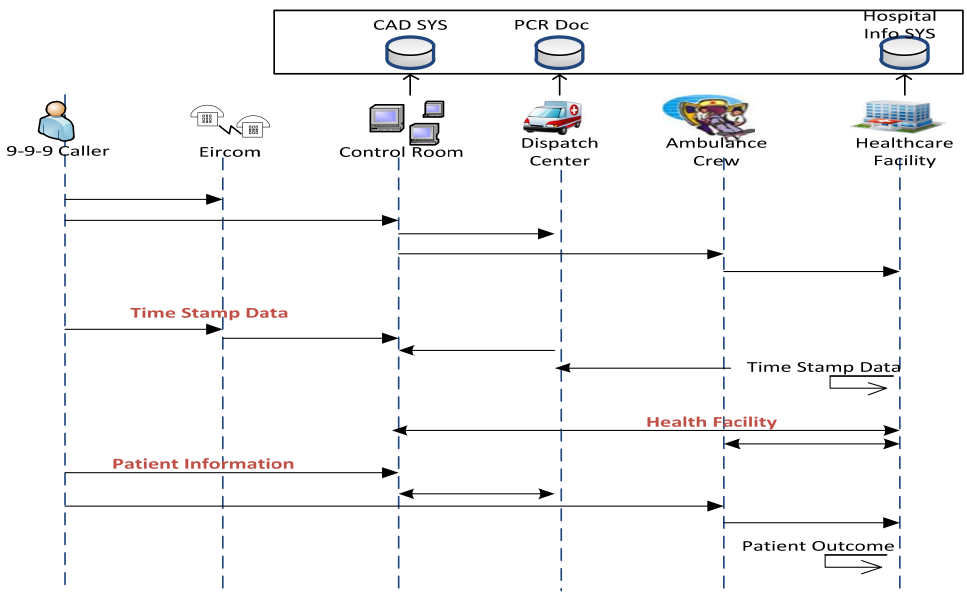

Figure 3: Information Flow across Organizations.

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