Knowl Inf Syst (2011) 27:115–140
DOI 10.1007/s10115-010-0292-1

REGULAR PAPER

Architecturing large integrated complex information systems: an application to healthcare

Daniel Pascot · Faouzi Bouslama · Sehl Mellouli

Received: 5 February 2009 / Revised: 5 December 2009 / Accepted: 16 January 2010 /
Published online: 19 March 2010

Abstract The global enterprise-wide approaches help organizations to model and understand the enterprise key components and their relationships and manage the organizations' transformations and change. However, many of these approaches lack of insights into how to manage complexities related to the multitude of applications developed in silos such as the various systems in health organizations that were designed independently from each other. This paper contributes to the solutions addressing this issue by proposing a methodology and tools to create foundations based on key components to help develop the information architecture at the heart of the enterprise architecture that can guarantee the evolution of the organization. These core components are a set of reusable Field Actions representing the non-contextual persistent information, a common canonical Corporate Conceptual Data Model capturing all the vital data in the organization, and Views or sub-schema of this global data model that represent information for different stakeholders in the organization. To show the effectiveness of the proposed approach and to gain more insights into its practical value, the architecturing approach is applied in the healthcare domain to create the information architecture and the enterprise architecture for the Quebec healthcare network.

Keywords Entreprise architecture · Information architecture · Field actions · CCDM · Views · Business processes · Two track model · Health informatics

D. Pascot · F. Bouslama · S. Mellouli (✉)
Management Information Systems Department (SIO) Faculty of Business Administration (FSA),
Laval University, Pavillon Palasis-Prince, 2325 rue de la Terasse,
Quebec (QC), G1V 0A6, Canada
e-mail: sehl.mellouli@sio.ulaval.ca

D. Pascot
e-mail: daniel.pascot@sio.ulaval.ca

F. Bouslama
e-mail: faouzi.bouslama@fsa.ulaval.ca

1 Introduction

Many organizations today recognize the importance of investing in information technology (IT) to face competition and to respond quickly to new business opportunities and changing environments while meeting their business objectives [1,2]. These organizations have been continually transformed to adapt to environment demands and to meet their strategic goals. The transformation very often involves adjusting business processes along with changing environments [3] to reply to evolving needs while maintaining competitiveness therefore creating new information requirement for decision making process. Each transformation is generally performed without considering its impact on the organization as a whole. In fact, the increasing need to integrate and use IT in those organizations has gradually created this environment of heterogeneous applications leading to the need of an Enterprise Architecture (EA) to overpass the lack of integration and sharing of information and resources. The ANSI/IEEE Std 1471-2000 [4] defines EA as "The fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution".

Transformations in organizations pose a number of new challenges and opportunities for enterprises to quest for solutions that are expected to help represent, understand and respond properly to these transformation-related complexities [5]. In addition, these solutions are expected to allow managing the evolution of the multitude of applications while getting the control over the organization's global model of information. Over the years, enterprise modeling [6] has emerged as a wide approach to represent and understand transformation-related complexities. Global approaches of enterprise architecture that attempt to coordinate the evolution of transformation of organizations, including a description of its static and dynamic parts, provide formal descriptions of the enterprise and its transformations. These global approaches, such as Framework-based architectures [7–9], Urbanization of information systems [10], and Project-based techniques [11–13], describe how organizations operate and how their transformations can take place in line with the strategic objectives and constraints. Moreover, to address the transformations within specific silos, many approaches have placed the focus on the development of an integrated and stable information architecture [14–16] bringing an enterprise-wide solution especially for medium and large organizations. The global enterprise-wide approaches, which provide a holistic view that enables organizations to represent and understand transformation-related complexities across the enterprise, can help those organizations translate that understanding into effective policies and processes. However, these approaches have not shed the light on how to manage complexities related to the multitude of applications in silos.

This paper contributes to the solutions addressing these issues by proposing a methodology to create foundations based on key components to help develop the information architecture (IA) at the heart of the enterprise architecture that can guarantee the evolution of the organization. These core components are a set of reusable Field Actions (FAs) representing the non-contextual persistent information, a common canonical Corporate Conceptual Data Model (CCDM) capturing all the vital data in the organization, and Views or sub-schema of this global data model that represent information for different stakeholders and usage in the organization. To show the effectiveness of the proposed approach and to gain more insights into its practical value, the results are applied in the healthcare domain to create the information architecture and the enterprise architecture for the Quebec healthcare network [17,18]. While recognizing the fact that the Quebec healthcare system must live with the many existing applications, the approach shows how to identify the stable pivot on the common part of the information architecture of this highly complex network. The

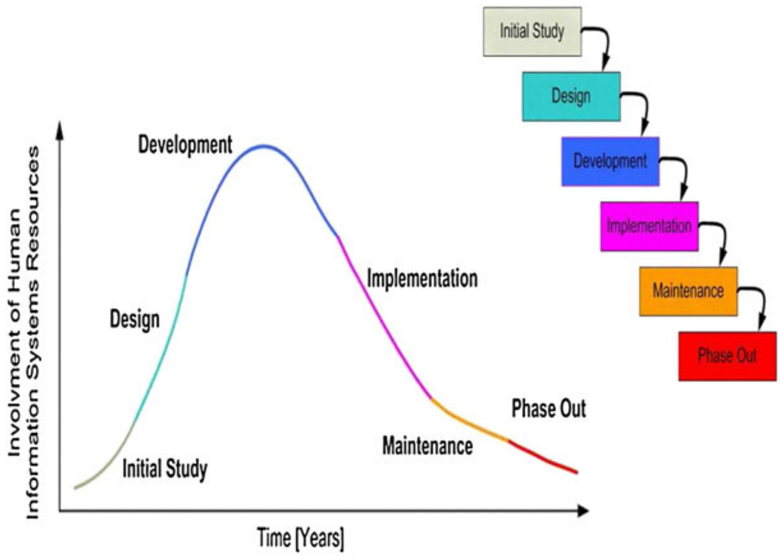

Fig. 1 The waterfall SDLC of a single application and the involvement of human IS resources in the process

proposed information architecture enables the Quebec healthcare organization to model and understand its transformation-related complexities. Moreover, it provides foundations that guarantees for the network a certain degree of independence between its business needs and the required investment in IT.

The rest of the paper is organized as follows. Section 2 presents a historical perspective showing the problems that are facing today's organizations. Section 3 provides a brief summary of the existing solutions. Section 4 presents the proposed enterprise architecture framework with its key components. Section 5 shows how to create the FAs, the CCDM and the Views of the information architecture, and how to use the technique of Coupling between the various levels of modeling abstractions. Section 6 introduces the Quebec healthcare network and shows how to build the information architecture for this organization. Section 7 is a discussion and a highlight of future research work. Finally, Sect. 8 is the conclusion.

2 From application design to IS architecture and EA

When looking at the design methods of information systems from a historical point of view over the years, they were all based on one single application development. These design methods included methodologies such as MERISE [19,20], Information Engineering (IE) [21,22], and Structured Analysis [23,24]. The system development life cycle (SDLC), which is the logical process used by designers to develop an information system, originally took the form of Royce's waterfall model [25] and included six main phases as shown in Fig. 1. These phases are as follows: the initial study phase which includes planning and analysis, the design phase, the development phase, the implementation phase, the maintenance phase, and the phase-out or obsolescence phase.

Organizations use the SDLC to develop systems that meet their business needs and requirements and expect the system to work effectively and efficiently. When a system reaches its phase-out phase, a new design project is initiated and a new life cycle begins. As shown in Fig. 1, the degree of involvement of human information systems' resources changes from a phase to another. The waterfall model is in fact a project management cycle whose primary objective is to deliver an application. The cascade structure of this model does not allow to iterate between its phases, and this leads to a major difficulty in the definition of the requirements. Moreover, those requirements are not always stable. In fact, the SDLC closely links the definition of requirements with the choice of technology and any changes in either one affects the other as both of the needs and technology are integrated in the same cycle.

A number of researchers in Information Systems Requirements proposed new approaches to solve the problem of requirements unstability in methodologies implementing SDLCs. The Objected-Oriented (OO) techniques [26], for example, utilize Use-Case diagrams to identify and model the requirements in software engineering. In Agile methods, users are made to interact with and adjust technology as the requirements change. These approaches may work well for applications of small size concerning a small number of users. However, if the requirements are complex or ill-defined, the situation can be confusing. These days, very few organizations develop their systems by following the original structured design methodology of the waterfall approach. If they use it, it takes them too long before they can discover the real problems of the information requirements. Moreover, most of the design methodologies were meant for one application where the whole content of the analysis was limited to that application. Defining user needs and creating a data model of the database therefore necessitate a stabilization of those requirements for the life cycle.

These days, organizations are faced with the difficult task to manage many heterogeneous applications and to plan for their evolution while achieving the coherence and synergy. However, given the considerable overall size of these applications, organizations can no longer continue to apply a single life cycle to all applications at the same time. In fact, there are a multitude of different cycles (*n* cycles) taking place any time in any organization as shown in Fig. 2. These *n* cycles need to be continuously piloted and managed to allow the organization to evolve over time.

To manage this level of complexity, organizations represent the knowledge domain as an ontology in the form of a Corporate Conceptual Data Model (CCDM) as is suggested in this study. The CCDM can be thought of as the union of the individual Conceptual Data Models (CDMs) for each application. But still there are many unanswered questions about the design of information systems in such context. To overcome these challenges, organizations sought the help of information integrating solutions and enterprise architecture frameworks to model their operations and transformations, to understand their complexities, and to manage their evolutions. The following section provides a summary of these solutions and shows how they deal with transformation-related complexities.

3 Existing solutions to transformation-related complexities

For the last two decades, organizations have been using various solutions and techniques to model, understand and later act upon their transformation-related complexities. These complexities have resulted from the large number of applications. The implemented solution included a variety of approaches ranging from Enterprise Resource Planning (ERP) systems [28] to Enterprise Architecture (EA) frameworks [7] and Urbanization of Information

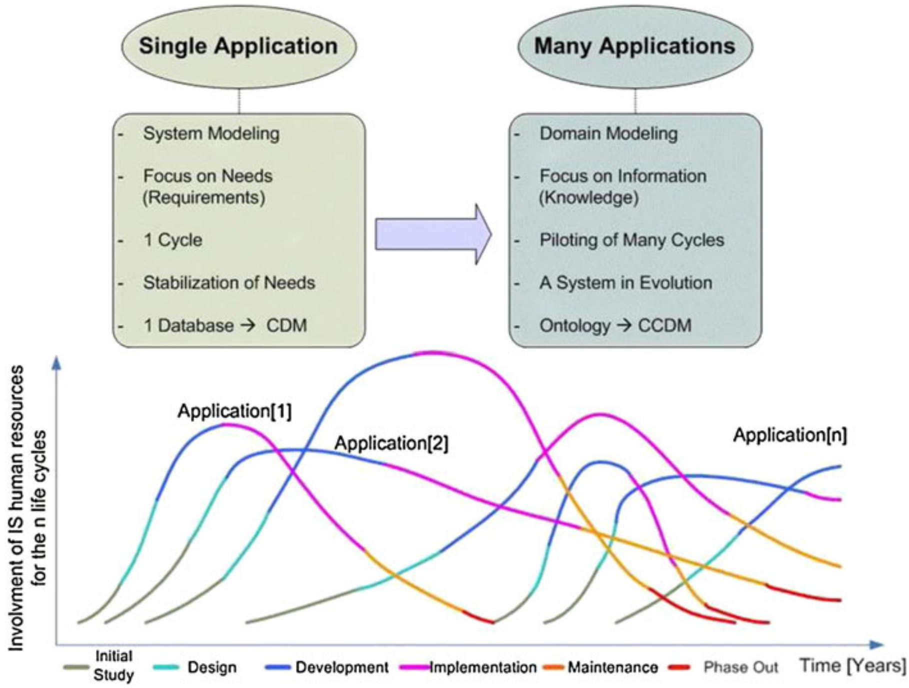

Fig. 2 From single to many applications

Systems [10]. The following sub-sections provide a highlight of the most important approaches.

3.1 Modified SDLC models and agile methods to stabilize needs

To manage the complexities of systems and applications, a number of SDLC models have been created based on the original waterfall model. The new models attempted to speed up the design process, improve communications and interactions between project stakeholders, and stabilize the needs for the life cycle. These new models and methodologies included the typical V-shaped cycle [26] where instead of moving in a linear fashion, the development process form a V shape to reflect on the relationships between the phases of the cycle and the associated phase of testing; the spiral life cycle model [27] which combines the features of the waterfall model and prototyping, the Rapid Application Development (RAD) [12] that involves minimal planning in favor of rapid prototyping; the Extreme Programming (XP) [13] intended to improve software quality and responsiveness to changing user requirements; and Agile methods [11] that focus on short development life cycles and close interaction with users. These new models are iterative or sequential software approaches aiming at speeding up the analysis, design and implementation phases of the SDLC, and therefore the development of an application. Though there is an attempt by each model to stabilize the user expectations and system requirements, there is still much work to do to manage user needs in a global and efficient way. Some of these new approaches have tendency to increase complexity as they do not address the articulation of the multiple cycle of applications. Therefore, they can only be considered as local solutions falling short to address global transformation-related problems.

3.2 ERPs to integrate business processes

The use of Enterprise Resource Planning (ERP) systems [28] as a solution to transformation-related problems has helped organizations collect all business areas in one system to support most of the business system needs. ERPs maintained in a single database all the data necessary to run the organization. Each functional unit within the organization uses its own supporting software applications, and the ERP software links these applications and ensures their compatibility through the use of the common data storage. The benefit of using ERP is to streamline business processes, which achieves efficiencies and therefore lower costs. However, ERP systems can grow to become very complex and difficult to manage as organizations transform themselves and become more complex themselves. ERPs are often customized for the specific business processes that they support and to suit the needs of the organization. Very often, this customization is quite complex, leading organization to rely on vendor solutions and external service providers to run and maintain the ERP solution. As vendors of this technology do not allow any altering of the structure of the software, this situation has created a dependency between the organization from one side and the vendors and the service providers from the other side. This dependency resulted in more expenses and less efficiency. Though ERPs address the incoherence problem and the lack of synergy, their difficult and costly implementation provided only a partial solution to problems of complexity-related transformations. If this approach is used in a health facility, we are still far from being able to consider this approach in the health system of a country.

3.3 Enterprise architecture frameworks to model transformations

Many large- and medium-sized organizations today are investigating Enterprise Architecture (EA) frameworks [29] to model their operations and transformations to cope with complexities and change. The EA are intended to provide a mechanism enabling to describe the key components and their relationships for an enterprise. These key components include dimensions such as strategies and business processes, data and information, systems and applications, and technologies. The EA frameworks are expected to provide integrated models and solutions that help increase the synergy in the organization, improve the business agility, support accountability, and understand the enterprise complexity to manage the organization' change and evolution while improving its effectiveness and competitiveness. Framework is a very wide concept ranging from the whole organization to software architecture.

The Zachman Framework [7] is the most known EA framework. It classifies and organizes the types of the enterprise knowledge in the form of artifacts that describe the business, the information and the technology architectures, respectively. This classification can be thought of as an ontology that describes the organizing architectural artifacts. The framework uses a six-by-six two dimensional matrix to classify the artifacts of the enterprise. The rows of the matrix represent different phases or roles of the information system development process, whereas the columns model different perspectives of interest. The framework refers to a typical project management and is very useful to use it as a foundation, as it incorporates all levels of modeling abstraction underlying many approaches to EA.

The Open Group Architecture Framework (TOGAF) [8] is a comprehensive framework to design, plan, implement and govern enterprise architectures. The framework is being developed by the Architecture Forum of Open Group as a broad EA approach covering various domains. The framework provides a Business architecture to define the business strategy, the governance, the organization, and the business processes; a Data or Information architecture to describe the data assets and the data management resources; an Application or Systems architecture to provide a blueprint for the application systems; and a Technology architecture to give an overview of the software and hardware capabilities that support the business, data, and application services. The framework can be used to develop a wide range of different architectures. In fact, the TOGAF architecture principles were applied in a number of different ways to support the architecture governance and change management in organizations, and to find solutions to complexity-related problems.

Other EA frameworks have been adopted by organizations especially in government sector to help design and create their enterprise architectures. This includes frameworks such as the Department of Defense Architecture Framework (DoDAF) [30] and the Federal Enterprise Architecture Framework (FEAF) [31]. The DoDAF is a framework used to model the US Department of Defense (DoD) as an enterprise. It is used to identify the operational requirements, make IT investment decisions and improve the interoperability among the various systems in the DoD. This architecture helps the DoD to rapidly respond to changing business, IT needs and strategies, and to be able to govern its evolution. The FEAF was created by the Office of Management and Budget (OMB) in the US to help transform the Federal government into one enterprise that is citizen centered. The framework, which is a business-based framework for government-wide improvement, consists of various approaches, models, and definitions for communicating the overall organization and relationships of architecture components required for developing and maintaining a Federal Enterprise Architecture. It is used to ease the sharing of information and resources across the US federal agencies while improving services to citizens and reducing operational costs.

The enterprise architecture frameworks attempt to bring an understanding to transformation-related complexities in organizations while trying to achieve agility and improve the synergy between the various organization units. In fact, the CEISAR's (Center for Excellence in Enterprise Architectures) three dimensional cube [32] which uses complexity, agility and synergy as a base can be used as an underlying referential to investigate these solutions. The CEISAR's work focusing on enterprise architectures provides a simplified yet consistent view of an enterprise based on only three key dimensions. These dimensions were based on the main business concerns of splitting the real world from its model, splitting the operations processes or the present from the transformations processes or the future, and appropriately balancing centralization vs. decentralization and specific elements vs. shared and reused ones. Splitting the real world from its model leads to understanding the enterprise complexity, whereas splitting the present from the future leads to an increase in agility. As for finding the good balance between on one hand the centralization and decentralization, and on the other hand between the specific and shared or reused elements, the CEISAR's model leads to identifying the right synergy level for the enterprise. Though EA frameworks are successful in streamlining enterprise-wide businesses and addressing information sharing problems, they still encounter difficulties with respect to their implementation.

3.4 The Urbanization of information systems to cope with complexities

Similar to urban planning, the urbanization of information systems [10] attempt to create a plan with which it is possible to model and understand existing information systems and create new systems to answer future needs and constraints while managing the overall evolution of the enterprise. The concepts of urbanization organize the gradual and continuous transformation of information systems while optimizing their operations. The meta-model

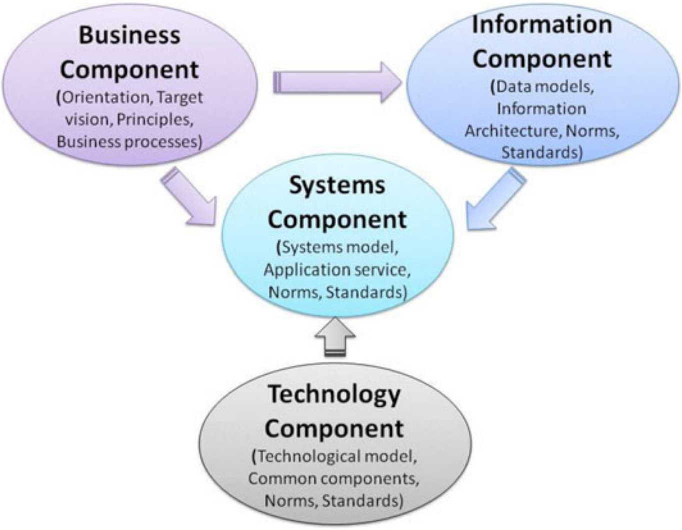

Fig. 3 The interrelationships of the EA dimensions

for urbanization includes four perspectives: the business view (the Why), the information system view (the What), the application view (the How), and the technology view (the Using What) as shown in Fig. 3.

The urbanization plan should describe how to act on the four dimensions of Fig. 4 to model and develop the enterprise architecture in its current, target, and future evolution states, respectively. It has a general goal of achieving consistent and progressive information systems to ensure efficiency and flexibility, while the organization transforms itself. The development of a system in complex and large organizations follows the logic of a business process-based approach within an urbanization perspective and is based on the fundamental components of the overall architecture. Though the urbanization bring in an increase in agility, better alignment with strategies, needs, and technology, better coherence of systems, and effective management of information and technology, it is not clear how to deal with the management of the multitude of life cycles with this approach.

4 The proposed enterprise architecture framework

Many system developers have shifted the focus in modeling for information systems design and development away from modeling the system itself and toward a representation of the knowledge domain. This transition has been driven by a number of factors, both conceptual and technological [33,34]. The main drivers have been the growing recognition of the importance of integrated systems and the sharing of information and resources. Therefore, there is a shift in focus toward the management of the evolution of the enterprise architecture as a whole. To create an information architecture within an enterprise architecture that guarantees the operation and the management of the organization where a multitude of heterogeneous cycles co-exist, there is a need for an effective design of the enterprise architecture that uses concepts based on the knowledge of the domain and the organizational reality. The proposed enterprise architecture is therefore based on such concepts

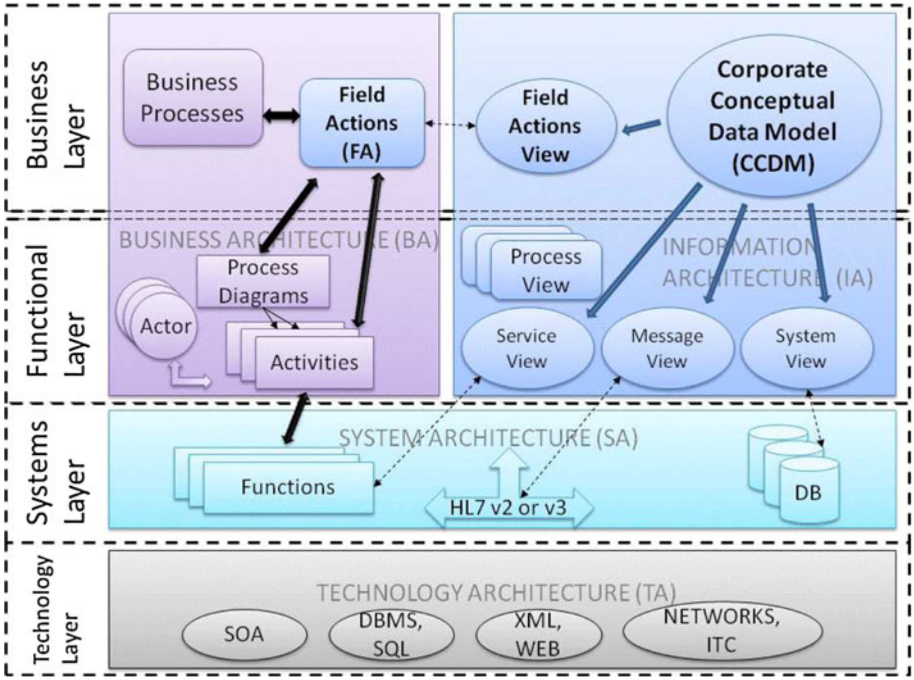

Fig. 4 The proposed enterprise architecture framework

or foundations used within a reference enterprise architecture framework that ensures articulation and flexibility. For several years, there is an agreement on the fact that an enterprise architecture includes several dimensions, and a fairly good consensus exists on the identification of these dimensions. A framework that depicts an enterprise architecture is proposed as shown in Fig. 4.

This framework is based on three core organizational concepts: Field Actions (FAs), a common canonical Corporate Conceptual Data Model (CCDM), and Views or sub-schema [16]. According to urbanization **approach**, this framework has a Business, a Functional, a System layer, and a Technology layer, respectively, four domains that are meaningful to different stakeholders in the organization. Views are created to meet the individual needs of different stakeholders such as the Field Actions view, the Message view, and the System view. The FAs capture the persistent data and information of the reality. They are any action, decision, or event involving one or several players [35]. The FAs are the key reusable building blocks that make a business process. Each business process may involve one or many FAs. For each FA, a view mapped to the global data model can be designed showing the entities and relationships that concern a particular FA. A catalog of all the FAs can be later established along with the process of modeling of the knowledge domain. These FAs views within the corporate conceptual data model are used to give a coherent and global information model. The CCDM [35], which provides a holistic view of the information, is a conceptual data model where the entities and attributes common to various information systems in the enterprise are defined. The Views, which model information for different stakeholders, show the relationship between the information architecture and the business and systems architectures [35] which themselves are articulated around the CCDM.

In the proposed framework, the CCDM is at the heart of the information architecture of an organization. It can be considered as a switching platform that connects the various models that constitute the information architecture. These models, called views here, are the various reusable components and the deliverables of a project with regard to information. Several views can be created to fulfill the needs of different stakeholders in an organization such as:

- The Field Actions view: it describes the information representing the actions and decisions that take place on the ground.
- The Business Domain view: it brings together all relevant data to a project as well as the view of business processes and activities that describe the information created and used by a business process.
- The Systems view: it represents the views of databases and interfaces (services) of existing systems or those being designed.
- The Messages view: it describes messages in use or under development in systems, and how they match with present or future standards of exchange and norms in the organization.

In the information architecture, the CCDM is a fully normalized data model, and as the views are sub-schema they are also normalized. They are at the same level of abstraction as with the CCDM. The field actions view and the messages view have an aspect of generality, they are a priori independent of a particular business process context that leads to the important feature of reusability. The same FA can be encountered in several business processes of the same business domain or several separate business areas. In the same way, each business process may have more than one FA, leading to a many-to-many type of relationship [16] *between the FAs and the business processes.*

5 Building the information systems enterprise architecture

The information architecture is built based on two main organizational concepts or foundations: the context-independent field actions views and a global conceptual data model as shown in Fig. 4. The aim of the global conceptual and corporate data model or CCDM is to represent the many concepts and their relationships that are encountered in the reality of a particular business domain. These concepts are used in the design of the various information systems of an organization. However, attempting to model this whole knowledge domain at once can be a very challenging task. Furthermore, attempting to construct a graphical representation of this global data model can easily become so large and complex that it will ultimately be difficult to read or maintain. Therefore, there is a need to appropriately make a partition of this large and complex modeling task into smaller and manageable parts within the information architecture.

5.1 The field actions views

The field actions (FAs) [14,16] are the building blocks used in any business process and which reflects the persistent and most important business information across the various business units of the organization. These are any action, decision, or event involving one or several players. The concept that was introduced by Pascot [16] reflects the close natural relationship between data models and the business reality. An FA view is a non-contextual information component. It represents the common persistent information across the various existing information systems or systems developed which are scattered across the many business units of the organization. An FA can be described in a neutral way independently of any particular business process. They are the reusable elements in the enterprise architecture. Each of these actions can be depicted distinctively and explicitly with a separate data model involving an ensemble of concepts depicting the reality on the ground and their relationships. However their views cannot be defined independently because they share common information. That's why they should be designed as sub-schemas of the CCDM. A list of all the FAs in the enterprise architecture is progressively formed to reflect on all the actions, decisions, and events that take place in the enterprise. The set of the FAs views are used to form the global corporate data model at the conceptual level. This model provides a coherent information model of the reality on the ground.

5.2 The Conceptual Corporate Data Model (CCDM)

FAs are identified within the business processes. Their views can be used to progressively and iteratively build the global data model or the CCDM of the organization. The CCDM provides a holistic view of the information in the entire organization. This abstract data model is a formal representation of a set of concepts within a particular domain, and the relationships between those concepts. In other words, it is the ontology for this domain that represents knowledge about the reality. The components that make this model are the ground level objects or entities, their attributes depicting their properties, relationships showing ways to connect an entity with another in the model, and the rules and restrictions. This model is said to be corporate as within which only data that are primary or natives can be found. These are data that describe events or decisions defined from a point of view that is as neutral as possible, in other words independently of a particular use. It is conceptual, implying that this model represents only the meanings (i.e. definitions) and the relationships between the meanings. The CCDM is not a representation of the materialization in physical systems such as databases.

5.3 The other views and sub-schema

Another component of the proposed information architecture are the different views or sub-schema. The whole information architecture expends with these views. Different views are meaningful to different stakeholders of the enterprise architecture. They are articulated around the CCDM that forms the hub of the information architecture putting in relation these different models. Figure 5 shows four views that are pertinent to health systems. These are the Field Action View, the Business Process View, the HL7 Messages View, and the Systems/Database View.

A Business Process View is a subset of the global model that contains all the relevant entities and relations that are specific to a particular business activity. The System/Database View is a view representing the physical databases and the corresponding interfaces of existing systems. This view can also be taken as a view of systems that are currently being implemented. As for the HL7 Messages View, it represents the relevant entities that compose an HL7 v2 or v3 message, HL7 is a messaging technology used in the health domain. All of these views along with the CCDM global model or ontology and the FAs form the core re-used foundations and components that make the heart of the proposed information architecture and EA. These views are normalized, and they need to be linked to data structure that are not normalized in the same way. To do this, a dedicated coupling method and tool is developed.

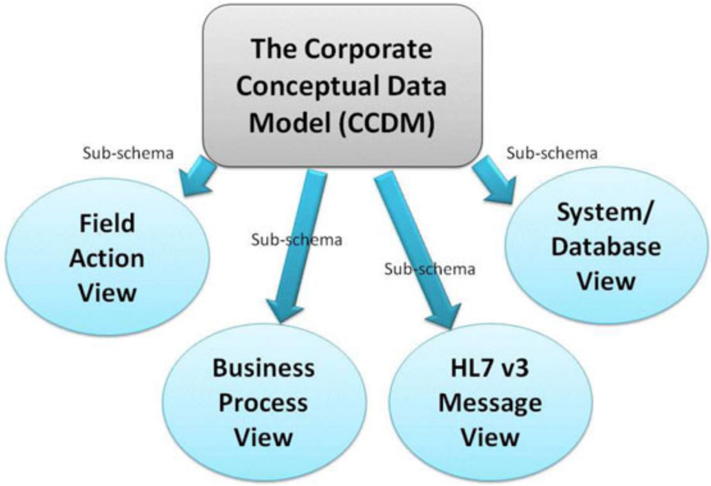

Fig. 5 The views of the CCDM

5.4 The CCDM-Coupling method

The coupling method allows the representation and the transition between the various levels of modeling abstraction which are the conceptual, the logical, and the physical modeling level, respectively. All the sub-schemas directly linked to the CCDM are Conceptual Data Model (CDM) in their respective domain view. Each sub-schema contains entities and their associations normalized in the same way as with the CDM. This allows a coherent approach for the information system under development since the entities will always be taken from the same source which is the CCDM model. The coupling method to link conceptual models to logical models can be used in two ways: to create a logical model from the CCDM or to link an existing logical model to the CCDM.

A Conceptual Data Model (CDM) is an abstract view. Its realization in a computer system is a Logical Data Model (LDM) in which information is organized and translated according to the context of implementation [36]. Thus, an existing (or under development) application can be described by a conceptual data model and then a logical data model. To link this logical model to the global architecture, it is preferable to have a local conceptual model rather than the global conceptual. A conceptual model, from the local perspective of the application, is a logic model from the perspective of the information architecture of the EA, because it presents a deformation in order to satisfy local requirement of the overall conceptual structure. A method and a technique to ensure this linkage are therefore developed. At first, there is a need to have a means to establish correspondence between two domains structures of different form but having the same semantic content. Then, in a second step, there is a need to ensure the matching of a system view, called LDM in the context of architecture, with the CCDM. This is done through a view of the conceptual level that is called CDM.

The process of creating a CDM and connecting it to a Logical Data Model (LDM) follows a set of steps that are depicted in Fig. 6 and explained hereafter. The first step of the coupling method consists of creating an LDM of the information system, application, database or message to be linked to the CCDM. This logical model is basically a conceptual model,

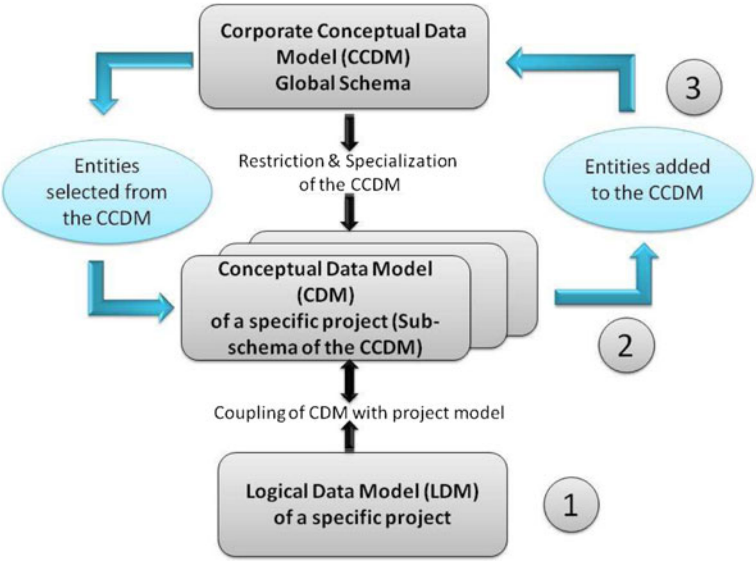

Fig. 6 The CCDM-Coupling method

but instead of using the terminology coming from the CCDM, terms originating from the information system under consideration are used. The terminology at the common conceptual level can be sometimes different from the one used in a context. To integrate each of the logical models to the global one, there is a need to find corresponding entities and attributes in the CCDM. Every element from each of the logical model is matched to an element of the CDM that is being created for that particular LDM. If a corresponding entity or attribute in the LDM cannot be identified in the CCDM, the pertinence of adding it to the global model is then evaluated and an action is taken. The semantics of this new information is verified to see whether the global data model remains comprehensive and most importantly coherent. The CDM of the information system under investigation is gradually built, while at the same time the global data model or CCDM may be updated by adding new entities and attributes if necessary. This bottom-up analysis approach allows the discovery of new data by analyzing existing information systems, and by adding it gradually to the global data model as shown in Fig. 6.

The CCDM represents, therefore, the global information architecture where the data it comprises can be spread across a sub-schema taking the form of an CDM. The CCDM can be seen as the stable pivot that inter-relates the various sub-schemas that compose the information architecture. The views in the CCDM, therefore, improve the cohesion between systems, harmonize the information, and allows the process of reutilization. The CCDM serves as an effective tool to improve communication and understanding between all the stakeholders of an information architecture including business managers, system analysts, and application developers.

The proposed CCDM-based information architecturing approach is used to create the information architecture of a complex network in the health domain: the Quebec healthcare system. The following sections detail the implementation process and show the information artifacts.

6 Implementation in the Quebec Healthcare System

In the healthcare domain, many organizations are in the process of transforming themselves to create enterprise architectures (EA) and to implement the use of electronic healthcare records (EHR) to streamline the healthcare delivery processes [37]. The EHR is expected to improve the sharing, storage, and management of information about patients [38,39] and to increase healthcare takers' efficiencies while reducing service costs [40]. However, the transformation process requires a careful consideration of many factors such as the transition and integration of the physical data into electronic form, the ability of healthcare information systems to consolidate geographically dispersed medical records, and the architecturing of the information architecture within an enterprise architecture.

The healthcare system in the Province of Quebec is facing similar challenges. The Quebec healthcare and social services system (MSSS) is a very complex network [17] made of 18 regional authorities or agencies, 4,000 community organisms such as private clinics, and 95 centers for health and social services (CSSS) such as hospitals and re-adaptation centers. This network has approximately 300 institutions providing a set of integrated health as well as social services in more than 1,700 service points. The agencies are in charge of coordinating and implementing health and social services with regard to funding, human resources deployment, and the access to specialized services in their respective regions. The CSSS centers are a merger of local community centers (CLSCs), residential and long-term care centers (CHSLDs), and hospital centers (CHs). A large network of this complexity definitely necessitates an enterprise architecture to monitor its operation and progress, and to plan and accompany its evolution over the time. In order to achieve this goal, the CCDM-based approach has been applied to the modeling of the Quebec health care system where it is expected to provide a global view of information and a mean to manage its complexities and evolution while urbanizing its complex network of services. The MSSS has been working for a few years now with a goal to develop and maintain a coherent vision of the digitization of its network of health and social services. Here, the proposed CCDM-based approach has been called upon to create the information architecture of this organization. The development of the information architecture for the Quebec healthcare system is initiated with the identification of the FAs which are later combined to form the overall corporate conceptual data model.

6.1 Identifying and modeling the field actions for the Quebec healthcare system

The FAs can be identified in an analysis by business process mapping techniques [41] or through an investigation into the reality. For example, prescribing drugs to a patient, taking a blood sample, or performing a diagnosis can all be considered as field actions. There are three prerequisites for an activity to be considered an FA in the healthcare domain. It must generate information relevant to the achievement of a clinical or a social service. This information must be sufficiently persistent so that it can be registered. Finally, the activity must represent the healthcare reality and should not be taken from an IT perspective.

There is a many-to-many type of relationship between the FAs and the business processes. The same FA can be identified in several business processes, and each business process may have more than one FA as building blocks. Each FA is associated with both a descriptive form and a view of the action or a data model. The description form [42] of the FA contains secondary information in support of the FAs. These are the metadata of the action. They include entries such as the name of the FA which should be generic enough to be reusable and sufficiently precise to be recognized by people, a standard code of the FA, and the

Field Action Code	RCAI_AT000002QC01
Field Action Name	**Drug Prescription**
Definition	A prescription is a written recommendation made by a doctor, for a user so that he or she can acquire drugs. The doctor may prescribe either a drug or a common name. In this case, the pharmacist selects the drug to deliver based on the common name identified.
Main Actor	Doctor
Other Actors	Health worker, Pharmacist, User
Inputs (Triggers)	Meeting a doctor, Meeting a health worker
Reference Documents	Preliminary architecture of information systems on drugs- Delivrable 5 preliminary version, RAMQ, Quebec, February 25, 2005
Legal Aspect	The constraints of Law 83
Example	Upcoming

Fig. 7 Descriptive form of the Drug Prescription FA

definition of the FA which identifies the main actor as well as other information. Figures 7 and 8 show an example of a descriptive form and the view.

Gradually, as the information architecture is built, a list of all FAs is formed. This list is iteratively maintained along with the CCDM as new FAs are identified and new entities are added to the global data model. This gives a coherent and global information model of the Quebec healthcare system. An FA is consequently a sub-schema of the CCDM where a sub-schema can be defined as a subset of a parent schema. The sub-schema is therefore composed of relations and connectors taken exclusively from the parent schema. For example, the Vaccination FA contains concepts such as ‘Caregiver’, ‘Contact’, and ‘Patient’. These concepts are also present in other FAs and are consequently constantly reused. However, some other concepts such as ‘Vaccination Equipment’ and ‘Vaccination’ are very specific to the Vaccination FA. The CCDM hence contains entities and attributes that are taken from every FA which can actually be seen as the aggregate of all the FAs. Therefore, it is by integrating every FA in this common model that it is possible to manage and construct a global data model for the Quebec healthcare system.

When there is a need to identify a data model for a particular information system within the Quebec healthcare network, the proposed approach starts by isolating the FAs that are relevant to the system under investigation out of the overall list of all FAs included in the CCDM. Here, the corresponding business processes can be used to identify which events are relevant to the project. For example, Fig. 9 shows the identification of the seven business processes for the RSIPA project. RSIPA is an information system that will be used to manage integrated services given to autonomy loosing persons in Quebec.

What is important to understand is that for every identified business process such as Evaluation for example, there will be a corresponding FA, either taken from the CCDM or created specifically for RSIPA, and eventually added to the CCDM. Therefore, during this procedure, business processes are first identified independently of existing FAs. Afterwards,

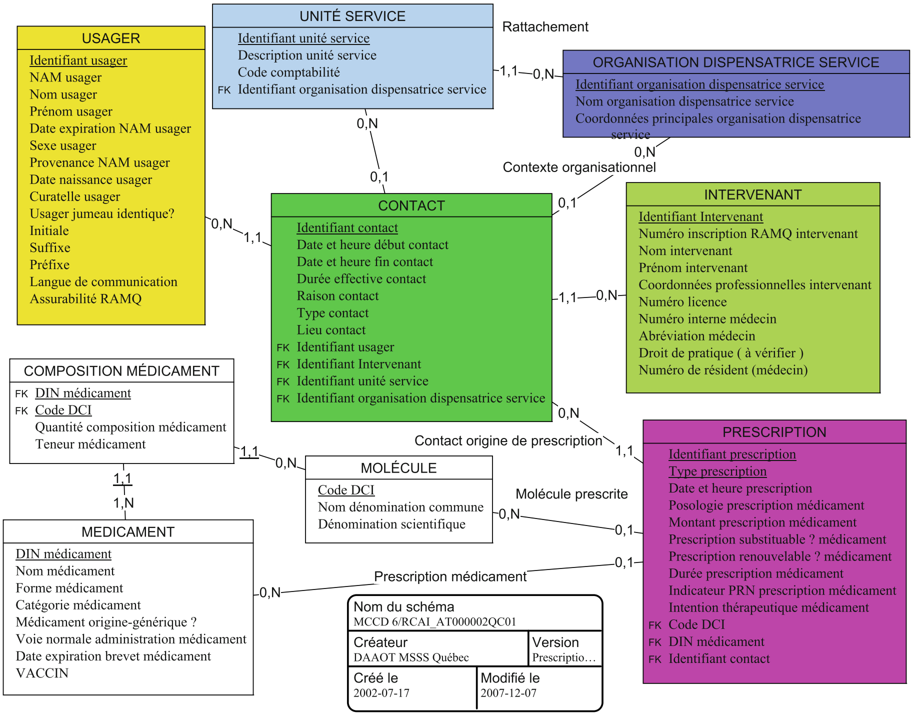

Fig. 8 View of the Drug Prescription FA

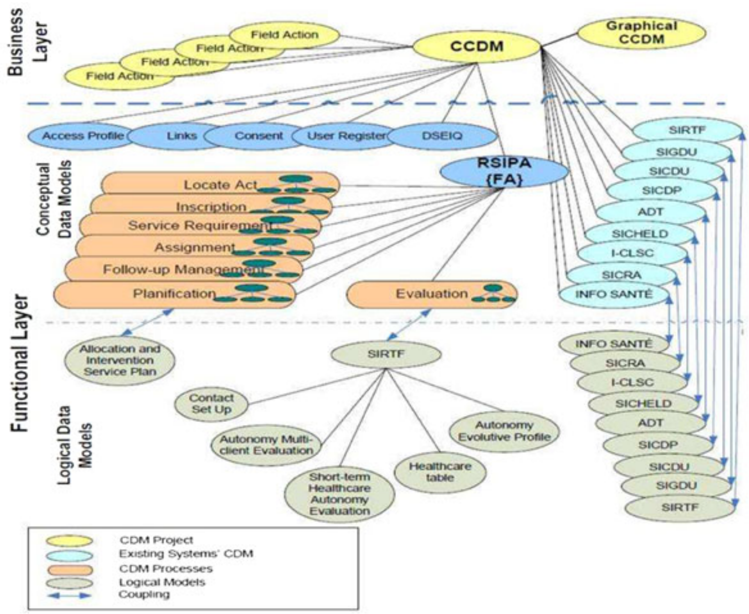

Fig. 9 Business processes and IA for RSIPA project (Source: MSSS)

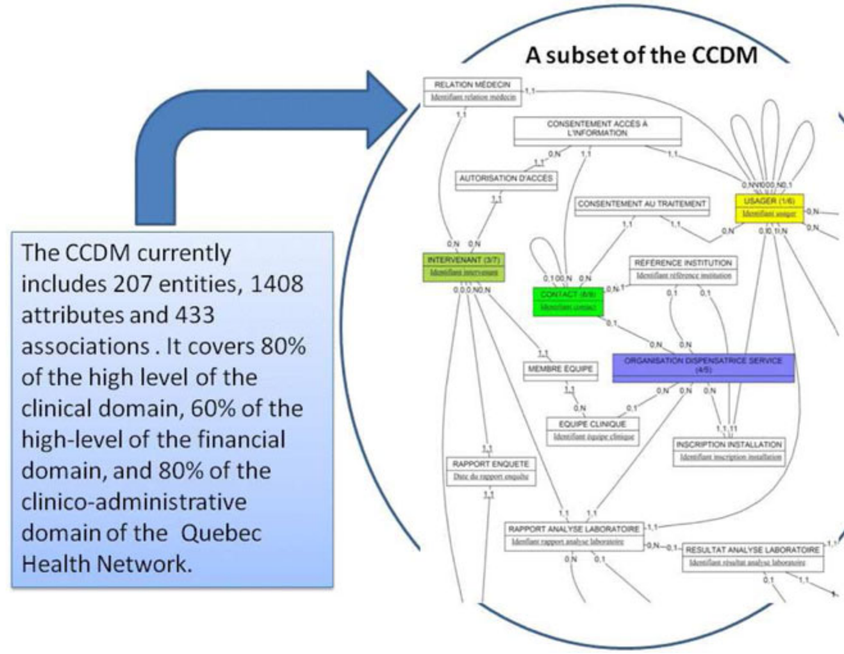

Fig. 10 The CCDM of the Quebec healthcare system

existing FAs are selected in the CCDM. If a corresponding FA does not exist in the CCDM, then there is a need to create it. To add the FA to the CCDM, the information architect can either use existing concepts from the CCDM or create new ones as needed. The FA will then be integrated to the global model and can be reused and later updated and improved. When all the necessary FAs have been identified, the analyst can integrate them altogether and create a sub-schema of the CCDM which will be specific to the project at hands. This helps guarantying a high degree of coherence between projects since every concept **is reflected in the** CCDM or is eventually integrated to it.

6.2 Creating the CCDM of the Quebec healthcare system[1]

The CCDM provides a global view of information for the Quebec healthcare system. This model uniquely refers to primary data that describe components such as Patients, Caregivers (Physicians, Nurses, etc.), Hospitals, and real-life events such as a Diagnosis, a Prescription, and a Medical Examination [43]. The CCDM hence contains a representation of the main actors and actions that can generate data in the Quebec healthcare system and shows how these components can interact with each other. Figure 10 lists the statistics of this global data model and shows a graphical snapshot of some of its entities and their relationships. This CCDM is currently being developed at the DAAOT (Direction Adjointe a l'Architecture et aux Orientations Technologiques) business unit [18] at the Ministry of Health and Social Services of Quebec [17].

[1] The information on the CCDM can be accessed at http://architecture-orientations.info/alfresco/faces/jsp/browse/browse.jsp.

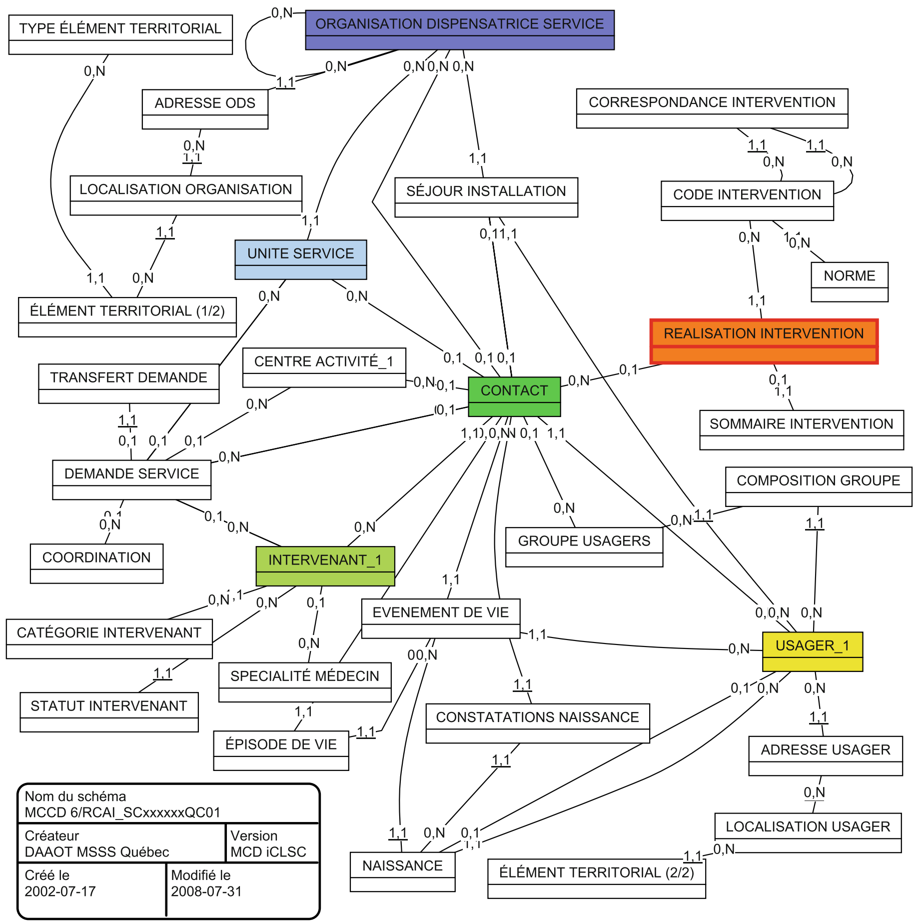

Fig. 11 The CDM of the i-CLSC information system

In this information architecture, the CCDM is used to select concepts that are relevant to a specific project. When it is necessary to model a particular healthcare information system, only parts of the CCDM will be used. However, there are common subsets of entities found in nearly all healthcare contexts such as a PATIENT (or USAGER in French), a CONTACT, a PRESCRIPTION, and CLINICIAN (INTERVENANT in French) which constitute the reusable part in most information systems. Figure 11 shows a subset of the CCDM representing a conceptual data model (CDM) for the i-CLSC information system. The i-CLSC keeps track of the CLSC (Local Centers for Community Services) clients and the provided services as well as supports the activities of physicians and managers of a CLSC center.

In order to manage the size of the Quebec healthcare global model of information, it is thought around two different subsets: a common subset and a context-dependent subset. The common subset includes entities and their relationships that exist in almost any operational domain such as CAREGIVER, PATIENT, and CONTACT. However, the context-dependent subset has the entities that are specific to a particular context such as VACCINATION, PUBLIC HEALTH, and DRUG PRESCRIPTIONS. The CCDM, therefore, gives a view of the entire information domain while showing how the different subparts are interrelated. This method allows to constantly reuse the common concepts while still having a satisfying level of granularity to fit different specific healthcare domains.

6.3 Designing views from the Quebec healthcare global model

The CCDM-based information architecture can be very easily exploited to create views to answer the needs of the different stakeholders in the network. One of these needs relates to systems interoperability and messaging of healthcare data and information. In fact, the Quebec healthcare system is subject to Canada Health Infoway [44], a pan-Canadian initiatives for information integration, systems interoperability, and vocabulary and communications standards and norms [45,46]. In the Quebec healthcare system, a major effort is made to integrate the HL7 v3 norm in the different healthcare systems. HL7 v3 [47] provides a framework for the exchange and sharing of electronic health information. The electronic messaging of HL7 is expected to support the Quebec healthcare applications through the specification of message artifacts for the exchange of health records within the province and with other jurisdictions across Canada. These records can be both of clinical and of administrative nature.

The proposed information architecture can be used to create views of messages. In fact, using the terminology coming from the CCDM, it is possible to understand how each of the HL7 messages relates to the reality. The messages are created based on two semantic foundations: a reference information model or RIM, and a set of terminology domains. To model HL7 messages, Canada Health Infoway uses software engineering tools to support the process. This includes object-oriented (OO) concepts, Unified Modeling Language (UML) diagrams, and other viewing software tools. Many OO abstract concepts that relate more to programs rather than reality on the ground are used in the refined reference models for messages. The message models that include the payloads, the wrappers, and the common message element types or CMETs are constrained models of the original RIM. Therefore, it becomes unclear to dissociates the functional requirements for an HL7 message from its technical and software needs.

By using the CCDM-based information architecture, it is possible to create message views as sub-schema of the CCDM that can be very easily understood by business modelers. For this purpose, according to the coupling method, an HL7 message is modeled at both the conceptual and the logical levels of abstraction. The logical view of an HL7 message is built based on the business view of the message provided by Canada Health Infoway. A logical view is an LDM that represents an HL7 message content and its technical details. Figure 12 shows the logical view of the message ‘Add Client Request’ [44] for adding a new Client in a source system that wants to request a client identifier from a jurisdictional client registry system. This message, which is provided by Canada Health Infoway, is used at the DAAOT Business Unit [48] as part of the administrative domain of Client Registry.

The information architecture is also used to create other views for other needs. For example, a system view for the i-CLSC, the information system that keeps track of the CLSC patients, was designed. Using the CCDM-coupling technique presented earlier, it is possible to map the artifacts of the two modeling levels. Figure 13 illustrates the coupling of two models showing the mapping of the entities in the system at both levels of abstraction. The LDM is shown in the lower part of the Fig. 13, and the CDM is depicted in the upper part. The coupling between the two models of the i-CLSC system is represented by the connecting (red) lines.

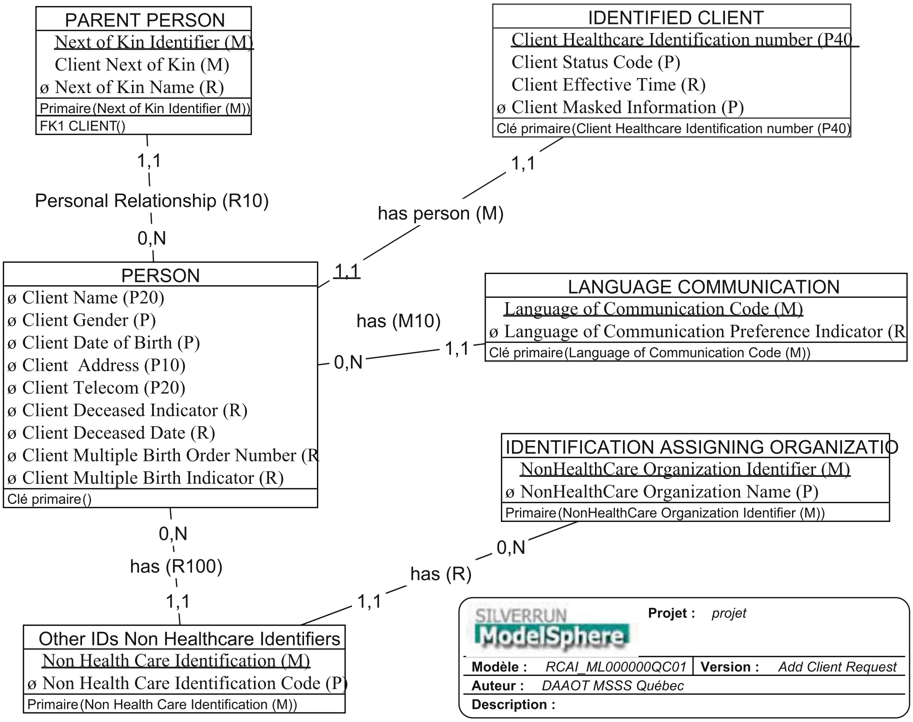

Fig. 12 Logical view of the message Add Client

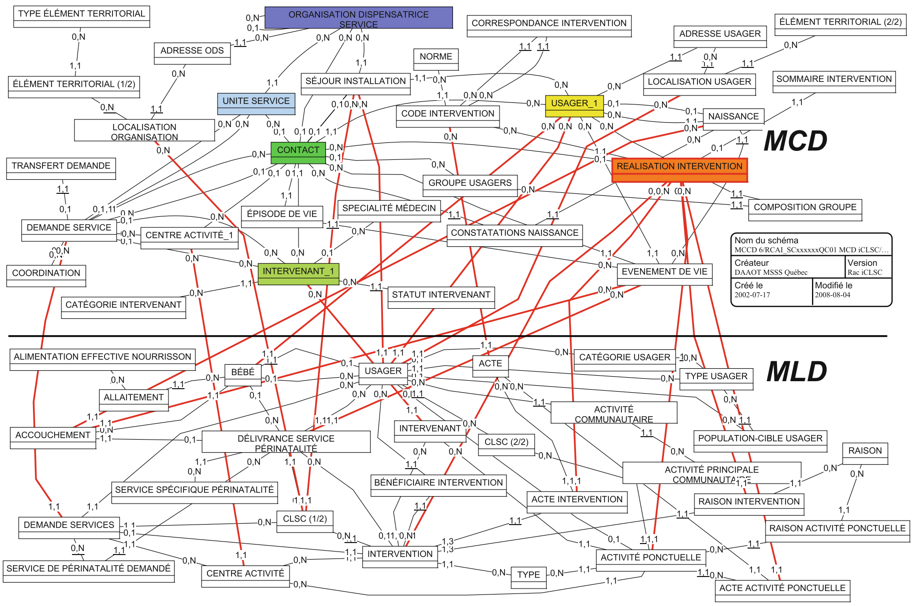

Fig. 13 The LDM and the CDM of the i-CLSC, and their coupling

6.4 Managing the graphical and other complexities of the CCDM

The modeling process of the Quebec healthcare network has resulted in an information architecture composed of a very large number of sub-schema and models. This has required the use of an appropriate modeling tool that can record and manage the many artifacts in their respective levels of modeling abstraction and the inter-dependencies and relationships between these models. The only software tool available on the market which provided capabilities to manage such complexities was the SILVERRUN software [49] package. The successor version for this software tool, the Open ModelSphere, a freely accessible tool with a GPL licence, is being used. This tool provides a flexible environment for the management of the business processes, systems, and field action view, respectively, which can greatly help manage the complexities facing developers when dealing with multiple schemes and sub-schema. This software tool that is designed in Java and works on a standard virtual machine can be installed on different platforms such as Linux and Windows. Users of this software tool can easily build their data models either from scratch or via reverse engineering from a variety of sources such as relational database management systems.

As the number of data models keeps growing, it becomes necessary to have a tool with which developers can map entities and attributes encountered in the global data model or the systems investigated. The CCDM_Extract [35] tool is used to generate CCDM mapping matrices. The CCDM_Extract is a simple Web-based software that allows the comparison of different data models with the global data model. It allows the identification of common elements and attributes between the models under investigation. Figure 14 shows an example of model matrix generated using CCDM_Extract where the letter 'X' indicate that an element is present in a specific model. The CCDM_Extract tool helps identify any redundancy with respect to entities present in existing information systems and applications. With the help of CCDM_Extract, it is possible to create new systems based on the reuse of concepts already in use, hence improving the network efficiency while reducing costs.

7 Discussion and future work

The proposed solution to architecturing complex information systems in large organizations provides an appropriate methodology to develop information systems enterprise architecture. This architecture can be used to model, understand, and address transformation-related complexities in organizations. Two main organizational concepts were used to build this architecture. Existing approaches to enterprise architectures and urbanization of information systems were instrumental in the development of the solution. The enterprise frameworks, which can be used to split the real world from its models, are useful to organize the many models of any enterprise and help understand the business and reduce complexities. The urbanization of information systems approach which can identify the right synergy level between centralization and decentralization and between the specific elements and reused or shared elements shows how the components of the enterprise architecture interact with other to guarantee the evolution of the organization.

As for future work, the authors are focusing on extending this research projet to include Service-Oriented Architectures (SOA) [50]. For creating durable systems, the state of the art to write programs that are flexible refers to the use of SOA [51]. The SOA by itself cannot identify the elementary components that serve to write these programs. There is a need to use inputs of the business processes of the organization in the form of field actions. SOA, which offers a modular vision of an application where functionality is grouped as services, attempts

Entities/Attributes	CCDM	User Register	RODIS	RSIPA	OEMC
ADRESSE INTERVENANT	X			X	
Date début validité adresse inetrvenant	X			X	
Type adrese intervenant	X			X	
Date fin validité adresse intervenant	X			X	
Identifiant intervenant	X			X	
MEDICAMENT (DRUGS)	X			X	X
D IN médicament	X			X	X
Nom médicament	X			X	X
Forme médicament	X			X	X
Catégorie médicament	X			X	X
Médicament origine-générique?	X			X	X
Date expiration brevet médicament	X			X	X
Voie normale administration médicament	X			X	X
ORGANISATION DISPENSATRICE SERVICE	X		X	X	
Identifiant ODS	X		X	X	
Nom légal ODS	X		X	X	
Nom abrégé ODS	X		X	X	
Numero de permis ODS	X		X	X	
Coordonnées principales ODS	X		X	X	
Période de disponibilité	X		X	X	
Type ODS	X		X	X	
Type financement ODS	X		X	X	
Mode Financement ODS	X		X	X	
USAGER (USER)	X	X		X	X
Identifiant usager	X	X		X	X
NAM usager	X	X		X	X
Nom usager	X	X		X	X
Autre nom	X			X	
Autre prénom	X			X	
Prénom usager	X	X		X	X
Date expiration NAM usager	X	X		X	X
Sexe usager	X	X		X	X
Provenance NAM usager	X			X	X
Lieu de naissance	X	X		X	X
Curatelle usager	X	X		X	X
Usager jumeau identique?	X	X		X	
Prénom usuel usager	X	X		X	

Fig. 14 An example of a CCDM_Extract matrix

to provide an infrastructure where there is a loose coupling between the services with their underlying technologies. These services can be combined and reused in the making of business applications of an organization. For an organization that seeks an IT flexibility and a modularity of its processes, the deployment in the form of services that support its administrative tasks has become a strategic choice. In fact, the proposed CCDM-based approach can lead to the identification of these services and also can assist in the design, coding, and deployment of software applications. In fact, the field actions represent what an organization should offer in terms of services. Thus, the definition of SOA services based on field actions will lead to the development of information systems that can meet the challenging needs of complex organizations. It is also essential to note that SOA cannot be properly used unless it is supported by a global data model such as the CCDM where data representing the organization will be used in the execution of services. The use of the CCDM will allow services to communicate under the same logic base while using a common information architecture. The authors are also extending the research work to focus on how the architecture can be used as an integrated and efficient framework for conducting business intelligence and data mining exploration. Another very important use relates to the restructuring and development of data warehouses at the ministerial level used for decision making. The authors are investigating each of the 40 main decisional databases at the MSSS and how they could be linked to the

MCCD allowing to implement a plan for achieving consistency of these databases and to define an optimization plan by reducing redundant data entry.

8 Conclusions

This paper proposed an architecturing methodology to develop a stable and integrated yet extendable information architecture within an enterprise architecture for large and complex organizations. This architecture can be used to address the many issues and challenges related to the digitization and transformations of businesses and enterprises. The proposed methodology was based on two main organizational concepts or foundations: field actions views and a corporate conceptual data model. The field actions that captured and represented any persistent and essential information were used to model any action, decision or event of the reality on the ground. The global model provided a coherent and non-redundant conceptual data model of the knowledge domain. The views were generated to represent the interest and needs of various stakeholders. These organizational concepts can be used to create information and enterprise architectures for large and medium organizations that have not been structured to address horizontal challenges. They provided a mean to integrate applications and systems that were previously developed in isolation from each other and pilot their multitude of life cycles while consolidating and managing the information scattered across the many business units of an organization. Moreover, these key elements of the enterprise architecture provided solutions to address the complex cross-functional challenges and the horizontal management in large organizations. To demonstrate the effectiveness and usefulness of the proposed approach, it was used to create the information architecture at the heart of the enterprise architecture for the Quebec healthcare network. This implementation resulted in a coherent information architecture which was able to capture and understand the many business processes and entities of the network. The information architecture can be used to monitor, plan, and guide the evolution of this complex organization and help achieve a horizontal effective management.

Acknowledgments This research work has been conducted at the DAAOT (Direction Adjointe a l'Architecture et aux Orientations Technologiques) at the Ministry of Health and Social Services (MSSS) of Quebec in Canada. The name of the DAAOT business unit has been recently changed to SOSAE (Service des orientations strategiques et architecture d'entreprise).

References

1. Smirnov A, Shilov N, Levashova T, Sheremeteov L, Contreras M (2007) Ontology-driven intelligent service for configuration support in networked organizations. Knowl Inf Syst 12(2):229–253
2. Alvarado M, Sheremeteov L, Banares-Alcantara R, Cantu-Ortiz F (2007) Current challenges and trends in intelligent computing and knowledge management in industry. Knowl Inf Syst 12(2):117–127
3. Maruşter L, van Beest NRTP (2009) Redesigning business processes: a methodology based on simulation and process mining techniques. Knowl Inf Syst 21(3):267–297
4. ANSI/IEEE 1471-2000 Recommended practice for architecture description of software-intensive systems
5. Moller C (2006) On managing the enterprise information systems transformation: lessons learned and research challenges, IFIP international federation for information processing, vol 205. Springer, Boston 307–317
6. McGinnis LF (2007) Enterprise modeling and enterprise transformation, information, knowledge. Syst Manage 6(1–2):123–143
7. Zachman JA (1987) A framework for information system architecture; IBM. Syst J 26(3). IBM Publication G321-5298

8. The Open Group, TOGAF, The Open Group Architecture Framework. http://www.opengroup.org/architecture/togaf/
9. Berck D (2006) Presentation from the chief Architect's Forum, CAF quaterly meeting, FEA PMO Update, October 11, 2006. http://www.whitehouse.gov/omb/egov/documents/2006_CAF_Qtrly_Mtg.pdf
10. Jean G (2000) Urbanisation du business et des SI, Hermes 2000, Lavoisier 20002. ISBN: 2-7462-0135-6
11. Ambler SW (2002) Agile modeling: effective practices for extreme programming and the unified process. New York: Wiley. ISBN: 0-471-20282-7
12. Martin J (1991) Rapid application development, Macmillan Coll Div. ISBN: 0-02-376775-8
13. Beck K (2000) Extreme programming explained-embrace change, reading. Addison Wesley Longman, MA
14. Le Moigne JL (1973) Les systemes d'information dans les organisations, PUF 1973
15. Tardieu H, Rochfeld A, Colletti R, Panet G, Vahee G (1985) La methode Merise—Tome 2 Demarches et pratiques. Editions d'organisation (Paris)e: 460 p. ISBN 2-7081-0703-8
16. D Pascot (1999) La methode Datarun, Management Information Systems Department, Faculty of Business Administration, Laval University, Quebec, Canada. http://loli.fsa.ulaval.ca/fileadmin/Methodes/Analyse/pdf-datarun/DATARUN.pdf
17. The Quebec Health and Social Services System-Ministere de la Sante et des Services Sociaux (MSSS). http://www.msss.gouv.qc.ca/en/index.php
18. Cadre methodologique, Direction adjointe a l'architecture et aux orientations technologiques (DAAOT), The Ministry of Health and Social Services (MSSS), Quebec, Canada, 2007
19. Tabourier Y De l'autre cote de Merise: Systemes d'information et modeles d'entreprise, Les editions d'organisation, ISBN: 2-7081-0762-3
20. Rochfeld A, Morejon J, La Methode Merise (1989) Tome 3, Gamme operatoire, Les editions d'Organisation, 1989. ISBN: 2-7081-1057-8
21. Martin J, Finkelstein C (1981) Information engineering, technical report (2 vol), Savant Institute, Carnforth, Lancs, UK, November 1981
22. Macdonald I (1986) Information engineering in information systems design methodologies. In: TW Olle et al (eds). North-Holland
23. Gane C, Sarson T (1979) Structured systems analysis: tools and techniques. Prentice-Hall Inc. ISBN: 0-13-854547-2
24. De Marco T (1979) Structured analysis and system specification. Prentice-Hall Inc. ISBN:0-13-854380-1
25. Royce WW (1970) managing the development of large software systems, In: Proceedings of IEEE WESCON, August 1970
26. Gamma E, Helm R, Johnson R, Vlissides J (1995) Design patterns: elements of reusable object-oriented software. Addison-Wesley. ISBN: 0-201-63361-2
27. Pressman RS (2004) Software engineering: a practitioner's approach. The McGraw-Hill Companies. ISBN: 007301933X
28. Waldner JP (1992) CIM: principles of computer integrated manufacturing. Chichester: John Wiley & Sons Ltd, p 47. ISBN: 047193450X
29. The Federal Architecture Working Group (FAWG) (2001) A practical guide: federal enterprise architecture framework, Version 1, February 2001. http://www.gao.gov/bestpractices/bpeaguide.pdf
30. The Department of Defense Architecture Framework (DoDAF). http://www.defenselink.mil/cio-nii/docs/DoDAF_Volume_II.pdf
31. CIO-Council (1999) Federal Enterprise Architecture Framework version 1.1. http://www.cio.gov/Documents/fedarch1.pdf
32. Enterprise modeling: white paper, Center of Excellence in Enterprise Architecture-CEISAR, April 2008. http://www.ceisar.org/
33. Le Moigne JL (2002) La modelisation des systemes complexes, Dunod
34. Le Moigne JL Les formalismes de la modelisation systemique. http://www.mcxapc.org/docs/ateliers/0505formalismesvfr.pdf
35. Pascot D (2007) Conception des SIO, lecture notes, Management Information Systems Department, Faculty of Business Administration, Laval University, Quebec, Canada. http://loli.fsa.ulaval.ca/index.php?id=478
36. Tardieu H, Nanci D, Pascat D (1979) Conception d'un systeme d'information : Construction de la base de donnees, Edition d'organisation
37. Wang SJ, Middleton B, Prosser LA, Bardon CG, Spurr CD, Carchidi PJ, Kittler AF, Goldszer RC, Fairchild DG, Sussman AJ, Kuperman GJ, Bates DW (2003) A cost-benefit analysis of electronic medical records in primary care. Am J Med 5(114):397–403
38. Gans D, Kralewski J, Hammons T, Dowd B (2005) Medical groups' adoption of electronic health records and information systems. Health Aff 5(24):1323–1333

39. Miller RH, Sim I (2004) Physicians' use of electronic medical records: barriers and solutions. Health Aff 2(23):116–126
40. Silberzahn N (1997) Le dossier medical informatise : modelisation et consultation. Ph.D. Thesis, Faculte de medecine, Universite de Caen, France, December 1997
41. Mougin Y (2004) La cartographie des processus: maitriser les interfaces, La methode de la voix du client, 2eme edn, editions d'organisation. ISBN: 2-7081-3106-0
42. Gagon-Argion L, Vien H Typologie des documents des organisation: de la creation a la conservation, Presses de l'Universite du Quebec. ISBN: 2-7605-0943-5
43. Shapiro JS, Bakken S, Hyun S, Melton GB, Schlegel C, Johnson SB (2005) Document ontology: supporting narrative documents in electronic health records, In: Proceedings of AMIA annual symposium, pp 684–688
44. Canada Health Infoway- Inforoute Sante Canada (2008) http://www.infoway-inforoute.ca/
45. Systematized Nomenclature of Medicine-Clinical Terms, The International Health Terminology Standards Development Organization (IHTSDO) 2008. http://www.ihtsdo.org/
46. Logical Observation Identifiers Names and Codes (2008) http://loinc.org/
47. Health Level Seven (2008) http://www.hl7.org/
48. Logical view of message model PRPM_MT303010CA—Update Provider (2008) Direction adjointe a l'architecture et aux orientations technologiques (DAAOT), The Ministry of Health and Social Services (MSSS), Quebec, Canada
49. SILVERRUN Modeling Tools, Grandite (2008) http://www.modelsphere.com/
50. Schulte RW, Natis YV (1996) Service-oriented architectures, Gartner Research Report, Part 1, SPA-401-068
51. Bonnet P, Detavernier J-M, Vauquier D Le syteme d'information durable: la refonte progressive du SI avec SOA, Editions Hermes-Science. ISBN:978-2-7462-1829-1

Author Biographies

Daniel Pascot is professor and director of the Département des systèmes d'information organisationnels (SIO) de la Faculté des Sciences de l'Administration de l'Université Laval. He founded in 2009 the Centre de Recherche et de Transfert en Architecture d'Entreprise (CeRTAE). He holds a Ph.D. from Aix-En-Provence (1975). He participated in France in the development of the Merise method and later in Québec created the Datarun method and the Silverrun Case tools. He was involved in many development projects and is managing a contract to develop the information architecture for the ministère de la santé et des services sociaux du Québec.

Faouzi Bouslama received his M.Sc. degree in Electrical Engineering from Ibaraki University, Hitachi, Japan, in 1989, and his Ph.D. degree in Electronic Engineering from Shizuoka University, Hamamatsu, Japan, in 1992. From 1992–1994, he was a Researcher at Toshiba Corporation, Tokyo, Japan. From 1994–2000, he was an Associate Professor at the Faculty of Information Sciences, Hiroshima City University, Japan. He joined Zayed University, UAE, in 2000 as an Associate Professor at the College of Information Systems where he was promoted to full Professor in 2004. Presently he is a Research Professional and Instructor at the MIS Department, Faculty of Business Administration, Laval University, Quebec, Canada. He published over 80 papers and serves as program committees of several international conferences. His research interests include Information systems analysis and design, Information and enterprise architectures for government, Building dimensional data warehouses, Data mining and exploration, and Intelligent systems.

Sehl Mellouli is an Associate Professor at the Management Information Systems Department, Université Laval, Quebec, Canada. He received his Ph.D. in Computer Science from Laval University in 2005. His main research interests include issues related to multi-agent systems, semantic web, ambient intelligence and information systems design. His research has been published in international journals and conference proceedings.