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83

Turo Kilpeläinen

Genre and Ontology based Business Information Architecture Framework (GOBIAF)

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UNIVERSITY OF JYVÄSKYLÄ

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Editors
Seppo Puuronen
Department of Computer Science and Information Systems, University of Jyväskylä
Irene Ylönen, Marja-Leena Tynkkynen
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ABSTRACT

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In process industries especially, there is a growing acceptance of a domain-specific view in which business units within organizations are seen as an organized whole, functioning and developing as a totality. Business units within geographically dispersed business processes often diverge significantly from each other, leading to a situation where daily collaboration becomes difficult. To pursue integration between these units, a holistic but still comprehensive view distinguishing the fundamental characteristics of process industries is needed. The objective of this thesis is to provide a business information driven approach for enterprise architecture (EA) development, building upon high cohesion of business (processes) and information needed to operate the business. We use communication genres and information need interviews as a domain analysis method. Ontologies are used as a representation mechanism for the results to represent not only the existing resources but also the organizational requirements in Business Information Architecture (BIA) descriptions. Thus, GOBIAF satisfies the need for approaching EA development from a specific viewpoint with limited resources. Contributions and experiences of the Genre and Ontology based Business Information Architecture Framework (GOBIAF) application are described in the research articles, illustrating the phases of action research cycles in a long-term research collaboration in a process industry organization. The results suggest that GOBIAF brings independent business information forth for strategic decision making. Because 50 % of information flowing in business processes takes place outside information systems, only a half of total business critical information to be modeled in information architectures is taken into consideration when system architecture biased EA frameworks are applied. Thus, the use of GOBIAF can be rationalized for environments where the role of information and its management form an instrumental success factor of an enterprise. From a research viewpoint, GOBIAF brings closer the practical utility and the (initial) goals of the total EA development approach.

Keywords: Strategic information management, enterprise architecture, business information architecture, architecture descriptions, architecture development process, ontology, genre, business/IT alignment

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Author's address Turo Kilpeläinen
Department of Computer Science and Information Systems
University of Jyväskylä, Finland
P.O. Box 35 (Agora), 40014 University of Jyväskylä
tukilpe@cc.jyu.fi

Supervisors Pasi Tyrväinen
Department of Computer Science and Information Systems
University of Jyväskylä, Finland

Tommi Kärkkäinen
Department of Mathematical Information Technology
University of Jyväskylä, Finland

Reviewers Sandeep Purao
College of Information Science and Technology
Pennsylvania State University Park, PA, USA

Andreas L. Opdahl
Department of Information Science and Media Studies
University of Bergen, Norway

Opponent Mika Hannula
The Institute of Business Information Management
Tampere University of Technology, Finland

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II Tyrväinen P., Kilpeläinen T. & Järvenpää M. 2005. Patterns and Measures of Digitalisation in Business Unit Communication. International Journal of Business Information Systems, 1 (1/2), 199-219.

III Kilpeläinen T., Tyrväinen P. & Kärkkäinen T. 2006. Leveraging the Concept of Product Model in Process Industries. In Proceedings of the 1st Nordic Conference on Product Lifecycle Management. Gothenburg: Chalmers University of Technology, 63-74.

IV Kilpeläinen T. 2006. The Missing Link between Product Data Management and Organisational Strategies. In J. Ljungberg & M. Andersson (Eds.) Proceedings of the 14th European Conference on Information Systems [CD-ROM]. Gothenburg: Göteborg University.

V Kilpeläinen T. 2006. From Genre-based Ontologies to Business Information Architecture Descriptions. In S. Spencer & A. Jenkins (Eds.) Proceedings of the 14th Australasian Conference on Information Systems [CD-ROM]. Adelaide: Australasian Association of Information Systems.

VI Kilpeläinen T. & Nurminen M. 2007. Applying Genre-Based Ontologies to Enterprise Architecture. In M. Toleman, A. Cater-Steel & D. Roberts (Eds.) Proceedings of the 15th Australasian Conference on Information Systems [CD-ROM]. Toowoomba: University of Southern Queensland.

VII Kilpeläinen T. 2007. Business Information Driven Approach for EA Development in Practice. In M. Toleman, A. Cater-Steel & D. Roberts (Eds.) Proceedings of the 15th Australasian Conference on Information Systems [CD-ROM]. Toowoomba: University of Southern Queensland.

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1 INTRODUCTION

This section provides introductory knowledge to the content of the thesis by clarifying the fundamental issues related to motivation, research domain, and objectives, as well as the methodologies that have influenced the thesis work. That is, this section complements and binds together the included articles and expands the discussion in order to explain the utility and contribution of the thesis.

1.1 Background

This section explicates the underlying motivation of the thesis. Further, the fundamental terminology is provided in this section.

1.1.1 Motivation

Economic pressure has constrained organizations making them to focus on their core businesses. Tightened budgets and overall need for specialization have put organizational IT functions under rigid strategic considerations (Reich & Nelson, 2003). As a consequence, most of the large enterprises no longer develop information systems (IS) internally. Instead, they acquire and integrate Enterprise System (ES) packages to create a desired backbone for their organizational activities. This trend has two apparent implications. First, the traditional software development tools may become insufficient to represent the business critical issues (Hirvonen, 2004) that pose requirements and directions for ES procurement and customization processes. Second, without a formal and abstract method to describe the organization-wide business critical information (requirements), enterprises may not have control over their business (process) and information architecture descriptions. This is because they have to adopt the information and process models embedded in the software packages used.

The importance of information and knowledge as the core of intellectual and social capital of an organization has widely been acknowledged (e.g., Na-

hapiet & Ghoshal, 1998). Today successful learning business organizations are trying to climb up the so-called information ladder (Longworth & Davies, 1996, p. 93) motivated by the impact of information, or rather the lack of it, on the execution of all kinds of activities in business and production processes (Dietz *et al.*, 1998). Information modeling initiatives suggest that information used and communicated to operate the business is the most permanent aspect of contemporary organizations (e.g., Watson, 2000). That is, business processes and services as well as applications and technologies have changed their ways to manage, represent, and communicate information, but the information itself has remained almost unaltered. Due to information overload (De Alwis, Majid & Abdus, 2006) management and dissemination of business critical information is becoming more and more important strategic objective for today's organizations (Evernden & Evernden, 2003).

Identifying an architecture of an enterprise is an activity concentrating on certain business critical aspects that shape and set the characteristics for an enterprise. Generally speaking, Enterprise Architecture (EA) is an overall blueprint for applying information technology (IT) to achieve business objectives (van den Hoven, 2003). Because of the software architecture biased history of EA (e.g., Ekstedt, 2004; Pienimäki, 2005), existing EA frameworks seem to approach EA development mainly from the technical aspects of an organization. Defining business critical information through examining information communicated to operate business (processes) seems to provide another and potential extreme. Information in certain forms of deliverables, or information objects (e.g., production reports and work orders), has the function of making the execution of preceding activities in business processes possible. The reported high cohesion of business (processes) with information needed to operate the business (Kock & McQueen, 1996) seems, thus, to provide a novel point of approach for EA development.

The role of holistic tools and frameworks aiding the analysis, development, and maintenance of business critical success factors (e.g., information and knowledge management) is emphasized to aid better integration and collaboration in geographically dispersed and heterogeneous business environments. In its essence, the concept of EA was initially developed to aid organization-wide IT-related strategic considerations, thus acting as a strategic decision making tool within organizations. In addition to acting as a bridge between business and IT (Young, 2001), the role of EA is to provide a link (i.e., common ground) between the top management level and the operative level within organizations. Thereby, EAs traditionally aim at aiding communication between stakeholders (Richardson, Jackson & Dickson, 1990) in both horizontal and vertical directions. By *vertical communication* we mean communication taking place within organizational hierarchical structures. Typically, this kind of communication takes place through distinct functions. In case of information systems, we talk about application silos (see Ross, 2003). By *horizontal communication* we mean communication crossing the physical and/or artificial boundaries that exist between organizational entities such as dispersed business units. In silo

like application landscapes, different kinds of integration mechanisms (e.g., traditional enterprise application integration and service oriented architecture based solutions) should exist to enable the integration of the required data.

Traditionally, EA projects have been initiated based on several driving forces (e.g., Beznosov, 2000). Turbulent business environment has forced continuous alterations to business strategies, requiring revisions to IT. At the same time, operating budgets have been cut down substantially, making it more difficult or often impossible to undertake projects to build more flexible and functional IT infrastructure. On top of the infrastructure, applications that manage business critical information are supposed to be developed. Increased complexity of the IT infrastructure as well as the wide plethora of new and emerging technologies have negatively impacted on IT's ability to support business needs and requirements. There have been many difficulties in obtaining funding for long-term initiatives, such as EA projects, that yield longer term returns (Gotze & Christianssen, 2006). It is, however, apparent that benefits derived from EA initiatives are substantive (e.g., Schekkerman, 2004). Different kinds of direct benefits (e.g., cost reduction), indirect benefits (e.g., risk minimization), and inferred benefits (e.g., productivity gain) are often put forth in EA sales materials.

Architecting heterogeneous environments is a challenging task, involving critical challenges and problems (Kaisler, Armour & Valivullah, 2005). The full value of architecture descriptions is only realized when they are linked together in a way that recognizes the common shared elements and relationships at the information level (Akerman & Tyree, 2006). Instead of continuing to elaborate the existing mechanisms to present information in architecture descriptions (cf. Jonkers *et al.*, 2003), an expressive and flexible architecture description language should be adapted. Further, we need an architecture model, concentrating on and putting forward the soft side (business and information) of an organization (see Ylimäki & Halttunen, 2005). The domain analysis method must support the requirements of the EA framework, including its description language. Among other requirements there are the requirements that the business critical information can be found in its initial context, that business processes and information representing them can be integrated, that (information) content can be linked to (information creation) context (see Jokela, 2001), that information in the form of information objects can be described expressively and consistently, and that data definitions are understandable and available to provide a wide variety of data exploitation possibilities. All these requirements should, then, be organized in an architecture framework, aiding synergy between its elements. In this thesis, Genre and Ontology based Business Information Architecture Framework (GOBIAF) is developed to meet these requirements. Business Information Architecture (BIA) is an aspect of total EA satisfying the need for approaching EA development from a specific viewpoint instead of elaborating all the views. Thus, EA work can be initiated with limited resources.

1.1.2 Terminology

The intuitive idea that knowledge is something more than information has led many authors to make distinctions between raw data, information, and knowledge (Tuomi, 1999). Moreover, it is assumed that we first need to have data before information can be created, and only when we have information, knowledge can emerge. Within this thesis, *data* is perceived as simple facts, symbols or numbers that can be structured to create information (Quigley & Debons, 1999; Tuomi, 1999). Data is also a set of discrete facts (Choo *et al.*, 2000; Davenport & Prusak, 1998) or simple observations of the world (Davenport, 1997), which have not yet been interpreted (Spek & Spijkervet, 1997).

Information consists of facts and data that are organized to describe a particular situation (Wiig, 1993). Information is also seen as a commodity, product, or thing (Quigley & Debons, 1999) that can be owned, bought, and sold (Poster, 1990; Wildavski, 1983). According to Stenmark (2002) information can be made tangible and represented as objects outside the human mind. Knowledge, on the other hand, is a much more elusive entity (ibid.). Information becomes knowledge when it is interpreted, put into context, or when meaning is added to it (Tuomi, 1999). *Knowledge* is seen as a justified true belief (Choo *et al.*, 2000) and as an enabler for people to assign meaning and thereby generate information (Spek & Spijkervet, 1997; Nonaka & Takeuchi, 1995).

By *information object* we mean anything that can be addressed and manipulated by a human or a system as an identifiable entity (Lagoze & Van de Sompel, 2007). Information objects derive from organizational culture and its permanent vocabulary, and are used in everyday tasks. The name of an information object may be artificial, and its role is to aggregate related data and knowledge to form logical packages describing real-life entities (see Lagoze & Van de Sompel, 2007). As an example of an information object, a *trial point* is addressed in the included articles (e.g., Kilpeläinen & Nurminen, 2007). The term 'trial point' (see Table 6) is a target domain specific concept representing a state of a production process within a specific timeframe by characteristic properties of quality measurements and process indicators. The term ‘information concept’ is used in conjunction with the term ‘information object’ in the included articles. These two concepts correspond to each other in a semantic sense.

An *information system* is a computer based portion of a business system, where a business system includes the hardware, software, policy statements, procedures, and people that together implement a business function (The Open Group, 2006). Thus, information systems use information technology to capture, transmit, store, retrieve, manipulate, and/or display information used in one or more business processes (Alter, 1996). *Information systems development* is perceived as a change process with respect to systems in a set of environments by a development group using tools. It is also an organized collection of techniques collectively referred to as a method to achieve or maintain some objectives (Tolvanen, 1998). Information systems differ from *applications* in a sense that applications are special types of computer programs designed to perform specific tasks (The Open Group, 2006). *Enterprise systems* (ES), in turn, are usually com-

mercial, enterprise-wide software packages that impose their own logic on a company's strategy, culture, and organization (Davenport, 1998). The initial focus of ESs was to execute and integrate internally oriented applications, supporting and harmonizing general and cross-organizational functions such as finance and human resources. Traditional examples of ESs are Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Supply Chain Management (SCM) systems.

In a conceptual level, organizations and enterprises are synonymous but with slightly different connotations. Enterprise usually means a group of people organized for a particular purpose to produce a product or provide a service (O'Rourke, Fishman & Selkow, 2003). In the context of EA, enterprise can be used to denote both an entire enterprise, encompassing all its information systems, and a specific domain within an enterprise (Pienimäki, 2005). Enterprise is also defined as an organization (or cross-organizational entity) supporting a defined business scope and mission (CIO Council, 2001). The definition implies that organization is a subordinate for an enterprise but both concepts share characteristics. However, in this thesis we refer to the target organization for empirical work as *organization*. The term *enterprise* is used when organizations are discussed in a general manner.

Architecture is perceived here as a structure whether physical or conceptual, real or virtual, formed of components, their interrelationships, and the principles and guidelines governing their design and evolution over time (CIO Council, 1999; O'Rourke, Fishman & Selkow, 2003). Thus, as defined earlier, *Enterprise Architecture* (EA) is perceived here as the overall framework or blueprint for an enterprise to employ information technology to achieve its business objectives (van den Hoven, 2003). *Business Architecture* defines business processes, information flows, and information needed to perform business functions in relation to the organizational mission and goals (CIO Council, 1999). *Information Architecture* is a high level map of the information requirements of an organization showing how the major classes of logical and physical information assets are related, first, to each other, and, second, to major business processes of the organization (cf. Brancheau, Schuster & March, 1989; Pienimäki, 2005). Thereby, *Business Information Architecture* (BIA) is aimed to define business processes, information flows, and information objects needed to perform business functions within and between organizations. Further, business information architecture depicts how the contents and semantics of information objects are mediated, first, between themselves, and, second, between major functions/business processes of the organization (cf. Brancheau Schuster & March, 1989; Pienimäki, 2005, CIO Council, 1999). *Application Architecture* is a set of business applications needed to manage (create and use) information and support business functions (van den Hoven, 2003; Pienimäki, 2005). *Technology Architecture* is a physical depiction of the technology environment including procedures and instructions on how to organize IT resources (Seger & Stoddard, 1993; CIO Council, 1999). *Systems Architecture* (SA) identifies applications and technologies used to provide and manage information to support business operations.

A framework is a logical structure for classifying and organizing complex information (CIO Council, 1999). Frameworks do not usually include explicit and rigid mechanisms and models to aid architecture descriptions, which are perceived as a collection of products to document an architecture (IEEE, 2004). An *architecture framework* assists in developing, analyzing, and managing EAs (Pienimäki, 2005), describing a method for designing solutions (e.g., information systems) in terms of a set of semantically interconnected building blocks (The Open Group, 2006). It also contains a set of tools and provides a common vocabulary (ibid.). That is, EA frameworks are used as a mechanism to structure and integrate the elements that are required to develop an EA. The main difference between architecture frameworks and *architecture models* is that an architecture model focuses on certain aspects of total EA. In case of GOBIAF, we talk about architecture model as GOBIAF does not include all the aspects of EA at this point of time. When GOBIAF is leveraged to cover the SA side of EA (see the discussion later), we can start calling it an architecture framework.

Genres are prototypical models for communication (Swales, 1990). Genres of organizational communication represent a typified piece of information, responding to a recurrent communicative situation, carrying an identified name, serving specific purposes, and enacting social substance(s) and form(s) (Yates & Orlikowski, 1992; Orlikowski & Yates, 1994). Thereby, genre instances usually include domain specific information object(s) expressed as part of organizational communication. Genre systems (Bazerman, 1994) represent the communication of a process according to the rules typical for the community of users / practice (CoU/CoP (Orlikowski & Yates, 1994)), while in industrial processes machine readable data is used extensively. Information management of an organization manages both the process data and the genre repertoire (ibid.) related to human communication of an organization.

Open and semi-structured information need interviews (see Yin, 1994, Fontana & Frey, 2000) are perceived within this thesis as an approach to support ontology and BIA development by deepening the qualitative results derived from the genre analysis. That is, information need interviews are applied here as a tool to discuss issues at hand in an open but still structured atmosphere, assuring focused interviews. An *ontology* is an explicit specification of conceptualization (Gruber, 1993). When discussing ontologies not just in a conceptual level but also in an implementation level, one should note that the concepts of data, metadata and ontology are highly interdependent and context-specific. Informally, ontologies can be regarded as vocabularies (or schemas) for metadata (Antoniou & van Harmelen, 2004). This means, for example, that ontology may contain both class definitions and instances of classes, whereas metadata is concerned only with instances. *Metadata* is perceived here as data about data.

A *development process* is perceived as a specific ordering of work activities across time and place, with a beginning, an end and clearly identified inputs and outputs (Davenport, 1993). *Methods* (or *methodologies*) should be understood as predefined and organized collections of techniques and sets of rules that state by whom, in what order, and in what way the techniques are used (Smo-

lander, Tahvanainen & Lyytinen, 1990). A *research method* is a strategy of inquiry that moves from the underlying philosophical assumptions to research design and data collection (Myers, 1997). A *technique* is a procedure, possibly with a prescribed notation, to perform a development activity (Brinkkemper, 1996). Thus, a technique is an essential part of a method, specifying the accomplishment of development activities. *Architecture development process* is a specific ordering of work activities across time and place that normally begins from acquiring information required to model an *as-is* architecture and ends when a *to-be* architecture is specified. Within this thesis, architecture governance is not seen as belonging to the architecture development process but to a separate process. *Business process*, in turn, is a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer (Hammer & Champy, 1993). *Production process* is a practical process that aims at delivering products or services to customers. Thus, a *production process line* is perceived here as a set of sequential operations established in a geographically dispersed production environment where material flows through a predefined process to produce an end product.

1.2 Prior Research on EA

This section discusses the state of EA research in general and critically analyses relevant EA frameworks and EA taxonomies. At the end of this section, the EA taxonomy of this thesis is provided.

1.2.1 State of the EA as a Research Field

Even though EA as a research discipline has its roots in the early 70's, well documented pure EA studies are still more than scarce. The academics seem to focus on the theoretical aspects of EA whereas practitioners are well ahead in applying the existing frameworks and their instantiations in practice (Beznosov, 2000). Thus, in spite of EA being quite new (Langenberg & Wegmann, 2004) it is a highly applied research discipline. This is because there seem to be no consensus in the field what, for example, the commonly accepted set of concepts, tools, and viewpoints to construct valid architecture descriptions are (e.g., Ylimäki & Halttunen, 2005). Throughout its history, EA has been applied most often in the government (Gotze & Cristianssen, 2006) and in the defense sector (e.g., Hjort-Madsen, 2006; Janssen & Hjort-Madsen, 2007). Extensive industrial studies, particularly those related to process industries, cannot be found. To give a quick glance on the state of the EA field in general, we reflect the findings of a survey made in the governmental sector on a national level (Gotze & Christianssen, 2006).

The results of the study of Gotze and Christianssen (2006) show that EA is emerging fast on a national level, because over 90 % of the participating governments (14 nations in total) are already having or planning to have a national

EA program within the next two years. Only about a half of the governments have succeeded in a limited realization of the EA goals, fewer than a half of them measure the EA program performance (see Rico, 2006), fewer than one fifth currently calculate the ratio of EA benefits to cost, and fewer than one third know whether their published EA processes are being used. In addition, the physical abstraction level is covered only by 28 % of the governments, and 67 % of the governments have no guidelines suggesting a specific modeling approach or tool to use. This implies that only 36 % of governments are using commercial EA tools. As a consequence, only few governments have a central data repository for architecture descriptions.

The research shows that 44 % of the governments use the so-called traditional EA frameworks, mainly the Zachman framework, as the baseline or inspiration in their EA work. However, existing EA frameworks have been criticized about being focused on technical aspects of organizations (e.g., Ekstedt, 2004; Pienimäki, 2005). Partly for that reason, the existing EA models and frameworks concentrate on information already managed in digital formats (see Niederman, Brancheau & Wetherbe, 1991). As EA is not just IT anymore (Mayo & Tiemann, 2005), it should be possible to incorporate non-digital information and knowledge in architecture descriptions as well. In addition, the excessively pervasive and complicated (Hirvonen & Pulkkinen, 2004) nature of the existing EA frameworks and models for development, implementation, and maintenance is seen as the major impediment of EA. The reasons for this can found in inefficient domain analysis methods (Pienimäki, 2005), in a high level of abstraction (Teng & Kettinger, 1995), and in inconsistent information representation mechanisms (Vogel & Wetherbe, 1984; Brancheu & Wetherbe, 1987).

1.2.2 Analyzing Relevant EA Frameworks

The so-called shell model is developed and traditionally used for characterizing different methodological facets that are neither exclusive, nor orthogonal. According to Tolvanen (1998) each type of facet of the shell model complements the others, and all types are required to yield a "complete" method. The shell model builds upon the idea that all methods are, or at least should be, based on some conceptual structure. The *conceptual structure* of a method is represented with some modeling technique through which the models are formulated with some *notation*. Further, the *processes* that a method includes define how and in which phase of the method the modeling techniques are used. These processes are based on the notation of the method. *Participation and roles* concern the different roles involved in the process. Every method should also have some *development objectives and decisions* to meet the need of the development process. Further, there are some *values and assumptions* of the reality embedded in the method that are modeled during the method use and development. EA frameworks should be regarded as approaches, and in some cases even as methodologies, with a specific and diverging mindset, that provide a basis for EA development. We believe that the categorization of issues (methodological facets) in the shell model can help in bringing forth the fundamentals of the EA

frameworks also. Further, the shell model provides a unique categorization of the facets the frameworks are built upon.

In the literature, there are quite a few reasonably thorough evaluations related to recent EA frameworks (e.g., Leist & Zellner, 2006; Greefhorst, Koning & Vliet, 2006). In such evaluations, TOGAF (The Open Group, 2006), the Zachman framework (Zachman, 1987; Sowa & Zachman, 1992), and FEAF (CIO Council, 1999) are frequently depicted and evaluated from among the jungle of EA frameworks and models, reflecting the fact that these frameworks are the most cited, used, and elaborated/applied in practice. In Table 1, the fundamental elements of the TOGAF, Zachman, and FEAF frameworks are presented in accordance with the fundamentals of the shell model (Tolvanen, 1998). The table shows the main similarities and differences of the frameworks. Generally speaking, the Zachman framework has drawn the line for the EA discipline as a whole - the framework was the one and only framework for a long time. Developed for the aircraft manufacturing industry in the mid-1980s, the Zachman framework today requires tailoring when utilized. There are at least two reasons for that. First, the way the Zachman framework is used in these days is as an extensive reference model for architecture development from which the most essential parts of the matrix are selected, applied, and developed case-by-case. Second, an architecture development method and tools as well as modeling approaches must be adopted because the Zachman framework only recommends possible mechanisms but does not force their use.

Currently, the most relevant contribution of the Zachman framework is the explicit decomposition of EA into distinctly defined views. In addition to the structure of the matrices of the Zachman framework and FEAF that are used to describe different views of an organization (as architecture descriptions), it is easy to observe from Table 1 that FEAF was developed based on the fundamentals of the Zachman framework. For this reason, FEAF does not provide a significant contribution to the body of knowledge in the methodological sense. As it was the case in the Zachman framework, FEAF does not contain a detailed description of how distinct deliverables for each cell in the architecture matrix should be generated. Further, only a high-level, unspecified approach for architecture development is presented.

TABLE 1 Fundamental elements of traditional EA frameworks analyzed by using the facets of the shell model as attributes of the frameworks.

Facet	TOGAF (The Open Group, 2006)	Zachman framework (Zachman, 1987)	FEAF (CIO Council, 1999)
Conceptual structure	Agnosticity about what modeling approaches or tools to use, but does not get into detail on models.	Specific reference modeling techniques recommended in distinct cells in the 5*6 matrix.	Component and model-based architecture (5*3 matrix) with an asset base.
Notation	No modeling notations specified, but in some phase of ADM, certain techniques are proposed.	Different techniques and graphical representation mechanisms are appropriate for different cells, e.g., data flow diagrams and ER-diagrams.	The framework does not contain architecture content, but rather, is a placeholder for the content once developed.
Process	Clearly articulated and prescriptive ADM, consisting of 1+8 iterative phases.	There is no guidance on sequence, process, or implementation of the framework.	An unspecified EA development approach is represented. The activities are: data collection, preliminary product generation, review and revision, and publication and delivery.
Participation and roles	No specific role description exists.	Depending on what ADM is adopted, planner, owner, designer, builder, and subcontractor work on their own abstraction levels and with their concepts to aid in EA descriptions.	A list of functional roles and associate responsibilities assigned to EA core team members. The core team consists of a planner, an owner, and a designer.
Development objectives and decisions	To support business by providing fundamental technology and process structure for an IT strategy.	To provide a taxonomy for relating the concepts that describe the real world to the concepts that describe an information system and its implementation.	To promote shared development for common processes, interoperability, and sharing of information among operating parties.
Values and assumptions	Strategic context for the evolution of the IT system in response to the constantly changing needs of the business environment should be supported. Further, the right balance between IT efficiency and business innovation should be identified and supported.	The world contains entities, processes, locations, people, time, and purposes. Computer systems are filled with bits, bytes, numbers, and programs that manipulate them. If the computer is to do anything useful, the concrete things in the world must be related to the abstract bits in the computer.	Architectures should serve as a reference point to facilitate coordination of common business processes, information flows, systems, and investments. In time, business processes and systems will operate seamlessly in an EA that provides models and standards that identify and define the information services used.

TOGAF is a detailed, industry standard architecture framework, using a set of supporting tools (i.e., TOGAF Enterprise Continuum and TOGAF Resource Base) in architecture development. In its essence, TOGAF is an architecture method and a resource base. When compared to the two other frameworks described above, TOGAF contributes where the other two frameworks are in their weakest. That is why especially the Zachman framework is applied by utilizing an instantiation of the Architecture Development Method (ADM) and, in some cases, the governance material from TOGAF. Instead of using TOGAF's ADM, FEAF supports the usage of Enterprise Architecture Planning (EAP) methodology (Spewak & Hill, 1993). However, there are no special constraints that would prohibit the usage of TOGAF's ADM during FEAF development.

As a conclusion of the content of Table 1 and discussion so far, the existing EA frameworks seem to be directed to provide structure for holistic business and IT alignment. The direction of emphasis is, however, technically-oriented, lacking operative and business viewpoints. Especially in the matrices of the Zachman framework and FEAF, enabling technologies are seen as separated from business planning and design. Further, the use of view-based architecture may easily result in application silos, as target architectures are dictating architecture development (see DODAF, 2007). In general, the frameworks differ in their terminology and modeling approaches. To maintain pervasiveness and extensiveness, the utilization of such a framework requires adopting a number of modeling approaches. In a situation of this kind, the interconnection between descriptions in diverging formats in distinct cells may seem minimal. Clearly, an incorporation of an EA tool (e.g., METIS or System Architect) is recommendable in this case. In addition, the architecture descriptions in the frameworks are static in a sense that they cannot be executed in information systems as a functional program code. Further, the frameworks do not seem to enforce the usage of architecture description repository. As an implication for this thesis, no complete models seem to exist to bring forth the business critical information side of organizations in architecture descriptions. Thus, this research builds upon the above described findings and contributes by providing an architecture model approaching EA development from the soft side of organizations.

1.2.3 Existing Architecture Taxonomies

Essentially, EA is a way of thinking, allocating and explicating organizational interconnections and semantics between its elements (e.g., business units, functions, and information systems), for example, in the form of a grid (e.g., Hirvonen & Pulkkinen, 2004). Within EAs, architecture taxonomy is used to depict sub-architectures and their interconnections that together form the EA. The importance of explicit specification of architecture taxonomy in EA models is emphasized, because the EA development is approached from a specific point of view. The chosen sub-architecture thus sets the scene for the development of the other parts of the EA as well as the EA itself.

We consider the soft side (business and information architectures) of contemporary organizations (Kilpeläinen, 2006a) to be a promising starting point in

decreasing the possibility of the traditional business/IT alignment problem. However, the fundamental problem in recent EA taxonomies (e.g., Pienimäki 2005, Morganwalp 2003) seems to be how to position informational issues when reflecting the dual nature (business and information as a soft side and applications and technologies as a hard side) of organizations. In Figure 1, a traditional EA taxonomy (CIO Council, 1999) is presented. In practice, the four sub-architectures are highly interconnected, setting constraints to each other. As the FEAF concentrates on the total EA instead of specific parts of it (the background color in Figures 1-3, which are related to the EA taxonomy, highlights the emphasis of distinct taxonomies), the structured approach where distinct sub-architectures are developed as individuals is not supported to a sufficient degree.

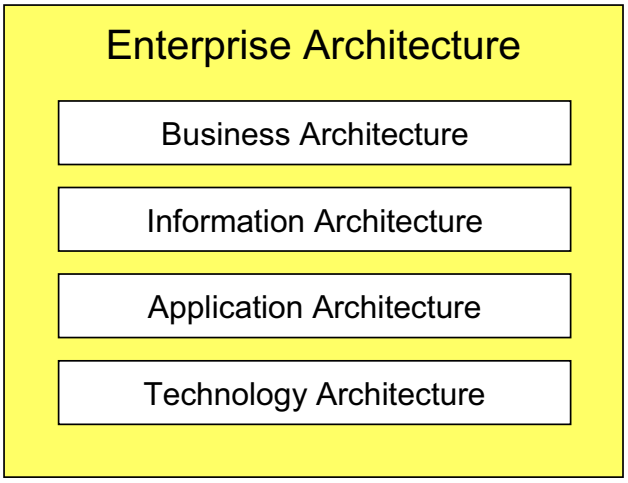


FIGURE 1 Architecture taxonomy of the Federal Enterprise Architecture (CIO Council, 1999)

In Figure 2, the taxonomy behind the business application architecture (Pienimäki, 2005), which is one of the first architectural models that satisfy the need to approach the total EA development from a specific single point of view, supports the division by categorizing the total EA to business and systems architectures. The systems architecture is further divided into information systems architecture and technical architecture, the former being composed of business application architecture and information architecture.

The categorization (Figure 2) seems to concentrate on information already managed in digital formats, because information architecture is placed on the hard side of the EA next to application architecture. The reality is that there is a lot of business critical information (i.e., tacit knowledge) that is not necessarily formalized to information systems, e.g., to digital documents. Thus, instead of placing information (architecture) on the hard side with applications and tech-

nologies, it might be better placed on the soft side with business architecture. The rationale for this is that information resides in organizations in all the elements that the business architecture consists of (Walsh & Ungson, 1991; Tyrväinen, 2003). Kock & McQueen (1996) stated that approximately 80 % of what flows in business processes in manufacturing organizations is information. At the same time, a network of independent entities, sharing experience, knowledge, and capabilities requires support for information flows among systems across enterprise boundaries (Naumenko *et al.*, 2005). Thus, as the general purpose of the technical side of an organization is to support the activities and requirements in the soft side of an organization, the lack of connection between business (processes) and applications seems to be a major flaw of the taxonomy presented in Figure 2.

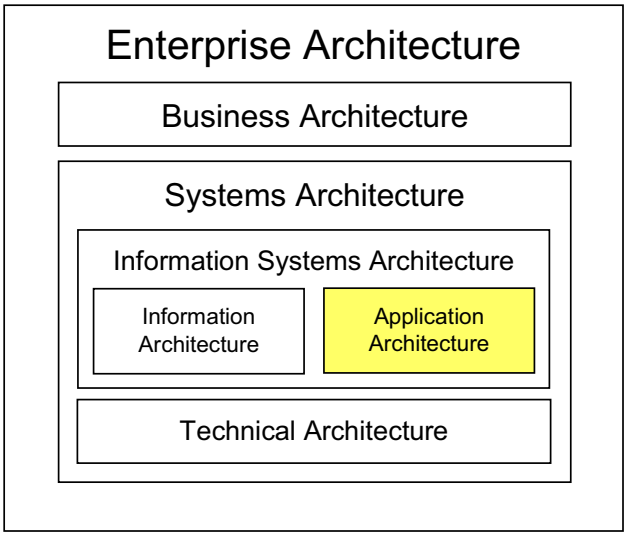


FIGURE 2 Architecture taxonomy of a business application architecture (Pienimäki, 2005, p. 45)

1.2.4 Architecture Taxonomy of this Thesis

The first impression regarding the presented taxonomies in the previous section is that applications are managed separately from the business (processes). This kind of a mental model reflects the traditional role and division of business and IT where business departments are "just" functions within an enterprise (see Kaarst-Brown, 1995). At the same time, IT is supposed to contribute to all organizational functions and activities. As the role as a function prohibits IT managers to reach function-specific requirements, the possibility of IT to operate wall-to-wall is minimal. In this kind of a situation IT departments manage IT as IT, not as IT to support specific business purposes. Thus, EA development should not be approached from technical directions (see Hirvonen, 2004). The

methodologies, tools etc. used in the EA development should support this fundamental premise.

The architecture taxonomy used in this thesis is presented in Figure 3. The idea of using architecture dimensions (Kilpeläinen, 2006a) in the taxonomy and, further, in the EA grid is that the grid itself cannot be perceived as the ultimate EA (cf. Hirvonen & Pulkkinen, 2004). That is, the grid can be regarded as an architecture framework (multidimensionality) whose usage, however, in direct decision making at the top management level is unlikely.

The fundamental sub-architectures of the taxonomy are derived from CIO Council (1999). The idea of categorizing the sub-architectures is adapted from Pienimäki (2005) but with a slightly different emphasis. As suggested earlier, information architecture is positioned next to business architecture to form Business Information Architecture (BIA). This kind of a categorization implies that information is loosely distinguished from the hard side, which, in turn, highlights the role of applications and technologies as supportive elements of business operations (Kilpeläinen, 2006a). The importance of information architecture as the connective element between the hard and soft sides of an organization becomes more evident here.

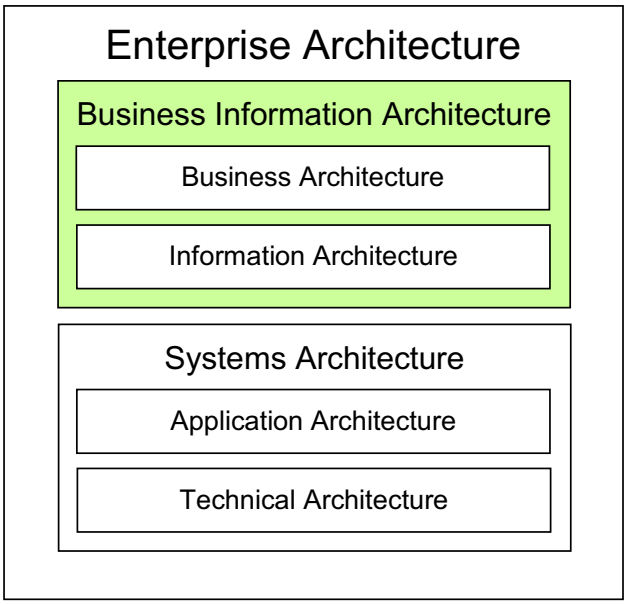


FIGURE 3 Architecture taxonomy used in this thesis

The counterpoint of BIA is Systems Architecture (SA), which is also divided into two sub-architectures: application architecture and technology architecture. As given here, SA deals with the issues related to the hard side of an organization. However, because technical issues can be overcome in a number of ways

in organizations (e.g., by applying commercial software packages or by preferring in-house software development) and, consequently, the tools vary based on the decision to which direction the organization will go, we leave the modeling of the technical aspects of the total EA to subsequent work.

In addition to showing the mindset through which the total EA is developed, the taxonomy presented in Figure 3 indicates the focus of the thesis as well. As we talk about EA framework and EA development, we mean BIA development, aiding EA development. Having stated that, we do not want to restrict ourselves to mere BIA development (by closing the door for leveraging GOBIAF to technical directions, for example). True organizational value is achieved only by incorporating the total EA in practice. We cannot develop a mere technology architecture without knowing the issues related to application, information, and business architectures of the EA (see Hirvonen, 2004). That is, the direction of EA development (see Table 2), as Hirvonen (2004) puts it, must be from left to right (from business architecture to technology architecture) and from top to down (from enterprise level to information systems level). We do not consider the modeling of the technical aspects of the total EA in this work.

TABLE 2 Principles of the EA taxonomy of the thesis

<table>
<tr><td colspan="4">EA</td></tr>
<tr><td colspan="4">Identifies organizational strategies and mission regarding how the enterprise uses ICT to achieve its business objectives in relation to the external factors (customers, environment…)</td></tr>
<tr><td colspan="2">BIA</td><td colspan="2">SA</td></tr>
<tr><td colspan="2">Identifies organizational relationships and information needs in business processes</td><td colspan="2">Identifies applications and technologies used to provide and manage information to support business operations</td></tr>
<tr><td>BA</td><td>IA</td><td>AA</td><td>TA</td></tr>
<tr><td>Underlying (organizational) structures of the business, business functions, business processes, service structure as well as their requirements</td><td>Information used, created, and stored in any defined BA or part of it</td><td>Logical structures of information systems and their interconnections</td><td>Tehcnology of information processing solutions, defined with a BA, IA, and AA</td></tr>
</table>

1.3 Target Domain

This section clarifies the target domain of the empirical work. The background provided here is used for evaluating GOBIAF later on in this thesis.

1.3.1 Geographically Dispersed Environments in Process Industries

In geographically dispersed environments, there is a long felt need for centralized information management related to decentralized business processes (Heimbigner & McLeod, 1985). In many cases, the entities (e.g., business units) within business processes lack the fundamental preconditions (e.g., shared vocabulary, information management principles, and organizational culture) which can aid in effective collaboration. Heterogeneous underlying structure of data is the key obstacle that makes elaborated data integration difficult, especially between application silos with diverging data models. Efficient and timely communication of business critical information in both vertical and horizontal directions has been seen as a prerequisite to rationalize, intensify, and develop alignment between related business units (e.g., Armour, Kaisler & Liu, 1999). With the aid of data level integration, a comprehensive data set, describing the information communicated, would provide extensive exploitation possibilities, e.g., for a reliable and exhaustive analysis of the business process in its entirety instead of by business unit by business unit. Thus, the difficulty in the management of distributed business processes is to specify, model, and manage the business critical information, the semantics within and between them, as well as the data representing them.

Large organizations in process industries are interesting targets for research in many ways. First, the nature and overall organization of the geographically dispersed business units vary because of the historical changes (i.e., mergers, acquisitions, subcontracting deals, and off-shoring) in power relations in process industries in general as well as within enterprises (e.g., Toivanen, 2005). Different business unit specific cultures, different levels of digitalization as well as diverging terminology and semantics disallow stepping one abstraction level above in order to examine the geographically dispersed business process as a whole. In these kinds of environments, a loosely managed integration type of approach for aiding collaboration between business units seems rational. According to the approach, heterogeneous business units are encouraged to organization-wide cooperation through managerial consolidation in order to reach synergies. However, the usage of ESs is not necessarily enforced because they alter some fine-tuned activities, taking place in distinct business units. Thus, high-level specialization cannot be supported with standard solutions.

Second, the importance of producing and managing information related to product and production processes for both internal (e.g., R&D and other business units) and external interest groups (e.g., customers or other counter parts of an extended enterprise) is increasing. Somewhat surprisingly, organizations in process industries are extremely technology-savvy. As an example, it is said that there is more technology in a modern paper machine than in an airplane. Thus, organizations aim at using highly valued knowledge arising from empirical activities in a wide variety of business objectives, e.g., for developing simulators and virtual prototypes. It is no more cost-effective if organizational memory is heavily based on the personnel's tacit knowledge. The need for digitalizing organizational business critical information and knowledge has become a

serious issue. However, several domain-specific constraints must be taken into account. According to (Naumenko *et al.*, 2005, p. 3), these include:

- product engineering processes and organizations extend across large enterprise systems with numerous heterogeneous data sources
- workgroups are geographically dispersed
- engineering drawings and engineering orders can amount to more than one million
- the problem of poor accessibility leads to a more general problem of data extraction from heterogeneous sources of information which usually are only partially structured
- insufficient information content
- documentation is difficult to maintain, mainly because of two reasons:
    - frequent change that causes documentation to be outdated soon, and
    - lack of collaboration between different interest groups across and even inside organizations
- the processes across the supply chain are mainly limited to companies' own points of view

1.3.2 Target of the Empirical Work

The practical aim in the case organization was to guide the alignment between distinct business units within a geographically dispersed production process line. This was to be done with the aid of a theoretically-sound and structured approach which could be utilized by all the parts of the corporation. The leading target of the research was to become aware of the practical working, naming, and information management practices and principles related to the production process line. Through this one would be able not only to evaluate the state of organizational information management but also to rationalize the identification of non-digital business critical information.

The fundamental problem in the target organization was that the business units along the production process line were not cooperating practically at all. In general, the business units had become so independent and autonomous that they did not see the organization as having any real substance (see Kohli & Kettinger, 2004). To aid in daily collaboration between the business units, especially when integrating unit-specific data describing the product and production process, it was found useful, for example, to intensify the subsequent analysis of the production process and customer service. Within this thesis, the role of product-related information is highlighted; it is the target of development, because its impact to other organizational activities is noteworthy, to say the least.

Table 3 recaps the organizational issues that were seen problematic from the perspectives of organizational performance and efficiency. The motivation of using EA as a tool to approach the issues has its origin in the academically reported results EA has provided. Based on the survey, other possible solutions, such as ITIL (2007) and COBIT (2007) as IT governance (processes) were not seen as providing the required structure, methodologies, and deliverables to examine and solve the issues with the limited resources at one's disposal. In

addition, EA as a research approach and backbone provided tools to discuss the issues iteratively, taking the practice and theory simultaneously into account.

TABLE 3 Organizational requirements in relation to the reported EA benefits

Organizational issues to be addressed	**Reported benefits EA have brought along related to the issue**
Better interoperability and knowledge sharing throughout the organization. In other words, business processes crossing the boundaries of geographically dispersed business units should be supported.	EA helps in creating insight, aiding communication between stakeholders (Watson, 2000; Richardson, Jackson & Dickson, 1990), and assessing the impact of changes within organizations (Jonkers *et al.*, 2003). EA provides a framework for planning and implementing a rich, standards based, digital information infrastructure with well-integrated services and activities (Watson, 2000) fostering order and structure (Inmon, Zachman & Geiger, 1997).
Guiding the alignment between distinct business units within a geographically dispersed production process line.	EA is a way to map the information needs of an organization, relate them to specific business functions, and document their interrelationships to guide software development and to facilitate integration and sharing of data (Brancheau, Schuster & March, 1989). Improved information flow among entities, reduced support costs for overall systems, and portability of software from one segment to another (Richardson, Jackson, and Dickson, 1990).
Evaluating and rationalizing the management/explication of non-digital business critical information (digital documents).	Because of its strategic notion, architectural descriptions can guide decisions about which applications should be built, highlight the required precedence for development, and suggest the required scope for each application in such a way that the resulting application and its data will fit into the overall plan for information systems (Brancheau, Schuster & March, 1989).
IT should support business requirements, e.g., better customer service.	EA acts as a bridge between the business and technical domains (Young, 2001). Further, EA reveals the redundancy and overlap in the business processes reducing information systems complexity (Cook, 1996).

1.4 Research Design

So far, we have set the scene for research by describing the motivational background of the study. Next, we first summarize the fundamental motivations, approaching the research from several viewpoints. After that, we address the actual research design that includes specifying research objectives and research questions. The research approaches and methods as well as the empirical research process through which the research questions are answered are also described.

1.4.1 Summary of the Motivations Vindicating the Research

Based on the content of the previous subsections, at least four clear themes arise that are relevant to this research, to process industries, and to the target organization (Table 4). All these interest groups approach the EA development from different viewpoints, posing specific requirements for those conducting research on the themes or issues presented in Table 4. The most obvious theme is whether EA is the right strategic tool for dealing with the issues in the domain specified. When going deeper in details, we should discuss whether business critical information should act as the fundamental baseline in EA development and, further, how the EA model itself as well as its development process should be orchestrated. In this way, the last three themes are highly interrelated.

TABLE 4 Summary of the motivations for the study from research, target organization, and process industries perspectives

Theme/ issue	Research	Process industries	Target organization of the case study
EA as a tool for strategic organizational information management	How organizational management principles in geographically dispersed and heterogeneous environments can be evaluated and developed by using EA?	Has EA as a research discipline reached the required level of maturity, being able to contribute significantly in practice to domains other than government and defense?	What benefits does EA, and BIA in particular, provide when compared to the existing solutions? What are the costs of applying BIA in practice?
BIA-driven approach for EA development	What elements an architecture model should contain to support specified practical requirements, being at the same time theoretically valid?	Do the fundamentals as well as tool selection provide a basis for extending the results to cover the entire process industry or other similar industries?	How cost effective and applicable is the development process?
The role of business critical information in the core of EA and BIA	How large a proportion of business critical information communicated in business processes is stored in digital formats?	Is the information flowing in business processes critical? Do we have to be aware of the state of its management?	How to depict information required to operate the business in its initial context? How is that knowledge explicated to aid in strategic decision making?
Model construction and governance of the BIA development process	How do the elements of GOBIAF complement each other to provide synergy between them in architecture descriptions?	How does BIA stand out from the jungle of EA frameworks, models, and approaches? Why should we invest in utilizing it?	Do the steps of BIA development process provide tangible deliverables that can be used for a wide variety of purposes? What are the maintenance costs of the descriptions?

1.4.2 Research Question and Objectives

The overall theme of the thesis is strategic organizational information management. The main research area thus emphasizes issues presented in the field of EA to bring forth the state of organizational information management in strategic decision making. To be specific, the fundamental phenomenon studied is the use of BIA as a viewpoint to develop and analyze total EA and to develop organizational information management.

This research focuses on exploring the potential uses of the soft side of an organization (i.e., business information architecture) as an approach for total EA development, and on the way such an approach can be used as a strategic mechanism to assist in the development of information management principles within organizations. The research goal, problem, and questions here are derived from Table 3 and Table 4 where the requirements and motivation for the study are presented from several viewpoints. The main goal of the dissertation is to:

> construct a light-weight business information architecture framework based on existing theories for differentiating, structuring, and representing business critical information to assist in the development of technical solutions in support of business operations for (geographically) dispersed organizations.

From the aforementioned research objective we can infer the main research problem of the study:

> How to define and support agile development of business critical information driven (enterprise) architecture descriptions for organizations where business processes cross the boundaries of a number of business units?

This problem can be decomposed into the following research questions:

1. What minimal elements are needed in an (enterprise) architecture framework to develop BIA descriptions?

2. How genres of organizational communication can be used as a domain analysis method to aid BIA development?

3. How to construct a BIA model and its adoption process in geographically dispersed, heterogeneous, and knowledge intensive environments?

The first research question is motivated by the issues collected with the empirical work reported earlier in this thesis. The second research question evaluates the use of genres in communication research in support of BIA development. That is, we demonstrate how the deliverables of utilizing genres in conjunction with open and semi-structured information need interviews as a domain analysis method to aid in BIA development. Further, we evaluate the value of a construction where ontologies are used as an architecture description language and

"repository" for architecture descriptions. The third research question is related to treating the organization under study as a particular environment where business processes cross the boundaries of separate business units. Here the context of GOBIAF is specified within the EA research field.

1.4.3 Research Approaches and Methods

The thesis uses three tightly interconnected research approaches (see Järvinen, 2001) that are applied in parallel. The conceptual-theoretical, the constructive, and the experimental approaches can, in fact, be regarded as aspects (or steps) of the action research (AR) methodology, which is used as the main research method in the thesis. The required theoretical background is acquired during the constructive work (the steps of diagnosing and action planning in the action research cycle (Figure 4)), and the constructions are used for experimentation (action taking and evaluating). The results of the constructive and experimental work (specifying learning) are used to refine the theory, i.e., GOBIAF. Accordingly, case studies (e.g., Yin, 1994) are applied within the distinct action research cycles. Case study enables us to study contemporary and complex social phenomena in their natural context, being one of the most widely used qualitative research methods in the IS field (De Vries, 2005; Yin, 1994; Walsham, 1995). Typically, case study and action research are forms of interpretative research. Interpretative research is usually qualitative in its nature, aiming to understand and explain social phenomenon while examining the researcher's own observations through theoretical presumptions (Myers, 1997).

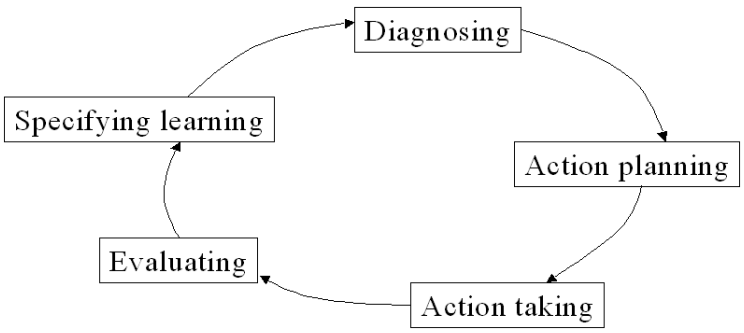


FIGURE 4 General action research cycles (adapted from (Susman & Evered, 1978))

As the research consists of both empirical and theoretical aspects, the above-mentioned action research (Susman & Evered, 1978; Kock *et al.*, 1999; Avison *et al.*, 1999) method provides the overall research framework under which both aspects are perceived (Kock, McQueen & Scott, 1997). The method used is both relevant and rigorous. In its essence, AR has been developed and used for business and IT research (Baskerville, 1997; Lau, 1997; Wood-Harper, 1985). To put it another way, AR is "one of the few valid research approaches that researchers

can legitimately employ to study the effects of specific alterations in systems development methodologies" (Baskerville & Wood-Harper 1996, p. 8). AR seems to be the most appropriate method for this research because the target of the practical development was quite well known in the very beginning of the long-term research collaboration in the target organization: a business information architecture – only the concepts, tools, and mechanisms to derive BIA changed during the process as understanding (knowledge) increased. All in all, the research is, according to the principles of action research, participative (genre analysis), qualitative, and constructive (e.g., GOBIAF).

The actual research process in AR is usually cyclic or spiral (Davison, Martinson & Kock, 2004) and alternates between action and critical reflection. In the later cycles, the methods, data, and interpretation are continuously refined in the light of the understanding developed in the earlier cycles (Action Research Resources, 2004). AR typically emphasizes group work settings (Rapoport, 1970), since many of its phases are usually carried out within small groups, which include both researchers and practitioners. One of the main characteristic of AR is that the researcher applies intervention to the participating organization while collecting research data (Kock, 2003).

The aim of using AR in this thesis is to highlight the learning process throughout the research process. Thus, neither the multimethodological development research approach (Nunamaker, Chen & Purdin, 1991) nor the design science framework (March & Smith, 1995; Hevner *et al.*, 2004) that are directed more towards systems development, can be applied in their entirety in this case. It is worth mentioning that the design science framework in particular could have been applied in certain phases of the process. The integration between the two research approaches was validated by Cole and his colleagues (Cole *et al.*, 2005). The reason for not embracing this approach was to get all the essential interested groups involved and engaged in the development process. This, in turn, was assumed to have a positive effect on adaptation of the required way of thinking in the later stages of the development process.

Within the distinct case studies, or AR cycles, there were different kinds of information collection techniques used. In the domain analysis phase, the genre-based analysis method was used to provide a basis for a participative, emancipatory, communicative, efficient, and effective (i.e., critical) debate on the relevant information requirements for information communicated in the organization (see Päivärinta, 2001). The method uses the diagonal matrix technique (Saaren-Seppälä, 1997) in group-working sessions for depicting the communicative context(s) in which genres are produced. Based on the results of the genre analysis, which are both quantitative and qualitative (Tyrväinen, Kilpeläinen & Järvenpää, 2005), we used open and semi-structured information need interviews (see Yin, 1994, Fontana & Frey, 2000) to deepen the abstraction level of the results of the genre analysis. In the later stages of the research process, a number of discussions, interviews, phone calls etc. so-called informal methods were used in information collection and approval operations.

1.4.4 Research Process

The research process in which GOBIAF was developed and applied consisted of three distinct research projects in the target organization that all had their own objectives and motives. The projects formed a kind of continuum where the results of the previous projects were exploited and elaborated in the upcoming projects. When placing the projects to the Action Research Cycles (ARC), we ended up with four cycles (see Figure 5 and Table 5) that are dealt with in this thesis. It should be pointed out that Figure 5 should take the form of a cyclical process. However, because of the space constraints, the cycles are presented as a linear process in the figure. Further, the author's contribution in the distinct research projects (RP) took place within a bigger research group that had its own target, i.e., directing the operations and requirements to the purpose of genre analysis. The results and findings of RP 1 are presented in two research papers (Kilpeläinen & Tyrväinen, 2004; Tyrväinen, Kilpeläinen & Järvenpää, 2005). The RP 1 formed the first AR cycle. A further analysis after the reporting phase included preparative investigations related to the upcoming research activity.

AR Cycle 2 continued the work done in AR Cycle 1 by specifying and developing an application to overcome the problems and bottlenecks defined during AR Cycle 1. The cycle started with thorough information need interviews where the business critical issues, the management of which should be enhanced with the application, were clarified. That is, all the related interest groups were interviewed to get a holistic view on how not only the information management but also the operations related to the information management should be arranged. The phases and results of the AR Cycles 1 and 2 are reported by Kilpeläinen and his colleagues (Kilpeläinen, Tyrväinen & Kärkkäinen, 2006).

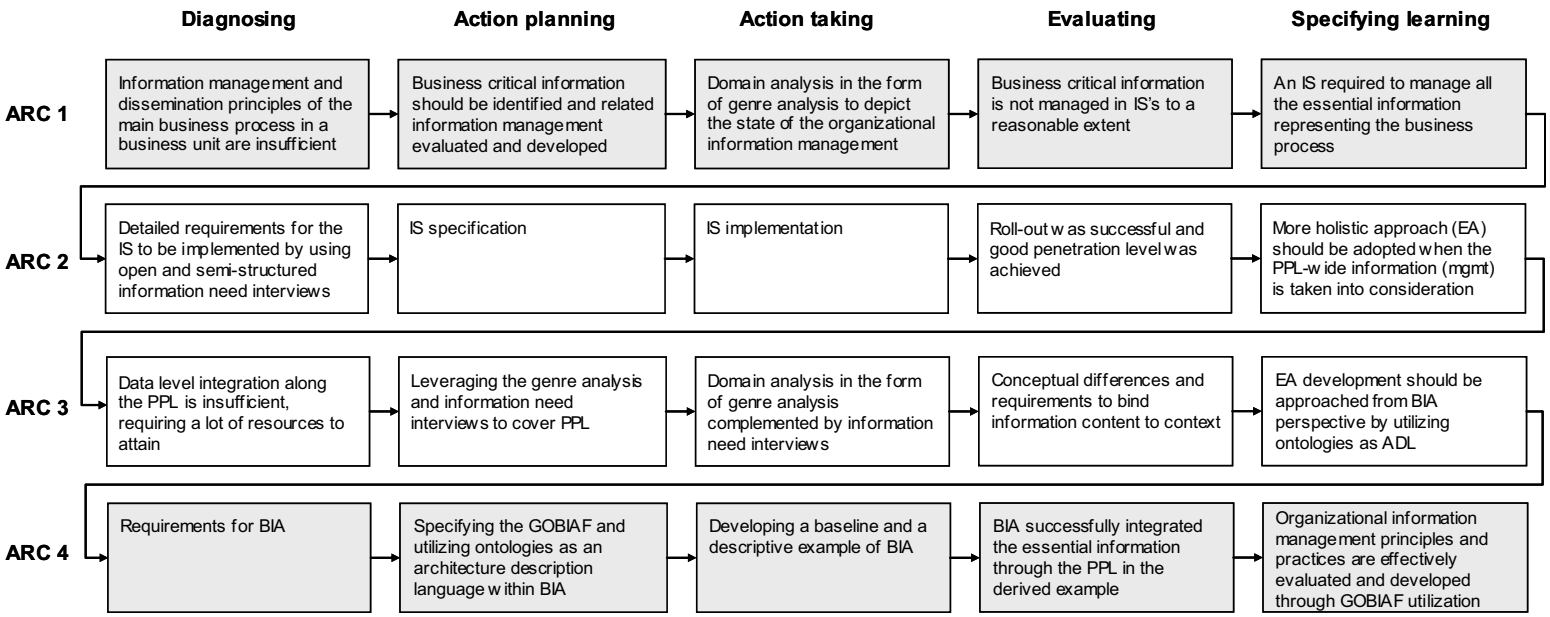


FIGURE 5 Research cycles of the research

The first two quarters in 2005 the author spent at home for family related reasons, and there was no actual research work going on during that time. The practical utility of the operations done that far in the target organization was analyzed and further developed, however. A lot of self-reflection, conceptualization, and mental activity as well as occasional on-site collaboration with the target organization took place during that period of time. As the author's academic interest became channeled towards holistic information management that seemed to correspond to the requirements of the target organization, a project proposal was specified, a proposal aiming to leverage the study to the business units involved in the production process line within the enterprise. These high level ideas of integrating organizational strategies to operative environment through the usage of EA are reported in (Kilpeläinen, 2006b). Using a literature review, the existing enterprise architecture frameworks were analyzed and compared in relation to the state and requirements of the target organization. The general finding was that there were no architecture models or frameworks that would fit with the aims of the research (see Kilpeläinen, 2006a) and provide results that would be helpful for the target organization. That is why we had to develop a new framework, which was part of AR cycle 3, and which coincided with the start of the author's parental leave.

Because the domain analysis method used during the second AR Cycle (genre analysis and open and semi-structured information need interviews) were seen successful in the context, it was applied to the other business units also in AR cycle 3. Another reason for that was that in this way the results of the domain analysis became comparable and integrable in terms of unified unit of analysis. During the architecture model evaluation that took place in the parental leave, the issue seemed to be the difficulty of finding a proper and coherent architecture description language that would be suitable to describe the results that the genre-based analysis method as well as the open and semi-structured information need interviews provided. It turned out that ontologies would provide such a functionality. Further, as the main target of AR Cycle 3 was to give directions on how to manage business critical information objects that are used to operate the business within and between business units, we had to concentrate on the soft side of total EA. That is why we developed Business Information Architecture (BIA). Both the ontology (Kilpeläinen & Nurminen, 2007) and BIA (Kilpeläinen, 2006a) levels of GOBIAF were specified, developed, implemented, and evaluated (Kilpeläinen, 2007) in AR cycle 4.

TABLE 5 Outline of the activities in the research process

			2003				2004				2005	2006				2007			
AR Cycles and phases		Process stage	RP 1				RP 2					RP 3							
ARC 1	Diagnozing	Process determination (BU1)																	
	Action planning	Process definition (BU1)																	
	Action taking	Genre analysis (BU1)																	
	Evaluating + Specifying learning	Article 1																	
ARC 2	Diagnozing	Further analysis																	
	Diagnozing	Information need interviews (BU1)																	
	Action planning	IS planning																	
	Action taking	IS implementation																	
	Evaluating + Specifying learning	Article 3																	
		Parental leave + Articles 2 & 4									Parental leave								
ARC 3	Diagnozing	Process determination (PPL)																	
	Action planning	Process definition (PPL)																	
	Action taking	Genre analysis and information need interviews (PPL)																	
	Evaluating + Specifying learning	Article 5																	
ARC 4	Diagnozing	Requirements for BIA																	
	Action planning	Ontology and BIA specification																	
	Action taking	Ontology and BIA development																	
	Evaluating + Specifying learning	Articles 6 & 7																	
ARC 5		Dissertation																	

It should be pointed out that the general target of research collaboration with the target organization was to develop a framework through which the enterprise can enhance the collaboration between the distinct business units within the production process line. That is, the author's responsibility was to develop the baseline architecture, draw the lines for the target architecture, and describe the roadmap in the form of a sketch for system implementation to reach the target architecture. To provide the required knowledge of the utility of the derived model for both the business and academic parties, we concentrated, due to the limited resources of modeling the whole BIA, on a single business critical information object ("the trial point") that was used as the baseline in the ontology and architecture development. Because the concept is versatile and forms an essential part of the collaboration in heterogeneous business units, the utility of the model in advancing harmonized information management was possible to evaluate in practice.

1.5 Introduction to the Constructive Work

In the included articles, the fundamentals of the elements of GOBIAF are defined. Regardless of the EA framework abstraction level in the thesis, we feel that the interconnection between domain analysis and ontologies needs more clarification.

1.5.1 Fundamentals of Domain Analysis and Ontologies in GOBIAF

Within this thesis, genres (e.g., Tyrväinen, Kilpeläinen & Järvenpää, 2005), information need interviews (Fontana & Frey, 2000), and ontologies (Abecker *et al.*, 1998) are perceived as theories, approaches, and tools to support BIA development. In GOBIAF the concepts are developed in parallel, supporting and complementing each other. That is, genres and information need interviews form a proper domain analysis method to establish ontologies. Ontologies, in turn, are used to provide a consistent architecture description language for EA. In short, genres and information need interviews are used as a domain analysis method (problem definition), ontologies as a representation mechanism for verification (problem solution), and BIA as a rationalization tool (decision).

Analyzing organizational communication has a solid theoretical foundation and forms one of the reasons why to apply genres and genre based analysis method to the target organization. Instead of focusing merely on information flows in business processes, genres capture also the social aspect of communicative actions (Yates & Orlikowski, 1992). Each community of discourse (Swales, 1990), such as a business unit, has a unique repertoire of genres (Orlikowski & Yates, 1994). Use of genres as the unit of analysis requires that the genre repertoire is elaborated to a level where the communication related to the mission of the organization can be divided into units that each have a specific communicative purpose and specific actors who use the information. The formal and in-

formal processes of the organization need to be identified between the processes of communicating work roles, in the actual context of the communication. Päivärinta (2001) evaluates alternative approaches for genres in the context of digital document management development. Other approaches include the structured approach (see Yourdon, 1982), object-oriented approach (see Jacobson *et al.*, 1992), and speech act based approach (see Auramäki & Lyytinen, 1996). The comparison between these approaches sheds light on the fundamental benefits (e.g., socially oriented and information driven approach) of using genres for BIA development purposes also.

The usage of the open and semi-structured information need interviews came about when we realized that we need to leverage the knowledge derived from the genre analysis and use it to produce detailed operative and technical requirements' descriptions. This kind of a technique for collecting information requirements fits well to the chosen action research method and to the logistics side of the research. The target organization made it possible for the author to participate in somewhat ad-hoc and informal meetings with the relevant stakeholders in its premises. Thus, there was no need to arrange the data collection sessions in any other, i.e., more formal and structured, ways.

During the domain analysis phase, the diversity and heterogeneity of the target organization become apparent. As there were no commercial EA tools available in the target organization, we were forced, in other ways, to overcome the issues of presenting the data in the required level of detail (breadth and width) in architecture descriptions, highlighting the fundamental aspects of the organization. The requirements to be met in the future in the target organization beckoned towards the idea of using ontologies to provide the functionalities and expressivity required. There were, however, several concerns related to ontologies. The first major issue was that introducing a new method for architecture development would require a new skill set to be taught to the EA team and later to the employees appointed as responsible architects in the organization. Another concern was the relatively poor state of development in the fields of ontology research and semantic web in general, the reported success stories related to ontology use being scarce in the literature. A survey of the state of ontologies was conducted to give a rationale for the organization to use ontologies within GOBIAF. The survey also acted as an extensive review for the researcher of the possible ways, structures, and tools that can be used in defining, structuring, and utilizing ontologies in practice.

The ontology-related survey concluded that ontologies are traditionally seen as a promising mechanism for rich information representation and modeling (e.g., Leppänen, 2005). Success stories of applying ontologies in business are, however, scarce despite the increasing research interest in the field. As an example, MuseoSuomi (e.g., Hyvönen, Salminen & Junnila, 2004) provides a semi-automatic process and a technical solution to enable annotation of heterogeneous database contents with shared ontologies with little adaptation and human intervention. Marine Metadata Interoperability (MMI, 2007) is another example that aims to promote the exchange, integration, and usage of marine

data through enhanced data publishing, discovery, documentation, and accessibility. MMI provides a number of useful tools, repositories, instructions, and other related materials for the management of marine related data. In addition to those examples, ontologies are used in information integration, retrieval, representation, and modeling (Wiederhold, 1996; Kim, 2000; Benjamins & Fensel, 1998) as well as in IS planning, natural language processing, medicine, product data standardization, E-commerce, and digital libraries (e.g., Guarino, 1998). Further, next-generation knowledge management systems will likely rely on conceptual models in the form of ontologies to precisely define the meaning of various symbols (e.g., Abar, Abe & Kinoshita, 2004). WordNet (Miller, 1995), Cyc (Lenat & Guha, 1990), TOVE (Gruninger & Fox, 1994), and $(KA)^2$ (Benjamins & Fensel, 1998) are other relevant examples, being more research oriented than the ones mentioned above. WordNet is an extensive domain independent ontology, describing English words and their interrelations. Cyc aims at formalizing and computerizing every day human knowledge that is better known as *common sense*. TOVE , in turn, seeks to support organizational integration by providing a universal and reusable information model (vocabulary) that can be used in collaboration. $(KA)^2$ is an academic ontology for knowledge acquisition, consisting of seven interoperable ontologies.

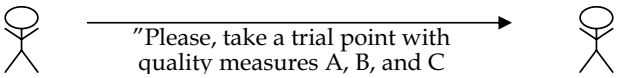
The survey indicated also that instead of adapting any of the above-mentioned generic ontology models, the ontology division described by Abecker *et al.* (1998) seemed to be the most suitable for our purposes. Note that the detailed model adaptation is presented in the included articles. When the ultimate research target is taken into consideration, the ontology division can be seen as a structure that makes it possible to link knowledge of the information creation context to information content through generic information characteristics. Roughly, this is done by modeling business process related information (context) in an enterprise ontology with the aid of knowledge acquired from the genre analysis. The information objects are modeled in domain ontologies. The required knowledge to model domain ontologies is acquired from the information need interviews that are based on the results of genre analysis. The linkage between the enterprise ontology (context) and the domain ontology (content) is done by information ontology, which is based on the fundamental elements of the genre-based analysis method and, thus, genre theory. Those elements include, among others, the categories of communication forms. Another benefit of the adopted model was that the overall structure of ontology descriptions became agreed upon in a way that the content of the enterprise and information ontologies would make them applicable to other domains also. The domain ontology, on the other hand, contains organization specific concepts that must be modeled case-by-case.

1.5.2 Genres and Information Need Interviews in Ontology Development

The knowledge acquired from the genre analysis is represented in context (see Article VII) in Table 6. A request, or a genre instance of a generic communication genre named "trial point request", describes a communicative situation

where an actor requests another actor to measure characteristic properties of a process substance associated with a trial point (a generic work task in process industries). The genre instance includes one or more domain-specific information objects (e.g., a trial point) that relate the communicative action (activity), being a part of a business process, to data representing it. Thus, genres not only describe the information creation context and information content as separate entities in a high abstraction level, but also provide mechanisms to link them in a rational way.

TABLE 6 Relationship between a genre instance, information object, ontology, and data

Communication genre	Trial point request		
Genre instance			
Domain specific information objects	Trial point, Measurable properties A, B, and C		
Attributes (metadata), describing the communicative action and information object, for user(s) of information	WHO, WHERE, and WHEN: Parties communicating interact in a business and/or production process within an environment.	HOW: Categories of communication forms (e.g., face-to-face, paper, mail…).	WHAT: Specifications of (related) information objects and their semantics.
Attribute specifications	In the communicative action, production leader (actor) requests operative personnel (actor) in a base paper production phase to take certain kind of measurements in a trial point.	In the communicative action, the request takes place in verbal communication.	Trial point represents a state of a production process within specific timeframe by measuring characteristic properties of quality measurements and process indicators.
Annotations	In a broader sense, different interest groups may be interested in information representing the communicative action (process) and/or information object, i.e., operative knowledge.	The actual data representing the information object is managed in digital formats, i.e., measurement data is managed in databases.	Specifications of the information objects, i.e., a trial point, may vary based on several attributes such as manufacturing unit, process stage, and machine concept.

The relation between domain knowledge, domain analysis, and ontologies is described in Figure 6, demonstrating how genres and information need interviews correlate to each other as well as to ontologies. The main focus of the

genre analysis was to provide somewhat abstract level process descriptions (communication genres indicate a flow of business process) to bring forth activities where certain data sets or knowledge are required to operate the business or run the operative process successfully. To be specific, the source data from genre analysis to ontology development include genres (process descriptions), the names of domain-specific information objects, information categories, amounts, and linkages to information systems managing the information specified. From information need interviews, the detailed specifications and semantics of the information objects are mapped to ontology descriptions. Thus, information need interviews focus on specifying the information objects as well as identifying the information systems where the related data is managed. In addition, information need interviews focus on (future) organizational requirements that channel the development of the *to-be* BIA. These are modeled in ontologies but are taken into account in BIA development and documentation as background information also. Based on this data, ontology development is conducted with required approval rounds, the specification of which is excluded from this discussion.

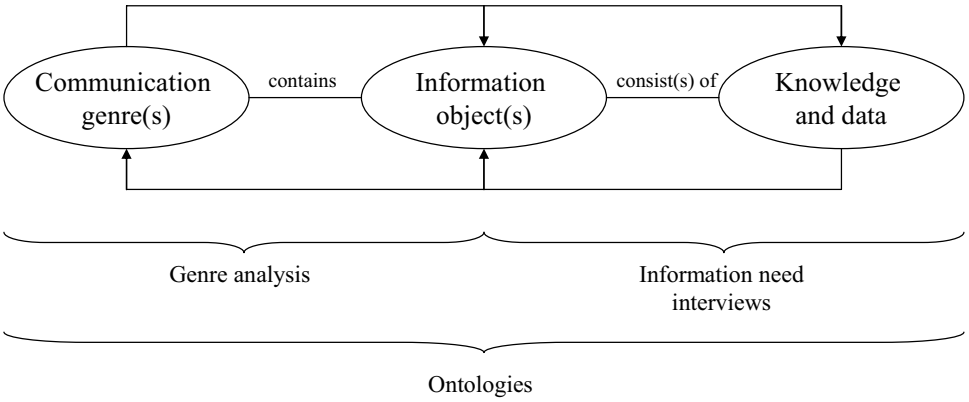


FIGURE 5 The views and interconnections of domain analysis and ontologies in BIA development

In general, genre analysis complemented with open and semi-structured information need interviews seem to form an effective and efficient domain analysis method for ontology construction, providing knowledge for information creation and utilization contexts. Genre systems provide means to model communication taking place in business processes. In doing so, genres highlight business critical information objects used for operating the business. These information objects are the classes to be modeled in ontologies. The data describing the information object do not necessarily follow the existing database schemas and may reside in several geographically distributed databases. The naming prac-

tices in case of information objects may differ according to communities of practices, which motivates the use of the genre lens (Yates & Orlikowski, 1992; Orlikowski & Yates, 1994) in ontology development, e.g., for analyzing the vocabulary differences used by different communities of users. In terms of ontologies, proper knowledge of the properties and instances of the classes must be acquired. Open and semi-structured information need interviews seem to provide a practical way to acquire this knowledge from key interest groups. In practice, these interviews are based on the results of genre analysis, reflecting the general targets of the BIA development process.

2 SUMMARY OF PAPERS

This section describes the main issues, i.e. the research objectives, methods, and results of the articles included in this dissertation. Further, this section articulates the logical interrelationship between the distinct articles. The papers structurally follow the steps of the action research framework, bringing forth the learning process throughout the doctoral dissertation process.

2.1 Article I: "The Degree of Digitalization of the Information Overflow – A Case Study"

Kilpeläinen T. & Tyrväinen P. 2004. The Degree of Digitalization of the Information Overflow – A Case Study. In I. Seruca, J. Filipe, J. Cordeiro & S. Hammoudi (Eds.), Proceedings of the Sixth International Conference on Enterprise Information Systems, Vol. 3. Setubal: INSTICC, 367-374.

Research Objectives, Process, and Method

The objective of the case study presented in this paper was to test whether a correlation between the degree of digital communication and the total amount of communication exist. We hypothesized that there exists a limit for the volume of communication, beyond which most of the additional communication takes place through digital media. To approach the issue we used a variant of the genre based analysis method (Tyrväinen & Päivärinta, 2003) as the research method. All the phases of the genre based analysis method (opening, determination, definition, genre, metadata, result analysis, and reporting) were conducted in the organization under study.

Results

The hypothesis addressed was verified from three viewpoints. We started by a quantitative analysis, comparing the degree of digitalization of the distinct employee roles against the communication volumes of the roles. This did not provide any clear correlation, because the employee roles communicating more did not have higher degrees of digitalization. Then we compared the total degree of digitalization with the reference values (Tyrväinen, 2003), which seemed to provide evidence for the correlation to some extent. Finally, we analyzed, in detail, those specific roles whose communication volumes were high. Without this final qualitative analysis the comparison of roles would not have supported the hypothesis to a sufficient degree.

The qualitative analysis disclosed that about 40 % of the analyzed genres were in digital formats. The second prevailing category of communication was in analogue formats (i.e., paper). Some of these genres in the analogue format occurred in other communication categories at the same time – most often in encoded and semi-structured formats. This meant that a major portion of this high volume of communication was produced with the aid of digital computers, although a major part of that communication was printed out on paper for delivery. Thereby, it was suggested that the media and formats used for the creation of new communication should be studied instead of, or in addition to, the media used for delivering the message.

Relation to the Whole

The aim of the paper was to evaluate the applicability of the genre-based analysis method to provide results that are academically valid and relevant for the target organization. As the resources used for the analysis were somewhat moderate, the paper reports on some positive and promising results of the usage of the genre-based analysis method in practice. From the thesis perspective, the role of this paper was to present the fundamental starting point, i.e., how things were at the beginning of the collaboration in a business unit in the target organization. In other words, the research started a long-term research collaboration where the initial results would direct future operations. Thus, the contents of the paper should be seen as an introduction to the target organization (content) and to utilization of the research method.

When the EA perspective is taken into consideration, it is interesting to notice that it is possible to manage only 40 % of business critical information with the components of the systems architecture alone if the organizational communication practices and/or principles are not altered. Thereby, using methods from the communication research domain (e.g., genres of organizational communication) can be useful in the IS research. Thus, genres seem to be a justified approach for EA development, as that approach encompasses all the relevant information regardless of the information format. Explicating the remaining 60 % of business critical information to make it a part of BIA descriptions seems, thus, rational even though its modeling would require extra resources. How-

ever, because thorough management of business critical information was seen as one of the key organizational objectives, resource allocation for such a modeling work was easy to motivate. Particularly, the requirements set a foundation for the need of BIA to be developed. Another important implication is that both the quantitative and the qualitative analysis of the derived data set must be undertaken in order to obtain accurate results. Qualitative analysis was seen as a prerequisite for getting hold of deep domain knowledge, in a form of context-specific genre metadata.

2.2 Article II: "Patterns and Measures of Digitalisation in Business Unit Communication"

Tyrväinen P., Kilpeläinen T. & Järvenpää M. 2005. Patterns and Measures of Digitalisation in Business Unit Communication. International Journal of Business Information Systems, 1 (1/2), 199-219.

Research Objectives, Process, and Method

The aim of the paper was to present and vindicate the usefulness of genre-based analysis method in conducting domain analysis in a reliable and comparable way in different kinds of environments. Particularly, the paper uses genres as the unit of analysis for analyzing digitalization of internal and cross-organizational communication of business units in three case studies. The paper is thus a comparative case study which provides quantitative data on communication media usage in organizational communication – a research area were empirical data is still hard to come by. All the case studies compared in the paper were conducted and reported as individual cases, and had no practical connections with each other. The common denominator was, however, the utilization of a variant of genre-based analysis method for case-specific purposes.

Results

In general, the study contributes by providing well-documented reference points on multiple variables measuring digitalization of internal and inter-organizational communication in real-life genre repertoires. Particularly, three classes of results are emphasized. In agreement with the discussion in the literature, digitalization of cross-organizational communication seems to be at the same level as digitalization of internal communication in all the case studies here. Nevertheless, more variation can be seen in the digitalization of inbound and outbound communication depending on the metrics used. We found organization-specific communication patterns reflecting the needs of the business units to impact on the degree of digitalization and the information systems needed. We also found out that the digitalization of communication patterns was influenced by the communication volume. Thus, the volume of communi-

cation and the dominating communication patterns seem to impact on media selection in organizations.

Relation to the Whole

This paper is more conceptual-theoretical oriented than Article I, thus providing more comprehensive and rationalized directions for the subsequent steps in the research process. In addition of being comparative in its nature, the paper is a reflective study where the genre-based analysis method is elaborated. However, the main contribution of the paper to this thesis is twofold. First, the paper discusses, in detail, the results of Article I in relation to other similar case studies. Second, the paper thoroughly describes the methodological background related to the genre analysis that acts as a key element in the domain analysis in defining the BIA. The importance of acquiring a consistent view of an organizational information resource and the extent to which the key information has already been managed and the extent to which it is available in a digital form is a valuable premise, which also has an effect on BIA development.

2.3 Article III: "Leveraging the Concept of Product Model in Process Industries"

Kilpeläinen T., Tyrväinen P. & Kärkkäinen T. 2006. Leveraging the Concept of Product Model in Process Industries. In Proceedings of the 1st Nordic Conference on Product Lifecycle Management. Gothenburg: Chalmers University of Technology, 63-74.

Research Objectives, Process, and Method

The paper presents a case study where the state of information management of a paper production system, including recipes, equipment configuration information, and intangible aspects of the end product were analyzed. The paper aims to define all the fundamental aspects of a manufacturing process that may have influence on the end product. At the same time the prevailing definition of the concept of product model and its usefulness is evaluated to be used as the baseline in the overall development of organizational information management.

The paper reports a research design where genre analyses are complemented by information need interviews to act as a domain analysis method in its entirety. The method is applied within one business unit in the target organization to collect requirements for an information system to be developed to overcome certain issues in the overall organizational information management. Thus, the paper complements the two previous papers by, first, leveraging the domain analysis towards organizational requirements that are discovered through information need interviews. Second, the emphasis of the paper is directed to product related information, which is seen as the most important as-

pect of the total organizational information resource to be developed and managed in the research project.

Results

The main conclusion of the paper is that product model and lifecycle management in process industries should also include management of the equipment and other process configuration information as well as the intangible aspects of the product (e.g., operative knowledge) with adequate information systems. That is why the paper follows and articulates the findings in the two previous articles. In addition, a comprehensive product model seems also to be a key factor for lifecycle knowledge management. Thus, the results of the case study lead us adding the modification information for equipment configuration and the intangible aspects of the product to the concept of product model. In this way, all the essential production-related information can be obtained through a single concept. This provides extensive possibilities to exploit product and process data for a reliable and multi-faceted analysis of the manufacturing process.

Relation to the Whole

The paper contributes as a practical description about the process improvement actions taken in one business unit before leveraging the study to cover the whole production process line. Basically, the notion of product model, or elements described there, acts as a baseline in defining the needed information management principles in the subsequent articles. The provided categorization of product information for process industries, especially its extended aspects, is pivotal for the thesis, because most of this particular BIA relevant information is not managed through the components of systems architecture. Further, the aspects that are not managed in digital formats seem to be the most valuable ones when organizational requirements are taken into account. The paper brings forth the importance of tacit knowledge that is a prerequisite for analyzing and managing the production process as a whole. The usage of the term product model in the subsequent articles is, however, minimized as it seems to be highly domain-specific and may give rise to confusion when discussed in the information systems domain.

2.4 Article IV: "The Missing Link between Product Data Management and Organisational Strategies"

Kilpeläinen T. 2006. The Missing Link between Product Data Management and Organisational Strategies. In J. Ljungberg & M. Andersson (Eds.) Proceedings of the 14th European Conference on Information Systems [CD-ROM]. Gothenburg: Göteborg University.

Research Objectives, Process, and Method

So far, the research had been concentrated on one business unit only. During the second AR Cycle and parental leave and at the start of the third AR cycle in the beginning of a new research project, the direction of interest veered towards holistic development of organizational information management. More business units within a production process line become involved, and the most apparent objective to aim at was their seamless collaboration. To be able to develop coherent information management principles throughout the production process line, we needed high-level, strategically sound tools to evaluate the state of the related organizational activities and information management principles. In other words, we needed some tools to bind the operative environment to organizational strategies, decreasing the gap between them. EA seemed to provide an answer to that. In practice, our earlier plans of utilizing EA in the target organization became reality at this point of the study.

The initial purpose of the study was to evaluate the capabilities of Product Data Management (PDM) development, as well as the existence of a PDM strategy, to support the development and introduction of EA in practice. Our motivation for this was related to the fact that as PDM systems manage strategically important information, the development of such systems should reflect organizational strategic objectives. The paper uses the conceptual-theoretical approach, giving a thorough literature review on the issues dealt with in the paper. Mainly promoting the findings derived from the literature, the paper was not intended to provide any practical data. The paper uses the shell model (Tolvanen, 1998) to provide methodological comparisons within the disciplines of PDM and EA by examining their intended and potential effects on information management in business processes.

Results

The paper discusses the alignment of EA and PDM from two distinct viewpoints. First, when the role of PDM development in the EA development process was considered, the potential impacts of the PDM development for the development of EA and the existence of a PDM strategy was demonstrated by examining PDM along the steps of the architecture development process. The main finding was that knowledge of PDM brings business to a more concrete level in architecture development. The relationship between PDM, EA, and organizational strategies was also studied. Methodological comparisons indicate that the disciplines of PDM and EA have major similarities as well as major differences. For example, both disciplines concentrate on key information management and, further, are driven by organizational strategic goals and objectives even when practised in different levels within organizations. PDM was also seen as a central ingredient in EA and seemed to provide a key driver for EA development in large manufacturing organizations.

Altogether, EA was seen as the link between business/operative and top management levels within organizations and had the effect of reducing the gap

between them. The study reveals an iterative relation between the concepts of product data management, enterprise architectures, and organizational strategies: these form a hierarchically shaped value chain that helps in introducing organizational strategic objectives to operational levels and in communicating business needs to the top management level. The relationship may set the scene for total information management principles throughout an enterprise, especially in cases where the roles of the product and production information are highlighted.

Relation to the Whole

As stated, the paper articulates the need for using EA as an approach for developing strategic information management in the target organization. While the overall research in the previous paper dealt with product and production related data, this paper deals with architectures, treating them as boundary objects between operational and top management levels in organizations. EA is seen here as a more holistic concept, abstracting organizational requirements better than PDM. The increased abstraction level allows us to think of PDM effectively as being part of EA. Even though the EA model presented in this paper proved later insufficient for bringing forth the required organizational characteristics, it nevertheless set the scene for GOBIAF development. The pivotal role of EA in geographically dispersed and heterogeneous environments with distributed (core) business processes is also acknowledged here.

2.5 Article V: "From Genre-based Ontologies to Business Information Architecture Descriptions"

Kilpeläinen T. 2006. From Genre-based Ontologies to Business Information Architecture Descriptions. In S. Spencer & A. Jenkins (Eds.) Proceedings of the 14th Australasian Conference on Information Systems [CD-ROM]. Adelaide: Australasian Association of Information Systems.

Research Objectives, Process, and Method

The reason why the Enterprise Information Architecture (EIA) type model presented in Article IV was not applicable in the given environment was mainly due to the limited resources we had at our disposal when compared with the plethora of heterogeneous applications and systems employed by the target organization. In addition, our interest had turned towards influencing business (processes) that produce and use business critical information. This business aspect, in the form of business architecture, was lacking in the EIA type of architecture model. Nevertheless, the relation between business information objects and applications used to manage the content of those information objects still needed explication. These kinds of changes in views are a part of the nor-

mal development during AR cycles and mainly due to the increase of knowledge within and between distinct cycles.

The aim of this paper is to specify how an architecture framework driven by business critical information should look like and how genre based ontologies can be used as an architecture description language. Thus, the paper describes the actual Business Information Architecture (BIA) descriptions and the generic steps in their development process. The elements of the Genre and Ontology based Business Information Architecture Framework (GOBIAF) are presented in a high abstraction level. The paper presents an approach level comparison of GOBIAF to its most prominent alternatives, indicating its contribution to the body of EA literature. The paper is conceptual-theoretical in its nature, aiming to describe and validate the artifact. No practical data is provided.

Results

In the paper, the synergies between the elements of GOBIAF are rationalized. That is, the paper motivates and justifies the usage of ontologies as a consistent information representation mechanism in EA models. The usage of genres and open and semi-structured information need interviews partially overcomes the traditional information acquisition bottleneck allowing an extensive domain-specific conceptualization. By combining tools, we are able to build realistic models at the architecture level. Our general impression about the approach level comparison between BIA, Business Application Architecture (BAA, Pienimäki 2005), and Service-Oriented Architecture (SOA) is that BIA seems to be more specific in describing abstract information objects. When compared to the others, it concentrates more on business critical information objects and their semantics. While the main interest of SOA seems to be more on processes and services, BIA focuses on the information used and/or provided in those services. It was also recognized here that SOA could act as an implementation mechanism for BIA descriptions.

Relation to the Whole

The paper takes the first true step towards GOBIAF. Article V is based on a thorough literature review and presents the first outline of the model to be implemented in the target organization. In contrast to Article IV, Article V derives from practical experiences related to integrating business units within a production process line in process industries. Thereby, this paper has a pivotal role in the thesis in a sense that it acts as a baseline for the EA model developed in the thesis. The ideas of this paper are leveraged in the subsequent articles. From the thesis perspective, the paper addresses the importance and usefulness of the organizations' soft side as a baseline in EA development. It is shown that the business information driven approach has remained somewhat unexplored in the literature. Further, the paper motivates the usage of genres in BIA development in order to differentiate business information from its initial contexts in an efficient, extensive, and standard way. In addition, the use of ontologies as an

architecture description language is rationalized to describe the semantics between the derived information sets.

2.6 Article VI: "Applying Genre-Based Ontologies to Enterprise Architecture "

Kilpeläinen T. & Nurminen M. 2007. Applying Genre-Based Ontologies to Enterprise Architecture. In M. Toleman, A. Cater-Steel & D. Roberts (Eds.) Proceedings of the 15th Australasian Conference on Information Systems [CD-ROM]. Toowoomba: University of Southern Queensland.

Research Objectives, Process, and Method

The objective of the paper is to elaborate the architecture level of GOBIAF in technical directions by deepening certain focal elements of GOBIAF. The paper presents the results of a domain analysis that provides the basis for ontology construction. The paper specifies the ontology level of GOBIAF to a sufficient extent to demonstrate its utility in the context. Further, the paper aims at a detailed description of the connections between ontology and EA descriptions. Generally speaking, the usage of ontologies as an architecture description language is recommended. The work is conceptual-theoretical, as well as constructive, in its nature. The study is experimental in the sense that the constructed artifact is elaborated to a certain level and a sketch for implementation is outlined. The article does not employ any specific research method. It is based on the previous work, and should thus be regarded as reflective by character.

Results

In the paper, the ontology level of GOBIAF is adopted, adapted, and applied in practice. The division of the ontologies is adopted from Abecker *et al.* (1998) where three ontologies span the dimensions of information modeling. The implementation of the ontology layer (classes) of the three ontologies is presented in the paper. The sample ontology was developed using the Protégé knowledge base framework (http://protege.stanford.edu/) connected to Pellet, a description logic reasoner (http://pellet.owldl.com/). OWL DL was used as a modeling language. Partial results of the ontology construction are illustrated with the help of UML. In addition, a preliminary software architecture of the GOBIAF architecture management system is provided.

Yet another contribution of the paper, a three-dimensional "knowledge cube" wraps up the elements of GOBIAF and their interconnections. The knowledge cube can be used to quickly review and scope the architecture development needs in a high-level view. In practice, navigating the cells in the cube reflects the relations that need to be taken into account when producing an architecture, especially BIA descriptions.

Relation to the Whole

As stated, the role of this paper in the thesis is to demonstrate the utilization of GOBIAF from a technical point of view. The content of product model in Article II corresponds, to a great extent, to the content of domain ontology presented in this paper. In a similar way, when the ontologies are compared to the architecture taxonomy of the thesis (Table 1) and to the EA grid presented in Article V, the enterprise ontology can be seen roughly equaling the business architecture. Further, information and domain ontologies deal with the issues related to information architecture.

2.7 Article VII: "Business Information Driven Approach for EA Development in Practice"

Kilpeläinen T. 2007. Business Information Driven Approach for EA Development in Practice. In M. Toleman, A. Cater-Steel & D. Roberts (Eds.) Proceedings of the 15th Australasian Conference on Information Systems [CD-ROM]. Toowoomba: University of Southern Queensland.

Research Objectives, Process, and Method

The objective of the paper is twofold. On the one hand, the paper was aimed to present unpublished data from the domain analysis phase of GOBIAF in the scale of production process line. On the other, the paper intends to recap the fundamentals of GOBIAF and to provide a process model of the BIA development process in which high-level mapping of the phases, activities, and deliverables of those activities are presented. In addition, it was seen useful to evaluate GOBIAF, basing that evaluation on the general evaluation principles derived from the literature. Keeping in mind the novel nature of BIA within the body of EA literature, the aim was to explicate practical lessons from the utilization of GOBIAF. In a similar way, the paper reflects the work done, clarifying its contribution to knowledge, especially in the EA domain.

Results

The main results of the paper fall to three categories. First, the high-level BIA development process is used to map the phases, activities, and deliverables of GOBIAF development. The detailed descriptions of the phases can be found in the previous articles, and the process model presented in this paper contributes by making the required mappings between the elements of the model. Second, the data set describing the production process line wide communication clearly articulates the importance of approaching EA development from the soft side of an organization in knowledge intensive environments - about 50 % of all information communicated is not managed in digital formats. Thereby, the BIA-side

of a total EA is required to cover the total organizational information resource. Third, eight clearly articulated and easily adaptable "lessons learned" guidelines help researchers and practitioners to understand each others' expectations and behavior better when GOBIAF is utilized.

Relation to the Whole

The role of this paper in recapping the main points is essential from the thesis viewpoint. In addition to highlighting the importance of BIA in EA development, GOBIAF is extensively evaluated by using the shell model to demonstrate its contribution to knowledge within the EA field. To be specific, the principles against which GOBIAF is evaluated can be traced back to the research questions addressed in Section 1.4.2. That is, the first, third, and the fifth principle correspond to the first research question by addressing the fundamental elements that are required for the developed BIA descriptions in practice. In addition, the first two principles support the second research question by highlighting the importance of genre analysis in BIA development. The fourth and sixth principle accentuate the applicability of the tools as well as the fundamental way of thinking behind GOBIAF, providing possibilities of applying GOBIAF to business areas other than process industries.

2.8 About the Joint Articles

The author of this thesis wrote Articles IV, V, and VII by himself.

The authors' contribution in the writing process of Article I was as follows. Once Kilpeläinen had conducted the case study and analyzed the results, both Kilpeläinen and Tyrväinen equally contributed in the writing process.

In the second paper, the responsible author was Tyrväinen. Kilpeläinen contributed by presenting the issues related to his case study organization. Further, Kilpeläinen iterated the content of the paper mainly with Tyrväinen. Järvenpää acted more as a reviewer whose comments were taken into account during the writing process.

Tyrväinen came up with the idea for Article III, but the paper itself was written by Kilpeläinen. During the writing process, Tyrväinen and Kärkkäinen acted as reviewers, commenting related to the content and overall organization of the paper. They influenced the final format and content of the article.

The fundamental idea behind Article V is Kilpeläinen's. The GOBIAF system was specified in cooperation with Kilpeläinen and Nurminen, who at that time were responsible mainly of the technical implementation of the GOBIAF system. Kilpeläinen was the responsible author, while the iterative writing process took place with Nurminen.

3 RESULTS, IMPLICATIONS, SHORTCOMINGS, AND DIRECTIONS FOR FURTHER RESEARCH

In this section, the main arguments of the thesis are explicated, based on the results reported in the included articles. The contributions with regard to the research questions formulated in Section 1.5 are also stated. Finally, the shortcomings of this thesis, which can be regarded as potential areas of further work, are discussed.

3.1 Research Questions Revisited

In this section, the research questions are answered. Roughly speaking, this is done in a way that Articles IV and V respond to the first research question, Articles I, II, and III to the second research question, and Articles VI and VII to the third research question.

3.1.1 What minimal elements are needed in an (enterprise) architecture framework to develop BIA descriptions?

Business Information Architecture (BIA) is an aspect of total Enterprise Architecture (EA), integrating Business Architecture and Information Architecture together. In the utilization of BIA business critical information should play a prominent role. The role of applications and technologies should be seen as supportive in managing, disseminating, and even refining the elements described in BIA. Thus, the development of Systems Architecture, consisting of Application Architecture and Technology Architecture to support business objectives, should be based on BIA descriptions. According to the findings of the thesis, business critical information can provide a consistent base for approaching organizational strategic development, because it seems to be the most constant aspect of contemporary organizations. The management of business critical information in this case has an effect, both deliberate and emergent, on or-

ganizational activities in all the functional interest groups. With this knowledge, we can start specifying and evaluating the business requirements for the System Architecture side of EA and organizations, i.e., information systems and technologies underneath.

As EA is, in general, diverse in its nature, so are the requirements that EA development poses to its elements and development process, including the requirement to be efficient and effective in practice. When focusing on business information, the requirements for EA framework to aid in BIA descriptions need to be applied. These requirements are not fully supported in the existing EA frameworks, though. In addition to the business information driven EA model and the taxonomy behind it, we need theories, methods, and tools to support BIA development in its different phases. First, we must be aware of the business processes and business critical information flows within those processes. In other words, the chosen domain analysis method should explicitly generate the information creation and utilization contexts and information content. These are then integrated with the help of a versatile and expressive enough representation mechanism (architecture description language).

To bind the above-specified elements of BIA development together, we need an explicitly specified BIA development process, in which the transition points between elements/phases building synergies between them are indicated. The seamless integration is a must because of the limited resources that are normally available for an initiative of this kind. In practice, the chosen elements should share some aspects and concrete deliverables through which their utilization can be effected top-down, the upper-level elements setting the requirements for the lower-level elements. In this way, the actual development process would accentuate not only the results of the distinct levels as such, but also the fundamental premises in the upper abstraction levels within the framework.

To recapitulate, the elements of an EA framework to aid BIA descriptions should include:

- BIA-driven EA taxonomy: accentuates the fundamentals and the right way of thinking in BIA development
- BIA model: provides information in different abstraction levels to aid strategic decision making
- BIA development process: binds the elements of BIA framework and builds synergies between them
- Domain analysis method: brings forth the business process and information management issues to aid binding between the information creation and utilization contexts and the information content
- Architecture description language: describes the results of domain analysis at the architecture level in an expressive way.

3.1.2 How can genres of organizational communication be used as a domain analysis method to aid in BIA development?

In utilizing genres of organizational communication (see Yates & Orlikowski, 1992) to model business processes, several benefits can be identified when BIA development processes are taken into account. The benefits include gaining knowledge of:

- Business processes and activities from the organizational communication point of view
- Actors (e.g., work roles, persons, and applications) communicating
- Format independent business critical information flowing between actors in business processes
- Both quantitative (percentual distributions) and qualitative (detailed analysis case-by-case) characteristic values, describing the genre instances and business critical information objects embedded in those genre instances
- Domain-specific conceptualization used in the information objects
- Genre instance specific metadata
- Bottlenecks in organizational communication and information management.

The fundamental benefit of utilizing the genre-based analysis method in BIA development relates to its social aspect in identifying information flows in organizational contexts. In addition to the knowledge related to business processes and related issues, the information categorization model (Tyrväinen, 2003) included in the genre based analysis method (Tyrväinen, Kilpeläinen & Järvenpää, 2005) assures that we can obtain the business critical information in any format. As the results of this thesis show, about 50 % of business critical information is in digital formats, i.e., using the components of the system architecture. To be able to design the explication mechanisms for the implicit information, we must invest resources for modeling such information. The specification of domain-specific conceptualization and genre instance specific metadata (e.g., applications managing information communicated in the genre instances) are of special interest in providing the required information in BIA descriptions.

The actual binding between conceptual/logical information models and physical data models cannot be acquired by using genres. Thus, open and semi-structured information need interviews may be used to complement genre analysis to provide the required knowledge aiding in ontology development. In general, genres seem to complement ontologies: genres provide the means to model business processes from the organizational communication viewpoint, highlighting business critical information objects used to operate the business. Information need interviews are needed to deepen the knowledge of operational activities and requirements that are (intended to be) supported by information systems. In addition, the technical side of those systems (i.e., data models) is discussed in the interviews. In this way, the results of the genre analysis are extended to represent not only the existing resources but also organizational

requirements. Ontology development becomes convenient and comprehensible because of the results of domain analysis the way it was conducted here. This means that basically all the aspects to be modeled in ontologies were already reported in the domain analysis phase. This makes ontology specification and development somewhat more straightforward.

3.1.3 How to construct a BIA model and its adoption process in geographically dispersed, heterogeneous, and knowledge intensive environments?

Practical BIA development is approached in a bottom-up like fashion based on the BIA development process. However, it should be noticed that before the actual BIA development can be launched the organization specific architecture principles should be explicated, setting the guidelines, constraints, and the appropriate mental model for the development process. The usage of the architecture principles is seen as a top-down control mechanism through which the bottom-up BIA development is supported and evaluated. As an example of a general principle, GOBIAF exploits the cohesion of business (process) and information needed to operate the business as the baseline. Thus, the (information creation) context is aimed to be integrated to the (information) content. The fundamental idea of GOBIAF is to express the in-depth state of the most important aspects of the key business processes and related information, and their management, so that an extensive use of the business information can be assured in the organizational scale. Thus, the direction of emphasis is, first, on business, second, on information necessary to operate the business, and, third, on applications and technologies necessary to support business operations.

The BIA development process consists of three main phases: domain analysis, ontology construction, and BIA development proper. The domain analysis phase breaks up into two phases: genre analysis and open and semi-structured information need interviews. The results of these genre analyses provide overall knowledge about the present state of operational activities. The results also give hints of the state of organizational information management related to the information objects, occurring and flowing in business processes. The information need interviews, in turn, complement the genre analysis by providing extensive information about the state of information management and related (future) requirements, and knowledge of the usage of contemporary information systems, applications, and technologies underneath. The domain analysis phase is the most critical part of the BIA development. The descriptions made in the ontology and BIA development phases are based on these results.

Within GOBIAF, ontologies are used to define information objects related to cross-organizational value-chains in pre-defined periods of time, for example, specific communicative actions (genre) in a business process. The role of the ontologies is to link a specific timestamp of a business process (genre instance) to information describing it as well as to explicate its relation to the total organizational information resource. GOBIAF features three main ontologies. Genre instances describe the progression of a business process in Enterprise ontology,

which defines the fundamental organization of an enterprise, e.g., organization charts. In Information ontology, fundamental "constraints" for information (flows) as well as the competencies different interest groups may have over the information objects are presented. Domain ontology describes a relationship between the information content of genre instances and the other information objects within the domain at hand. The overall organization of ontologies in GOBIAF ensures that the separate sub-ontologies are highly intertwined.

Ontology descriptions in the form of a knowledge base are presented in the BIA dimension of the architecture level of GOBIAF. EA of GOBIAF is graphically represented as a 3*4 matrix with architecture views (business, information, application, and technology architectures) on the x-axis, and levels (enterprise, domain, and information system/operative levels) on the y-axis. The architecture dimensions are used to alter the traditional view-based architecture grid. Aggregated information, especially for strategic decision making, can be retrieved from the GOBIAF system, which acts as the central architecture description repository. To aid in the understanding of the numerous concepts related to GOBIAF, a three dimensional knowledge cube was developed. The knowledge cube may also act as a central navigator throughout the GOBIAF system.

From the organizational resource allocation point of view, a major part of time is spent in supporting the domain analysis phase of BIA development. Ontology construction is conducted by the researcher, domain experts acting as validators for the deliverables that the researcher provides. BIA descriptions are based on the knowledge base (ontology) with some declarative definitions – overall a somewhat straight-forward task to accomplish. Architecture descriptions derived from the GOBIAF system can then be used for a wide variety of purposes in the organizational scale, being based on the actual data flowing in business processes regardless of the boundaries of business units. That is why GOBIAF suits well to geographically dispersed environments and their architecture development.

3.2 Evaluation

In any empirical and constructive research, the fundamental question to be asked is whether the artifact constructed works in practice or not (March & Smith, 1995). This question can, however, be divided into more specific questions. In Article IV and in Article VII, GOBIAF is considered as a relevant and potential BIA-driven approach for EA development, especially in knowledge intensive and geographically dispersed environments. The abstraction levels of the BIA model can be seen as a novel feature, helping in abstracting business critical information for different stakeholders to aid decision making.

The genres of organizational communication and information need interviews were seen as an effective way, generally and cost-wise, to conduct domain analysis for the purposes of BIA development. The genre-based develop-

ment method was easy to adopt and adapt. As the theoretical background of the domain analysis phase in the BIA development process is limited to genre theory, its adaptability for practitioners was seen as a significant advantage. However, a proper tool for managing the vast amount of data in a standard way should be developed. This would help in ontology construction also. In addition to acting as an input for ontology development, the data derived from domain analysis can be used as a basis for application development as such as was the case in Article III. The implemented application follows the fundamentals of GOBIAF, thus being able to be introduced into other business units also.

From a technical point of view, ontologies were seen as an expressive information representation mechanism, helping to formally model the complex environment with all the interdependencies. In particular, the ability to use the GOBIAF system as a central architecture description repository seems to be one of the most prominent benefits GOBIAF brings along. In practice, the GOBIAF system may act as a light-weight EA development tool, providing advanced functionalities such as semantic information retrieval and reporting. Protégé, an open source ontology editor and knowledge-base framework, may be used as the actual annotation tool with which the required description languages (e.g., RDFS and OWL DL) can be imported. In general, Protégé was seen as an adequately documented and user-friendly editor. Further, Protégé is extensible and constantly updated. This kind of a combination could form a potential alternative for any of the commercial EA tools.

From a practical point of view, the main contributions of GOBIAF can be characterized by several factors. First, the results of genre analysis are helpful in structuring organizational activities from the business process perspective in a qualitative and quantitative way. Second, as a result of domain analysis a new information system was developed to overcome certain fundamental issues in the appropriate product data management. This system was seen as an important element when the information management principles and practices between the business units within the production process line were evaluated and developed. The information system planning was conducted according to the fundamentals of GOBIAF, providing us a starting point in specifying the fundamental elements required for integrating the business units. Thus, in addition to providing a functional information system with its specifications, the successful information system planning contributed as the first step in specifying the terminology and ontological knowledge in a conceptual level. Third, the developed ontology provided fundamental information required to understand the similarities and differences between the business units to be integrated in the information level. Fourth, the semantically integrated architecture descriptions that GOBIAF provided were considered as a tool aiding strategic decision making.

There is a wide plethora of skills required to accomplish BIA descriptions. When compared to traditional EA frameworks, the required skill set shares the same characteristics but also requires special proficiency. Regarding ontologies, the architect should possess a general level knowledge in metadata annotation

(e.g., RDF), in SQL-type enquiry languages (e.g., SPARQL), in interface design principles of the existing systems, in databases, in web services, in XML, in transformation of traditional (information) models to semantic models, in editors/annotation tools (e.g., Protégé) and languages (e.g., RDFS and OWL language family), in semantic web platforms (e.g., Jena), in description logic reasoners (e.g., Pellet, Racer, and/or Jess), and in ontology libraries (e.g., RosettaNet and BMO). In GOBIAF ontologies are used as an information representation/modeling mechanism (architecture description language), and most of the skill requirements listed above are realized in the actual software (architecture) development. In practice then, ontological modeling (editors and languages) is the only skill that regular architects need to learn when using GOBIAF. This does not differ much from traditional information modeling. The importance of specifying the transition points between the phases of BIA development process is, however, emphasized in projects where different roles are responsible for different phases of the process. At this point of time, GOBIAF does not yet provide detailed descriptions of the transition points.

The Action Research methodology was seen as a useful approach in conducting this kind of research. The principles of action research were seen as bringing required structure and acting as the overall outline for the projects. With the help of the iteration based approach, the projects were easy to divide into smaller general level entities whose management became controllable. Further, the principles of action research were seen helpful in outlining the reporting of the results during the projects. Iteration based reporting gave insights on the rationale based on decision making. In this way, causes and effects were easy to demonstrate and make explicit. One concrete example of this was the move from the EIA-type EA model to the BIA-type EA model. One could argue that this kind of reporting model puts excessive emphasis on reporting instead of on the actual architecture development. Graphical representation mechanisms such as MS PowerPoint, for example when used as a reporting tool provide a graphical interface, forcing text-based documentation to be framed as figures.

Another question to be addressed is the reliability and validity of the research. In qualitative research, reliability is often seen as a concept with which to evaluate quality (Golafshani, 2003) and truthfulness of data (Lincoln & Guha, 1985). Validity is seen as aiming to assure that the data actually measure the specific phenomenon that it is claimed to describe. Reliability, in turn, focuses on assuring the accuracy of data (ibid.). The discussion of the reliability and validity should, thus, be targeted to the domain analysis method used within GOBIAF. The fundamental validation and verification of the genre based analysis method itself is outside the scope of this thesis, the method having been developed elsewhere (Päivärinta, 2001). However, the usage of open and semi-structured information need interviews makes us question the validity and accuracy of the derived data. The usage of such a data collection method is, however, rationalized by the fact that it builds on and is based on the results of the genre based analysis method. Thus, even though the interviews cannot be

regarded as a rigorous and extensive method to conduct domain analysis, its utilization in the way done within this thesis is justified by the practical benefits it brings along.

As a conclusion, we would recommend using GOBIAF in environments where, first, the role of (format independent) information is emphasized. This may appear in practice as requirements for better information management, retrieval, dissemination, representation, and/or modeling. Second, the structure of knowledge should be more concrete and clear. Third, the existing applications cannot be replaced or embedded in ES. Fourth, ES can not be applied. Fifth, complex information models (metadata) cannot be converted only into relational database. This is an implication of a situation where databases have a number of tables and indexing solutions (inside which a number of heterogeneous information models occur), causing severe problems in traditional enterprise application integration (EAI). Sixth, knowledge should be integrated, not necessarily into a certain IS, but to a common organizational knowledge repository (e.g., social networks).

3.3 Shortcomings and Limitations

Despite of the research and practical efforts reported in this thesis GOBIAF is still in its infancy. More case studies, e.g., to study the relevant context (organizational form) of GOBIAF should be carried out. Further, although GOBIAF was definitely seen as helpful in guiding architecture development in the target organization, the extent to which the chosen theories were the key to the successful outcome of the development process needs further studies. Especially in case of genres as the baseline in domain analysis it would be interesting to find out to what extent GOBIAF can steer the development activity towards critical orientation (i.e., way of thinking) for it to be successful in the development activity. Moreover, the actual work flow to integrate genres (complemented by information need interviews) and ontologies should be specified more thoroughly. Thereby, a reflection on the specific contribution of the usage of genres versus other theoretical and conceptual approaches is needed.

Genres are used for finding out business critical information objects in business processes, especially those crossing the boundaries of business units. All the aspects of the genre theory are not utilized here to their full potential. For example, genre systems (Bazerman, 1994) can be used more effectively in modeling business critical communicative activities that are highly related to each other. In a similar way, ontologies were used here only for information representation purposes with the help of UML class diagrams. The special features of ontologies (e.g., inference rules) were not fully incorporated, because the ontology descriptions were focused only on a sub-set (i.e., trial point related data) of the total data set acquired. At the current stage of the GOBIAF system development, we can evaluate the relationship between the benefits of ontology development and the resources spent on it.

The research concentrated on business information architecture development, and did not go through the EA development as a whole. However, in order to link business information to applications that manage it, GOBIAF only shows the relation between business information and an application or a database related to it. When the total EA is considered, one should enlarge the presented ontological descriptions to cover the applications and technology aspects. However, these operations most likely induce alterations to ontology level descriptions that are out of the scope of this dissertation. Further, the BIA development method is intended for baseline architecture development describing the state where the organization is at the moment. Thus, it is not intended to include a road map for reaching the target architecture nor for describing it.

A drawback of the thesis seems to be that GOBIAF was tested only in one organization. However, even though GOBIAF was developed, tested, and utilized in a single process industry enterprise, the significant variety of the business units in its production process line provides us a positive indication that GOBIAF can be applied to other business areas also.

3.4 Directions for Future Research

In addition to the drawbacks and limitations of the study, several points for future research can be outlined. The first and an essential part of formalizing GOBIAF would be to develop a formal meta-model (Braun & Winter, 2005) the role of which would be to provide a single, continuous model with meta-elements that are intended to be used and reused within and between organizations. A metamodel would show the essentials and fundamentals of GOBIAF in a way that would allow its benefits as well as its suitability to a specific context to be evaluated easier. Further, a metamodel would act as a key enabler to architectural coherency in a sense that the metamodel would describe the meta-elements to be used in distinct parts of BIA descriptions. In a similar way, the clarity of the BIA descriptions would be increased with the aid of a metamodel.

Another clear research target is to leverage BIA to cover the total EA. In practice, this means developing the system architecture side of EA in a way that BIA was developed. There are two possibilities for this. First, the SA side could be developed as an independent entity providing knowledge related to the hard side of an organization, i.e., applications and technologies. In this case, the alignment should be done in the BIA/SA level (see the EA taxonomy provided in this thesis). The second possibility is to leverage the BIA model in a way that application and technology related issues can be modeled in the BIA ontology level. This may, however, create a large and complicated model that is hard to maintain. In both cases, the other elements of GOBIAF should be accommodated to the new requirements. The BIA development process in particular should include mechanisms that support application and technology architecture development. One possibility is to use EAP (Spewak & Hill, 1993). Accord-

ing to specifications, EAP is a set of methods for planning the development of information, application, and technology architectures, and for aligning the three types of architectures with respect to each other. The goal is to ensure that such architectures form the blueprints for sound, implementable systems that solve real business problems. The reason why EAP may fit in this context is that EAP requires that EA is developed as a sequence of business, information, application, and technology architectures.

In case of viewpoint oriented EA models, the definition, generation, and management of architectural views needs to be supported by the tool environment to be practically feasible (Steen *et al.*, 2004). However, commercial EA tools have not succeeded to establish position in the market where the end user organizations would purchase their tools and use them in architecture development (Gotze & Christianssen, 2006). The outline for GOBIAF system here may provide a basis for a light-weight EA management tool, because it already includes several interfaces to existing systems. Protégé may be used as a modeling tool in this context. This would, however, require that the syntax and semantics of the interfaces between different parts of GOBIAF were explicitly described. A unified notation and toolset for GOBIAF development would help practitioners to plan and apply GOBIAF in practice.

The extensive data set of Article II could be used to demonstrate the existence and importance of business critical information objects in cross-organizational communication in the other two organizations also. In practice, by going through the data and picking up the points of development based on the requirements the cross-organizational communication poses, common requirements for integrating information exchange could be characterized. This would provide a verification of the applicability of GOBIAF to other businesses also. In a similar way, it is also of special importance to specify detailed methods to develop and represent ontologies in BIA descriptions. However, this was seen as belonging to method development/engineering. It was left outside of the scope of this thesis in which the discussion is directed towards the framework level.

Yet another point of research would be to study the possibilities of using the soft systems methodology (Checkland & Poulter, 2006) as a tool with which to structure the described complex situation with diverging views about the definition of the problem. The SSM approach may provide a way to proceed in a situation where even the actual problem is difficult to agree upon based on the soft values and requirements of the target organization.

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YHTEENVETO (FINNISH SUMMARY)

Liiketoiminnan ja tietojärjestelmien yhteensovittaminen on keskeinen osa tietojärjestelmätieteiden tutkimusta. Kokonaisarkkitehtuurit (engl. Enterprise Architecture, EA) ovat yksi vaihtoehto liiketoiminnan ja teknologisten ratkaisujen yhteismitalliseksi suunnittelu- ja kehittämistavaksi sekä ajattelumalliksi. Käytännössä kokonaisarkkitehtuureita on käytetty organisaatioiden tietotekniikan hyödyntämistä koskevan päätöksenteon tukivälineenä organisaatiostrategioiden ja liiketoimintamallien ohessa. Kokonaisarkkitehtuuri kuvaa organisaation kriittisiä rakenteita ja niiden välisiä suhteita. Olemassa olevat kokonaisarkkitehtuurikehikot (engl. EA Framework) voidaan kuitenkin nähdä varsin tietojärjestelmäkeskeisiksi. Liiketoimintaprosesseja sekä liiketoiminnan kannalta kriittistä tietoa ei ole otettu kokonaisvaltaisesti huomioon nimenomaan kokonaisarkkitehtuurien kehitystyön lähtökohtana.

Tämä työ esittää, kuinka kokonaisarkkitehtuurien kehitystä voidaan lähestyä liiketoimintaprosesseissa välittyvän kriittisen tiedon näkökulmasta ja miksi uutta lähestymistapaa ylipäätään tarvitaan. Työssä kehitetään organisaation kommunikaation lajityyppeihin (engl. genres of organizational communication) ja tietotarvehaastatteluihin sekä ontologioihin pohjautuva arkkitehtuurikehikko, jonka avulla liiketoimintalähtöisen tietoarkkitehtuurin (engl. Business Information Architecture, BIA) kehittäminen mahdollistuu. BIA:lla on merkittävä suuntaava vaikutus järjestelmäarkkitehtuurin (engl. Systems Architecture, SA) kehityksessä. BIA ja SA muodostavat kokonaisarkkitehtuurin. Tämä työ kohdentuu kokonaisarkkitehtuurin BIA-osuuteen. Toimintatutkimusta käytetään tässä työssä pohjana GOBIAF:n määrittelemiseksi käyttökontekstissaan. Tutkimuksen kohteena toimii prosessiteollisuudessa toimivan organisaation maantieteellisesti hajautunut tuotantolinja, jonka strategista tiedon hallintaa kehitettiin GOBIAF:n periaatteiden mukaisesti.

Kokemusten mukaan GOBIAF (ja sen sisältämä kehitysmenetelmä) on osoittautunut varsin käytännönläheiseksi lähestymistavaksi EA:n kehittämisen alkuvaiheessa sellaisissa organisaatioissa, joissa informaatio ja sen hallinta muodostavat organisaation keskeisen menestystekijän. GOBIAF mahdollistaa kontekstin yhdistämisen liiketoiminnan kannalta keskeisimpien tietoelementtien (engl. information object) yhteyteen. Tämä on tärkeää erityisesti maantieteellisesti hajautuneissa organisaatioissa, joiden liiketoimintayksikkökohtaiset tietoresurssit halutaan yhteismitallistaa ja siten varmistaa tiedon esteetön kulku organisaation mittakaavassa. Myös dokumentoimattoman tiedon (esim. hiljainen tietämys) tuominen näkyväksi arkkitehtuurikuvauksissa voidaan nähdä GOBIAF:n yhtenä keskeisimmistä vahvuuksista. Työ osoittaa, kuinka genret, tietotarvehaastattelut ja ontologiat tukevat ja täydentävät toisiaan arkkitehtuurityön perustavanlaatuisina työkaluina. Aikaansaadut BIA-kuvaukset ilmentävät sovellusalueen lähtötilannetta kattavasti ja monipuolisesti, jonka perusteella yhteistoiminnallisia tietojärjestelmiä voidaan hallitusti kehittää.