Research Proposal
Jacquard Proposal
June 2004

Value-Based Business-IT Alignment (VITAL)

Applicants:
Prof. Dr. H. Akkermans (BI)
Dr. P. Van Eck (IS)
Dr. J. Gordijn (BI)
Prof. Dr. R. J. Wieringa (IS)

University of Twente:
Information Systems group (IS)
Vrije Universiteit, Amsterdam:
Business Informatics group (BI)

Principal investigator: Prof. Dr. R.J. Wieringa
Universiteit Twente
Information Systems Group
Tel: +31 53 489 4189
Fax: +31 53 489 2927
E-mail: roelw@cs.utwente.nl

1 Title

1a. Project Title: Value-Based Business-IT Alignment

1b. Acronym: VITAL

1c. Principal Investigator: Prof. Dr. R.J. Wieringa

2 Summary

Business-ICT alignment is the problem of matching services offered by ICT with the requirements of the business. In businesses of any significant size, business-ICT alignment is a hard problem, which is currently not solved completely. With the advent of network organizations, the problem gets a new dimension, because in a network, there is not a single decision point about ICT support and different actors in a network may have conflicting requirements. Networks exist when different businesses decide to cooperate by means of ICT networks, but they also exist in large corporations, which often consist of nearly independent business units. In VITAL, we will investigate an economic value-based approach to alignment in networked businesses. Our approach consists of three parts. All three parts build upon work in value-based requirements engineering and on ICT architecture design already performed by the proposers.

- We will develop techniques to describe ICT services as economic value objects from a consumer (i.e. business) perspective and investigate ways to match these services in a value-oriented way with ICT services described from a supplier (i.e. ICT) perspective.
- We will develop techniques to design networked ICT architecture that supports services required by the business, taking the value offered by those services, and the costs incurred by the architecture, into account.
- We will develop models of decision processes about ICT services and their architecture, and develop maturity models of those processes.

All three parts of the project will be done by means of case study research and action research.

3 Classification

Alignment of business processes and supporting software systems.

4 Composition of the Research Team

Prof. Dr. R.J. Wieringa (promotor)	Full Professor	University of Twente
Dr. P.A.T. van Eck	Assistant Professor	University of Twente
NN funded by Jacquard	Ph.D. Student	University of Twente
NN funded by Jacquard	Postdoc	University of Twente
Ir. D. Krukkert	Researcher	University of Twente
Dr. J. Gordijn	Assistant Professor	*Vrije Universiteit*
Prof. Dr. H. Akkermans (promotor)	Full Professor	*Vrije Universiteit*
NN funded by Jacquard	Ph.D. Student	*Vrije Universiteit*
NN funded by *Vrije Universiteit*	Ph.D. Student	*Vrije Universiteit*
Drs. W. Hordijk	ICT Consultant	Ordina
C. Lodder	Senior Consultant	Getronics
H. Hendrickx	Senior Architect	Cap Gemini
T. Tijdink	Senior Consultant	CIBIT/SERC
R. Drijver	Consolidation Solution Master	HP
A. van den Berg	Principal Consultant	Twynstra Work Innovation
J. van Puffelen	Principal Architect	Unisys
Dr. J.C. Voorhoeve	Principal Consultant	Deloitte
Drs. Ing. H. Mulder	Business Consultant	Atos Origin
Dr. E.R.M.R. Paalvast	Operations Director Mobile EMEA	Cisco Systems
R. Gray	Business Development Manager	Cisco Systems
P. Teeuwen	Senior Consultant	Labyrint
P. Laagland	Principal Consultant	OrangeWing Consulting

5 Research Schools

SIKS

6 Description of Proposed Research

Scientific aspect

The problem. In this project we want to investigate the business-ICT alignment problem in a networked business context. By a *networked business* we mean a network of profit-and-loss-responsible business units, or of independent companies. Networks exist when different businesses decide to cooperate by means of ICT networks, but they also exist in large corporations, that often consist of nearly independent business units. For example, large companies may acquire other companies that must remain profitable; or they may restructure themselves into a number of cooperating business units that are all profit-and-loss responsible. Businesses may outsource some or even most of their activities. In yet other scenarios, companies may join a value chain or start a cooperation with a number of other companies to implement an e-commerce idea.

Networked business places strict requirements on ICT support, because the very business idea itself is usually ICT-enabled: Without properly functioning ICT, there can be no business network. Networked business-ICT alignment has the characteristic feature that decisions about ICT are not centralized. Different actors are involved, with different and sometimes conflicting interests. Because economic value —monetary value— is a means to make trade-offs between actors with conflicting interests, in VITAL we propose to deal with the alignment

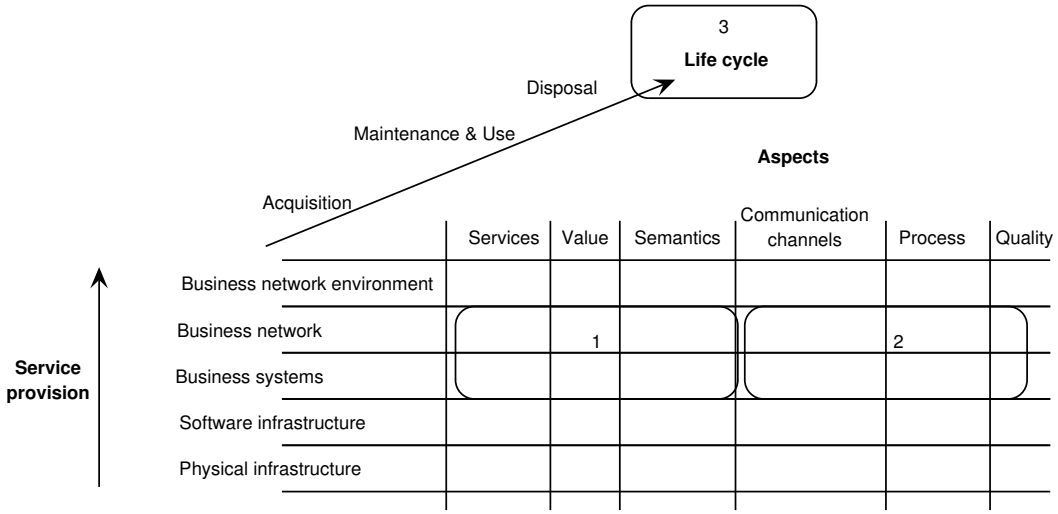

Figure 1: Research framework. The numbered rounded rectangles refer to the subprojects listed below.

problem using a value engineering viewpoint. We will investigate value-oriented techniques to design networks of services and implement these in a network of business processes and systems.

Research framework. To structure the problem and explain the research questions, we use the research framework shown in figure 1. First we structure a business network into a number of service provision layers. From the bottom up, these layers are as follows:

- The *physical infrastructure,* consisting of buildings, hardware, cables, printers, wireless access points, etc.
- The *software infrastructure,* consisting of operating systems, middleware, network software, database management systems, office software, etc. We define infrastructure (physical and software) as a utility service, required to be present and functioning for all users when and where they need it. Software infrastructure is rapidly growing in functionality; for example, the telephone system is nowadays integrated with the software infrastructure.
- *Business systems,* consisting of software applications and information systems acquired and used for the service of particular business processes and particular users. In contrast to infrastructure, business system design is driven by the needs of particular users, particular business processes, and particular business domains, not by the needs of all possible users, all possible processes and all business domains.
- The *business network,* consisting of processes, organizational roles and units that perform value adding activities and exchange physical objects and services of economic value.
- The *business network environment,* consisting of other business actors, customers, suppliers and other stakeholders.

The suitability of these layers for architecture research has been motivated elsewhere [33]. Cross-cutting these layers are several important aspects, including the following.

- *Services.* These are useful activities performed by entities at the various layers.

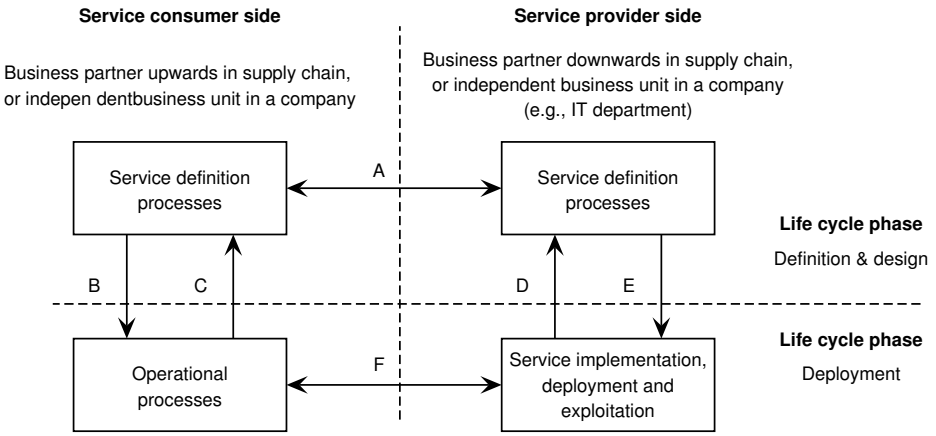

Figure 2: A networked business.

- *Value.* Services are useful, by definition, when they produce economic value for some actors.
- *Semantics.* The services we are interested in are ICT services, and these consist of storing and manipulating data, that have a semantics.
- *Communication channels.* ICT services are delivered by transmitting data across channels connecting actors.
- *Process.* At all levels in the hierarchy, services are delivered by sequences of interactions ordered in time, called processes.
- *Quality.* Service delivery has a certain quality, such as usability, efficiency, etc.

The relevance of these aspects, except the value aspect, have been extensively motivated in earlier research in software and systems design frameworks [30, 31, 32]. The value aspect has been added for the VITAL project.

Orthogonally to these two dimensions, there is a *life cycle dimension,* which indicates that entities at each of these layers have a life cycle starting with acquisition and ending with disposal. During their life, entities have properties as shown in our framework: They provide services that should be of value and that should have semantics, etc.

Research questions. In terms of our research framework, we will investigate value-based ICT service specification (subproject 1 in figure 1) and their realization by networked business processes and business systems (subproject 2). We will also investigate the architecture process by which these specification and design activities can be realized (subproject 3).

Figure 2 explains the relationship between the three subprojects in terms of a business network (service consumer and service provider) and life cycle phase. Arrow A represents decisions made by the provider and consumer about what services will be offered by whom. The key working hypothesis in VITAL is that we regard arrow A as *commercial service provisioning*, both in the case of cooperating independent companies, but also within one company. Arrow A corresponds to subproject 1. The vertical arrows B through E represent the realization of services in business processes and systems, and their influence on the service model. This is subproject 2. And where projects 1 and 2 study design techniques, subproject 3 studies the design processes involved in this life cycle phase. Arrow F in the figure represents IT service management, and is out of the scope of VITAL.

More in detail, the three subprojects contain the following questions.

1. **Value-oriented requirements engineering (RE).** The aim of this subproject is to specify ICT-services from a business value perspective. We build upon previous research bij Gordijn and Akkermans, in which the e^3-*value* method for designing a network of value activities and value exchanges was developed. We also developed a supplier-oriented service provisioning ontology, which has been used in an application of e^3-*value* to the electricity and entertainment industries to define bundles of services to be offered by cooperating electricity companies to consumers [2]. In this sub-project we want to design a service ontology from a consumer (i.e. business) point of view, and to specialize the supplier and consumer-oriented ontologies to the ICT service provisioning domain. We plan to address the following research questions:

   (a) Which ontological founded concepts are needed to conceptualize ICT-services, both from a consumer and a supplier perspective, such that preferably automated matching of consumer's ICT needs and supplier's ICT-services is feasable? Additionally, the ICT-services ontology should properly relate to the e^3-*value* ontology.

   (b) How can we match supplier-oriented and consumer-oriented ICT service specifications? We need to consider ways to compose supplier services into bundles that are valuable from a consumer perspective and profitable for all concerned. We intend to deliver software support for solving the matching and composition problem.

   (c) How can we estimate the economic value delivered by a service? The e^3-*value* approach and supporting software tool already have facilities for economic value analysis of services. In VITAL, we want to extend and specialize them for the ICT-services domain.

   We will investigate these questions by using our previous work on service specification and value engineering [2, 3, 15, 16], and by using theories from investment analysis [19] and software engineering economics [5, 29]. We will validate our results jointly with our business partners by means of action research.

2. **Business-ICT architecture design.** In this subproject we will investigate how to implement services in a networked business. In terms of our framework, this requires a definition of the business systems (applications and information systems), their external behavior, communication and quality attributes so that they support the desired business services, using as many existing systems as possible. This leads to the following questions.

   (a) How can existing systems be configured so that the desired services are delivered at the required quality of service? We need to link configuration decisions to desired services. Furthermore, we will investigate how to rank the relevant architectures on their support of different required services, and how to make value-based decisions among them. We will validate these techniques in simulated case studies and action research.

   (b) How can we design a network of business systems to provide the services as identified in subproject 1? Classical methods such as Information Engineering [20, 26] design modular systems by means of CRUD analysis but in a networked this is not sufficient, as ownership is not taken into account. Modular networks involve decisions about different kinds of ownership (of data, of processes, of systems) each with different cost and revenue structures, communication requirements, and access restrictions. We will investigate the use of value-based techniques to make these decisions in practice by means of case studies, design new techniques and validate them in simulated case studies and action research.

   (c) How does ICT-architecture influence the value network? We showed earlier that this influence exists [34]. For example, a decision to outsource ICT-services requires enterprises are to be added to the value network; and this may in turn

require adding an additional enterprise that assists in outsourcing, introducing additional value exchanges.

(d) All previous three research questions touch in one way or another on the question when a model of business systems and business processes (the rightmost columns of figure 1) is "correct" with respect to a model of value network (the leftmost three columns of figure 1). The value network expresses business requirements to be satisfied by an architecture of systems and processes on the right. The research question is what the appropriate correctness notion is, and how we can provide support for proving a correctness relation between the value model and architecture model.

We will investigate questions (b), (c) and (d) by means of action research and simulated case studies, i.e. we will propose techniques, and then validate them in simulations and in consultancy projects.

3. **Architecture maturity model.** Business-ICT alignment can be reached and done at various levels of maturity. There have been some proposals for architecture alignment maturity models [28], but these are oriented to single businesses and do not incorporate the value viewpoint. In this subproject, we study architecture processes in networked businesses and develop a maturity model for this that incorporates the value viewpoint.

   (a) Which decision processes take place in networked businesses when allocating services to a distributed ICT architecture? How can we use value-based specification and allocation techniques in these processes?

   (b) What is the relationship between these processes and known maturity models such as CMMI, the IT Service CMM and the REAIMS maturity model [21, 22, 27]?

   (c) How can maturity levels for architecture management be defined? What process areas are needed at each level?

   Except for the question how to use value-based decision techniques, these questions are empirical, not normative, and we will investigate them by means of case study research. The normative question how to use value-based specification and allocation techniques in these processes will be studied by simulated case studies, i.e. by showing how these techniques could have been used in the cases that we study. With our business partners we will identify user organizations where we can study the structure of architecture design processes.

Note that the research methods mentioned above are empirical: Very briefly, case study research is the analysis of projects performed by others [35], and action research is the analysis of projects in which the researcher participated [25]. We will also use *simulated* case studies, in which we will explore what would have happened if our techniques would have been used in a case studied by us.

Current research of the proposers. In earlier research, Gordijn and Akkermans developed e^3*-value* [15, 16], which is a method to represent and analyze a constellation of enterprises and end-consumers creating and exchanging value objects. Gordijn and Akkermans also developed tool support for this in the IST project Obelix [8, 23]. e^3*-value* will be used in all subprojects. In subproject 1, we will also use an e-service ontology and modeling approach that we developed and used in the electricity industry [2, 3].

Earlier research by Wieringa resulted in a framework for software systems [30, 31, 32], that is now used by Van Eck and Wieringa as architecture framework in the GRAAL project [9][1] in which the practice of architecture alignment in large enterprises is investigated [11, 33, 34]. This will also be the framework for VITAL. We showed that e^3*-value* can be combined with the GRAAL architecture framework to do a value-driven business process design [10]. We

[1] GRAAL is partially sponsored by the Telematics Institute

will use these results in subproject 2. Other results of previous research that will be of use in subproject 2 are a tool for checking properties of business processes using model checkers [12, 13].

Finally, about half of the findings of the GRAAL case studies are insights about the relationships between ICT architecture decisions and the structure and organization of the ICT architecture process [11]; this will be our starting point for subproject 3.

Innovation

The project has two important innovations. First, the combination of value engineering with service-oriented requirements engineering and architecture design is, to our knowledge, new and currently not investigated elsewhere. This approach leads to interesting new insights in requirements engineering. For example, in a recent paper we showed that value-based requirements engineering lifts Jackson's problem frame approach to software engineering to the level of business-ICT architecture [34].

Second, this project is about business-ICT alignment for networked businesses, and is not limited to alignment in a single enterprise. Classical methods like Information Engineering [20, 26] analyze functions, processes and semantics domains in one business to then design information systems using modularity arguments (i.e. CRUD analysis). In VITAL we take a network point of view and extend these techniques with value-based techniques to design and implement value networks.

Value-based software engineering extends software project management with techniques that relate decisions to their impact of budgets and business objectives [6, 17]. We do not study project management (although we will look at the architecture process) and we will focus on ICT service provision for networked business.

Asundi used techniques from investment theory in decisions about the mix of architecture styles to be used to support a given set of quality attributes [1], but this does not relate architecture to service requirements in a networked business, as we do.

The RAISA project (`http://www.ifi.uib.no/projects/raisa/`) investigates architecture alignment in a model-driven framework [24]. Although RAISA does allow inclusion of the network view, the focus on networked business integration and the commercial value of architecture decisions, that is at the heart of VITAL, seems to be absent from RAISA.

Industrial relevance

Current businesses face an architecture integration problem caused by the presence of legacy systems, vestiges of island automization, acquisitions and mergers of other companies, and the increasing importance of value chain automization and of business networks. These developments facilitate outsourcing of non-core business activities and, increasingly, of ICT development activities. In some cases outsourcing takes the form of offshoring to low-wage countries. This trend is currently very clearly observable. All these developments require a well-integrated and business-aligned ICT architecture. VITAL will deliver techniques to align business perpectives of various enterprises with ICT-architecture integration and outsourcing decisions, operationalize this by means of validated techniques for integrated business process and information system architecture design, and facilitate implementation of these techniques by means of an architecture process maturity model.

The business partners of VITAL will be involved in the project in a variety of ways. They are all members of a project advisory board that will meet four times a year to discuss project results and indicate directions for further research. Second, the VITAL project will allow members of the advisory board to use the results of VITAL in their own work, and will provide resources to support this. Third, the advisory board members will suggest user companies where we can perform case studies or do action research projects.

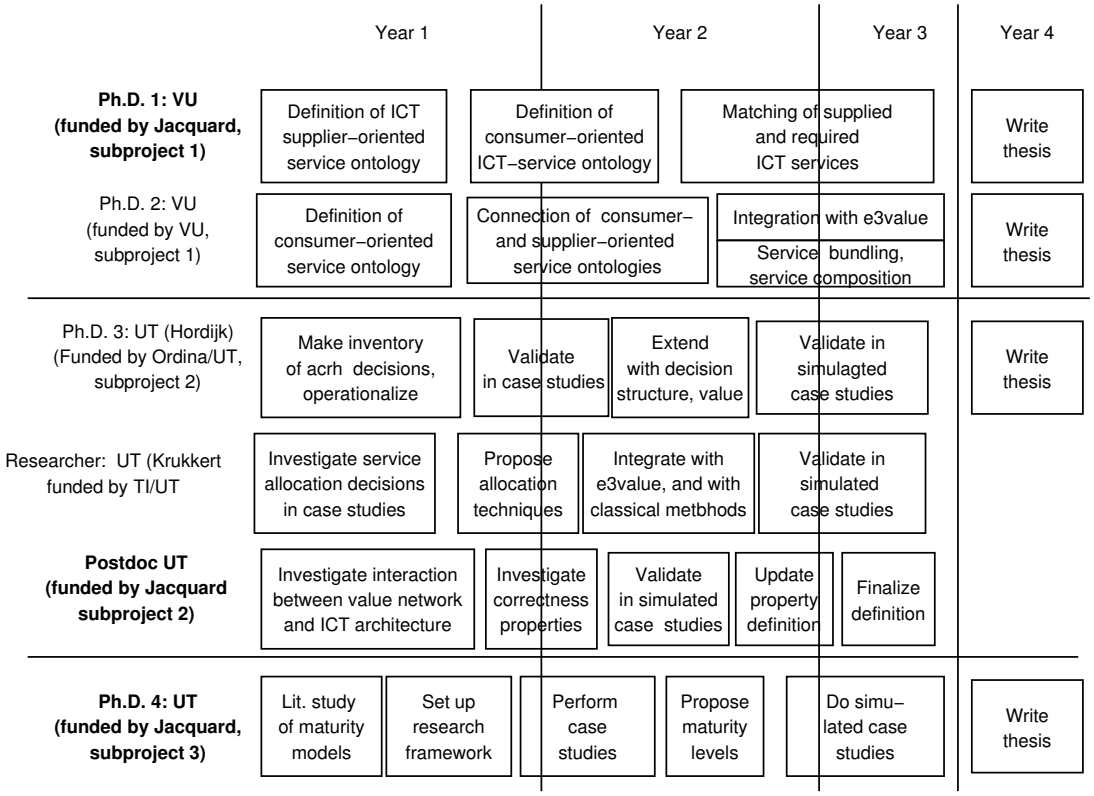

Figure 3: Plan of work.

7 Plan of work

Figure 3 outlines the plan of work, showing more detail for the first two years and less detail for the second two years. All researchers will be involved in case study and action research; this is not shown in figure 3.

Subproject 1.

- **Ph.D. 1, Jacquard funding requested.** This Ph.D. will work on research questions 1(a) and (b). He/she will specialize our existing service ontology into ICT-services ontology, first from the supplier perspective and next from the consumer perspective. Jointly with Ph.D. 2, this Ph.D. will work on matching supplier and consumer-oriented service descriptions.
- *Ph.D. 2, Funded by VU.* This Ph.D. student will work on questions 1(a) and (c). Based on our current supplier-oriented service ontology, this Ph.D. will develop a consumer-oriented service ontology to be used by Ph.D. 1 later. Jointly with Ph.D. 1, this Ph.D. will then work on defining service bundles using composition techniques. Additionally, the service ontologies will be properly integrated with the e^3-*value* ontology, in such a way that financial analysis and assessment for ICT services becomes possible.

Subproject 2.

- *Ph.D. 3, funded by Ordina.* This Ph.D. student will work on question 2(a). We will take currently known architecture patterns [4, 7, 18, 14] as our point of departure and study

a large number of cases to find out which ones are used, and how, in networked business environments. This requires operationalizing them in order to quantify the extent to which a pattern occurs and the extent into which a quality attribute is supported. The student will then analyze decision structure and trade-offs made in practice and propose techniques to make these decisions in terms of delivered value of the services.

- *Researcher, funded partially by the Telematics Institute.* The researcher will work on question 2(b). Based on case studies of service allocation to business systems, the researcher will propose techniques to make the trade-offs involved in these decisions. This will be embedded in "classical" architecture methods such as Information Engineering [20, 26], and in e^3-*value* as a requirements engineering methods. The result will be validated again in simulated case studies.

- **Postdoc, Jacquard funding requested.** A postdoc will work on questions 2(c) and (d). He/she will investigate the correctness problem of a networked architecture versus a networked value model, by first investigating the interaction between these two models: For example, a change in a business process or business system model may result in a change in the e^3-*value* model. Based on this, a proposal for a correctness criterion will be made, which will then be validated in simulated case studies.

Subproject 3.

- **Ph.D. 4, Jacquard funding requested.** This Ph.D. will work on question 3. He/she make an inventory of relevant maturity models, set up a research framework to analyze processes used at user sites, and analyze these processes in terms of the framework. This will be used to propose maturity levels, which will be validated by doing more case studies and by doing simulated case studies, exploring what the use of these maturity models would mean in these cases.

8 Expected Use of Instrumentation

VITAL needs no special instruments beyond the infrastructure to be provided by the hosting institutions, CTIT (University of Twente) and *Vrije Universiteit*.

9 Literature

The five most important references of the proposers in the area of VITAL are [10, 15, 16, 31, 32]

[1] J. Asundi, R. Kazman, and M. Klein. Using economic considerations to choose among architecture design alternatives. Technical Report CMU/SEI-2001-TR-035, Software Engineering Institute, 2001.

[2] Ziv Baida, Jaap Gordijn, Andrei Z. Morch, Hanne Sæle, and Hans Akkermans. Ontology based analysis of e-service bundles for networked enterprises. In *Proceedings of the 17th Bled International e-Commerce Conference*, page to appear, 2004.

[3] Ziv Baida, Jaap Gordijn, Hanne Sæle, Andrei Z. Morch, and Hans Akkermans. Energy services: A case study in real-world service configuration. In *Proceedings of CAISE 2004*, page to appear, 2004.

[4] L. Bass, P. Clements, and R. Kazman. *Software Architecture in Practice*. Addison-Wesley, 1998.

[5] B. Boehm. *Software Engineering Economics*. Prentice Hall, 1981.

[6] B. Boehm and L.G. Huang. Value-based software engineering: A case study. *Computer*, pages 33–41, March 2003.

[7] F. Buschmann, R. Meunier, H. Rohnert, P. Sommerlad, and M. Stal. *A System of Patterns: Pattern-Oriented Software Architecture*. Wiley, 1996.

[8] Busmod website. `http://busmod.e3value.com/`.

[9] Guidelines regarding architecture alignment. `http://is.cs.utwente.nl/GRAAL/`.

[10] Pascal van Eck, Jaap Gordijn, and Roel Wieringa. Value-based design of collaboration processes for e-commerce. In Soe-Tsyr Yuan and Jiming Liu, editors, *Proceedings 2004 IEEE International Conference on e-Technology, e-Commerce and e-Service, EEE'04*, pages 349–358. IEEE Press, 2004. Taipei, Taiwan, March 28-31, 2004.

[11] P.A.T. van Eck, H. Blanken, and R.J. Wieringa. Project GRAAL: Towards operational architecture guidelines. *International Journal of Cooperative Information Systems*, Accepted for publication.

[12] R. Eshuis and R.J. Wieringa. Verification support for workflow design with UML activity graphs. In *24th International Conference on Software Engineering (ICSE 2002)*, pages 166–176, 2002.

[13] R. Eshuis and R.J. Wieringa. Tool support for verifying UML activity diagrams. *IEEE Transactions on Software Engineering*, Accepted for publication.

[14] Martin Fowler. *Patterns of Enterprise Application Architecture*. Addison-Wesley, 2002.

[15] J. Gordijn and J.M. Akkermans. Value-based requirements engineering: Exploring innovative e-commerce ideas. *Requirements Engineering journal*, 8(2):114–134, 2003.

[16] J. Gordijn, J. Schildwacht, V. Kartseva, R.J. Wieringa, and H. Akkermans. A domain-specific cross-organizational requirements engineering method. In *12th IEEE International Requirements Engineering Conference*, sept 6–10, Kyoto 2004.

[17] W. Harrison. Economic-driven software engineering research. `http://www.grabpage.org/~edser/`.

[18] G. Hohpe and B. Woolf. *Enterprise Integration Patterns: Designing, Building, and Deploying Messaging Solutions*. Addision-Wesley, 2004.

[19] Charles T. Horngren and George Foster. *Cost Accounting: A Managerial Emphasis, sixth edition*. Prentice-Hall, Englewood Cliffs, NJ, 1987.

[20] J. Martin. *Information Engineering*. Prentice-Hall, 1989. Three volumes.

[21] Frank Niessink. *Perspectives on Improving Software Maintenance*. PhD thesis, Vrije Universiteit Amsterdam, Division of Mathematics and Computer Science, 2000. `http://www.serc.nl/people/niessink/publications/PhD.Niessink.pdf`.

[22] Frank Niessink. Perspectives on improving software maintenance. In *Proceedings of the International Conference on Software Maintenance*, pages 553–556, 2001. `http://www.serc.nl/people/niessink/publications/ICSM01.Niessink.pdf`.

[23] Obelix website. `http://obelix.e3value.com/`.

[24] A.L. Opdahl. Model-supported alignment of information systems architecture. In K. Kangas, editor, *Business Strategies for Information Technology Management*. Idea Group Publishing, 2003.

[25] C. Robson. *Real World Research*. Blackwell, 2002. Second edition.

[26] W. van der Sanden and B. Sturm. *Informatiearchitectuur: De infrastructurele benadering*. Panfox Holding, 1997.

[27] I. Sommervile and P. Sawyer. *Requirements Engineering: A Good Practice Guide*. Wiley, 1997.

[28] Han van der Zee, Paul Laagland, and Bas Hafkenscheid. *Architectuur als managementinstrument: Multi Client Study*. Ten Hagen Stam, 2000. In Dutch.

[29] C. Verhoef. Quantitative IT Portfolio Management. *Science of Computer Programming*, 45(1):1–96, 2002. Available via: `www.cs.vu.nl/~x/ipm/ipm.pdf`.

[30] R.J. Wieringa. *Requirements Engineering: Frameworks for Understanding*. Wiley, 1996.

[31] R.J. Wieringa. A survey of structured and object-oriented software specification methods and techniques. *ACM Computing Surveys*, 30(4):459–527, December 1998.

[32] R.J. Wieringa. *Design Methods for Reactive Systems: Yourdon, Statemate and the UML*. Morgan Kaufmann, 2003.

[33] R.J. Wieringa, H.M. Blanken, M.M. Fokkinga, and P.W.P.J. Grefen. Aligning application architecture to the business context. In *Conference on Advanced Information System Engineering (CAiSE 03)*, pages 209–225. Springer, 2003. LNCS 2681.

[34] R.J. Wieringa, J. Gordijn, and P.A.T. van Eck. Value framing: A prelude to software problem framing. In *1st International Workshop on Advances and Applications of Problem Frames (IWAAPF)*, 2004.

[35] R.K. Yin. *Case Study research: Design and Methods*. Sage Publications, 2003. Third Edition.

10 Budget

The University of Twente intends to hire the requested postdoc as an assistant professor after VITAL is finished ("*inbeddingsgarantie*").