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OPPORTUNITIES FOR THE USE AND PROVISION OF INFORMATION IN THE CONSTRUCTION VALUE CHAIN

Doctoral Dissertation

Christer Finne

Helsinki University of Technology
Faculty of Engineering and Architecture
Department of Architecture

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Doctoral Dissertation

Christer Finne

Dissertation for the degree of Doctor of Science in Technology to be presented with due permission of the Faculty of Engineering and Architecture for public examination and debate in Auditorium A1 at Helsinki University of Technology (Espoo, Finland) on the 9th of May, 2008, at 12 noon.

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Abstract

Information is an essential part of the construction value chain. In the early parts of the process information is all there is, in the later parts, information is a prerequisite for managing the process, for trade and communication between the participants in the process, and for the use of the buildings. Construction produces not only buildings, but also information about them. Important, but often unnoticed, actors in the construction industry are the infomediaries, who provide all parties with information. This information has traditionally been stored and distributed on paper, but exists now in digital form and consists mainly of text, pictures, computer files and, to some extent, software, i.e. information goods.

The internet has changed the border conditions for the infomediaries. It has created new business opportunities, and threatened the existence of companies who fail to re-engineer their operations. Infomediaries need to adopt a technical solution with internet-based services using a multi-tier architecture, which has separate parts for data storage, data maintenance, and data output. This platform can then be used to provide information goods, and focus needs to be on the value for the customer.

In order to gain a deeper understanding of value the author has, through the medium of a formal model, described the construction value network, where parts of the value chain relevant to the pursuit of customer value are modelled. The model can provide a helpful description of where information is produced and provided in order to help to pinpoint where and how value is produced.

One central user of information provided by infomediaries is the architect. When computer programs came into use in the architects' practises, there were prejudices towards the new technology and arguments that it might limit the creativity of the architect. Via the use of a triangular division of design work into creative, combinatorial and registering work, areas can be indicated where the use of computers can be beneficial. These areas coincide with the areas where the service offerings of infomediaries could be found.

Traditionally, value is dealt with as something that is inherent in the product; it is often seen as a part of brand building or the efforts of marketing, and can be produced and delivered as part of the product and then handed over to the customer. Later research argues that value cannot be pre-produced. It treats value as something co-produced by the customer throughout the relationship, partly in interactions between the customer and the supplier or the service provider. Value is produced and consumed simultaneously. Infomediaries need to gain a thorough understanding of their customers' business processes. Instead of producing products (or services), they can to become facilitators of value for their customers.

Keywords Infomediaries, Construction Value Chain, Customer value, e-business, CAD	
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Sammanfattning (Abstrakt)
Information är en central del av byggandets värdekedja. I de tidiga delarna av processen är information allt som finns, i de senare delarna är information en förutsättning för styrning av processen, för handel och kommunikation mellan parterna i processen, samt för bruk av byggnaderna. Byggande producerar inte byggnader allenast, utan även information om dem. Viktiga, men ofta obemärkta, parter i byggprocessen är informationsmellanhänderna, som förser alla parter med information. Denna information har traditionellt lagrats och distribuerats på papper, men existerar numera i digital form och föreligger huvudsakligen som text, bilder, datafiler och, i viss utsträckning, programvara, dvs. som informationsvaror. Internet har förändrat verksamhetsförutsättningarna for informationsmellanhänder. Det har skapat nya affärsmöjligheter, och hotat existensen för sådana bolag vars verksamhet stagnerar i sina tidigare former. Informationsmellanhänderna behöver ta i bruk en teknisk lösning med internetbaserade tjänster som stöder sig på en flerskiktad arkitektur med skilda lösningar för lagring, underhåll och output av data. Denna plattform kan sedan utnyttjas till att tillhandahålla informationsvaror, samtidigt som fokus riktas på det mervärde kunden får.
En djupare förståelse av byggandets värdenätverk kan uppnås medelst en formell modell där delar av värdekedjan som är relevanta för förståelsen av kundvärde har modellerats. Modellen kan tillhandahålla en användbar beskrivning av var information produceras och tillhandahålls i avsikt att peka på var och hur värde skapas.
En central användare av den information som tillhandahålls av informationsmellanhänder är arkitekten. När dataprogram började användas i arkitektens arbete uppstod det fördomar mot den nya tekniken och man argumenterade att den var ett hot mot arkitektens kreativitet. Med hjälp av en triangulär indelning av arkitektplanering i skapande, kombinatoriska och registrerande arbetsfaser, kan områden indikeras där användning av datorer kan vara till nytta. Dessa områden sammanfaller långt med de områden där informationsmellanhänderna erbjuder sina tjänster.
Av tradition beskrivs värde som något som är en del av produkten. Värde ses ofta som en del av byggandet av varumärken eller som ett resultat av marknadsföring, och som något som kan produceras och levereras som en del av den produkt som överlåts till kunden. Senare forskning hävdar att värde inte kan produceras på förhand. Den beskriver värde som någonting som samproduceras med kunden igenom hela kundförhållandet, delvis i direkt samverkan mellan kunden och producenten av varan eller tjänsten ifråga. Värde produceras och konsumeras simultant. Informationsmellanhänder bör bemöda sig om att uppnå en djup förståelse av sina kunders affärsprocesser, och baserat på denna förståelse sträva till att möjliggöra maximalt kundvärde i processer där kunden aktivt deltar, istället för att producera enbart varor eller tjänster.

Ämnesord (Nyckelord) Informationsmellanhänder, byggandets värdekedja, kundvärde, e-business, arkitektplanering

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PREFACE AND ACKNOWLEDGEMENTS

This dissertation has been a continuation of a journey into the unknown that started in the late 80ies. The trip has been undertaken in two phases. The first one ended with a licentiate thesis in 1993, and the second one with this dissertation. Although seemingly about two different areas, computer aided design in the first phase, and information middlemen, infomediaries, in the second one, there is more than unites than divides them. Both have been about finding out what is really happening when a new technology had entered my field of work, and both have explored the new phenomena and pointed towards new opportunities to use the new technology.

This work would not have been possible without the efforts of many people. In particular, Bo-Christer Björk has encouraged me, provided continuous support and help, as well as rapid and constructive feedback. Brian Atkin has given numerous advices, sharp and to-the-point comments, and improved comprehensibility and readability of my scribbling. Rob Howard has provided his support as well. Tor-Ulf Weck has been the person who has made finalizing and publication possible. My employer has, through the flexible and supportive attitudes of Gunnel Adlercreutz and Matti Rautiola, made it possible to write the dissertation while still working as R&D Director at Rakennustietosäätiö. Most of the work has been done as a part-time researcher, first at Hanken, The Swedish School of Business and Economics, and later at the Helsinki University of Technology, whose research funding has been made available through Bo-Christer Björk and Tor-Ulf Weck. My warm and heartfelt thanks go to all of them.

Finally, my most special thanks go to my lovely wife Gun and to my family, for love and support during this long and sometimes tedious journey.

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II Finne, C. 2003: How the Internet Is Changing the Role of Construction Information Middlemen, Journal of Information Technology in Construction, Vol. 8, Special Issue eWork and eBusiness, pp. 397-412

III Finne, C. 2006: Publishing Building Product Information – A Value Net Perspective, Construction Innovation, Vol. 6, No 2, pp. 79-96

IV Finne C. 2007: Perceived Customer Value in Construction Information Services, CIB W78 Conference 2007, Bringing ICT knowledge to work, conference proceedings ed. Daniel Rebolj, University Library Maribor, Maribor, pp. 125-133

AUTHOR'S CONTRIBUTION

This dissertation, named *Opportunities for the Use and Provision of Information in the Construction Value Chain,* consists of a summary and four papers, all of which have been published.

All of them are written solely by the author alone.

LIST OF ACRONYMS AND ABBREVIATIONS USED

BIM	Building Information Model
CAD	Computer Aided Design
CAD-SAFA	Special Interest Group for CAD (Computer-Aided Design) within SAFA, the Finnish Architects' Association
ECAADE	Education and research in Computer Aided Architectural Design in Europe) is a non-profit making association of institutions and individuals with a common interest in promoting good practise and sharing information in relation to the use of computers in research and education in architecture and related professions
IAI	International Alliance of Interoperability, developer of and maintenance organisation for IFC
ICIS	The International Construction Information Society, a worldwide association of organisations that provide national master specification systems and/or cost information systems for the construction industry
ICT	Information and Communication Technology
IDEF0	IDEF0 is a formal modelling method that combines graphics and text
IFC	Industry Foundation Classes, neutral data transfer format for BIMs
KTH	Kungliga Tekniska Högskolan (Royal Institute of Technology), Stockholm, Sweden
RATAS	Large BIM research effort in Finland during the late 1980s and early 1990s
RTS	Rakennustietosäätiö, The Building Information Foundation, information provider for the Finnish construction industry
SAFA	The Finnish Architects' Association
SARA	Technology program funded by TEKES
TCT	Transaction Cost Theory
TEKES	The Finnish Funding Agency for Technology and Innovation
UICB	The International Union of Building Centres
VERA	Technology program funded by TEKES

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1 Introduction

1.1 Background and Research Problem(s)

The background of the research lies in the emergence and growing use of ICT in two areas: computer aided design, or CAD, in the construction value chain and electronic trade in infomediary services in that chain. What unites the research areas is a new technology emerged and that it was seen by some as an opportunity for gaining significant benefits, whilst it was seen by others as a threat. Thus, the driver behind the research in both cases has been the need to describe what is happening in order to gain a deeper understanding about it and to explain why things are as they are in order to prepare for the future: this has been particularly true for the latter area. Furthermore, the author has had the unique opportunity to be in the middle of events, with personal experience of, and expertise in, the area under study and at the same time being a part of it. He was one of the earliest users when CAD came into architectural design in Finland in the 1980s and he was (and remains) Research Director of the main infomediary in the Finnish construction industry when electronic trade and the internet became an issue in its business at the turn of the millennium. The research has been undertaken in two separate phases. The result of the first was a licentiate thesis in the period 1989-1993. The work continued into a second phase in 2001 and has resulted in this thesis.

When the first phase started, CAD systems had been in use in Finland for some years. The systems were mainframe-based such as VAX/Dogs and Prime/Medusa, but PC/Mac-based systems such as AutoCAD and Archicad were soon to catch up. The benefits and drawbacks were studied from a single architect's point of view as well as from the perspective of the process and discussed in a number of reports (Anon. 1985, Björk 1982). At the Finnish Technical Research Centre (VTT), a large research effort concerning the use of product modelling in construction, RATAS, had completed its first stage and provided a theoretical foundation for the use of product models in construction (Enkovaara et al. 1988). When a follow-up project that further explored the RATAS concepts started, the author was invited to join the team at VTT (Björk et al. 1991). In his own research, parallel to that of the project, he assessed problems in the area of design, and architectural design in particular, in pursuit of the impact of the use of CAD. Areas of the architect's work where use of CAD can be beneficial in different ways were identified. Product models as a means of data storage as well as the use of external databases such as those of the infomediaries, were investigated in the second phase of this study. A theoretical framework, or model, which aids in structuring of the problem and in understanding the impact of CAD was introduced (Finne 1992 and 1993). When the first phase was finalised, Finland's economy was in a deep recession and the research team dispersed. Research in construction ICT and product modelling decreased. The author spent many years as a senior lecturer teaching architecture, becoming heavily engaged in developing a new education institution for bachelor level students which also included building design

When the second phase started around the turn of the millennium, Finland had recovered from the recession. The inheritance of the RATAS projects was continued and research into ICT in construction gained momentum within the technology programmes of the Finnish Funding Agency for Technology and Innovation (TEKES) in particular the VERA and SARA programmes. The author was back in construction as Research Director at the Building Information Group (Rakennustieto), which is an infomediary and the main information provider in the Finnish construction industry, i.e. the provider of external databases such as those discussed in the first phase. The general situation resembled the one at the beginning of the first phase. The author's employer faced new forms of technology, which offered opportunities as well as threats, and the author had a central position for action as well as observation. This time the technology was electronic trade and the internet was the platform for delivery. The need for more guidelines for business development, based on a deep understanding of the situation at hand, was evident. Sister companies in other countries were struggling with the same questions and start-ups in Finland were threatening the business of the author's employer.

The right opportunity to pursue this line of enquiry arose in connection with the research project "Strategic Business Networks in Electronic Markets" (B-Webs), a TEKES funded research project which was part of the Academy of Finland's LIIKE research programme (Anon. 2007a). The author participated in this project on a part time basis between 2001 and 2004 and between 2005 and 2007 he continued the work as a part of

the TEKES funded project "Taking E-collaboration techniques into productive use in the construction industry" (FoundIT) (Anon. 2007b).

Consequently, the overall research problems during the second phase dealt with how to "identify and describe a basis for the design of sustainable business strategies for infomediaries in the construction industry". The problems have been addressed in four academic papers. Three of them (Finne 2003a, 2006 and 2007) form the basis of this thesis together with an earlier paper from the first phase (Finne 1992) that reports on the results of the licentiate thesis. The first and second papers report on the need for infomediaries to adopt an e-business approach and to integrate into the construction value chain (Finne 2003a, 2003b). The third explores the architect's work processes as part of an information value chain in construction. This part of the research also utilises and provides a bridge to the results of the licentiate study. By the use of a formal model, it breaks down the value processes of the infomediary and its customers into parts where the production of value and its consumption can be discussed (Finne 2006). The last part of the study has had as the objective the establishment of a deeper understanding of customer perceived value, so that it can aid infomediary managers in the construction value chain in their pursuit of sustainable answers to the 'how' questions in their design of business strategies (Finne 2007).

1.2 Aim, Objectives and Scope of the Research

The background to the research represents a situation in which a new technology has emerged in the field in which the author works. When the two separate phases of the research were underway, there was uncertainty among the players in the field about how to react towards the new technology: was it a threat or an opportunity? How might it be utilised? Thus, the broad aim of the research has been to seek orientation in an unfamiliar situation then to clarify and understand what is happening in order to explain where and how new technology might be utilised.

During the first phase, the objectives could be characterised as, first, describing the field of an architect's work in such a way that it is possible to discuss how it might be affected by ICT (in this case CAD) and, second, to understand the ways in which the use of ICT might be beneficial. A further objective was to study what, in those days, was referred to as integrated design, or product modelling, and its affect on the construction value chain. The outcome was a paper (Finne 1992) and a licentiate thesis (Finne 1993).

The second phase dealt with infomediaries and electronic trade of information in the construction process and the aim has been to explain what the prerequisites for business success in this area look and to describe a sustainable way of deriving business strategies. The research utilised results from the first phase that concentrated on the work of the architect: where and how ICT (CAD) could be beneficial and where not. The second phase has been reported as four papers (Finne 2003a, 2003b, 2006, 2007), where each has influenced and partly set the objectives for the subsequent paper in turn.

The objective of Finne (2003a) was to describe the challenges that the whole field (the infomediaries and their customers) faced and to outline strategic directions for infomediaries to pursue. One aim of the paper was to describe the context for the following papers. In the paper, the need to know more about the value chain and the customers' requirements was identified. It set objectives for the second phase: learning more in detail about customer needs, and what information is needed when, where and in what format. Other issues identified where related to where and how information should be delivered, and what the information services and their business logic should be like. It also indicated that more needed to be known about the value aggregation network and its nodes and how infomediaries in this network could benefit from this knowledge and produce customer value in the networks. These issues were investigated in Finne (2006), which adopted a relatively limited definition of the value context. The literature studied suggested that a deeper analysis of the concept of customer value could lead to further insights. Thus, the objectives for Finne (2007) were to pursue the concept of customer value in the construction value chain in such a way that it could aid the infomediaries in their strategies.

In a work like the one at hand, which embraces several fields (construction, ICT, management, electronic trade, marketing) limitations are inevitable. The study, and thus the thesis, deals with construction information in general and when needed it has been narrowed down to product information. It deals with the

construction value chain, but from the perspective of the infomediaries' information services; when narrowing down has been needed it has focussed on the work of the architect.

Some issues are excluded from this research, either because they have been judged as adding relatively little to the results or simply because of the need to maintain focus and keep the work within reasonable limits.

The concept 'information' is used in a relatively straightforward manner to describe the contents of databases and documents. No elaboration in terms of discussing the differences between the concepts of data, information and knowledge has been made. Infomediaries function between two customer categories, backwards along an information value chain to those who supply information and frontwards to those who need and buy it. See Figure 1.

Figure 1: Infomediaries in the information value chain

The research focuses mainly on the customer who needs and buys information and those who provide this information; the infomediaries, whereas the infomediaries' own information suppliers it are given relatively little attention. No elaboration along the axis of products–services has been made. Instead, it is assumed that a service can be a product, which might include a physical product. The effects of organisational changes have been excluded too.

1.3 The Structure of the Thesis, and the Research Questions.

The thesis is based on four papers connected by this summary. In chronological order, the first is the outcome of a licentiate study. It approaches the use of ICT in the construction process from the user side, i.e. the perspective of architectural design, and focuses on where and how to use it (Finne 1992). One of the main questions was how CAD does affect the architect's work, and does it threat or limit creativity. Others were the effort to explore the architect's work in order to explain where and how CAD would be of benefit. The last three are more closely interconnected. They approach the same subject from the viewpoint of an information service provider, that of the infomediary (Finne 2003a, 2006 and 2007). In the narrative structure of this thesis, they are put in a different order, and used mainly from the infomediary's viewpoint. Figure 2 shows the structure.

In Finne (2003a) the full context is depicted. It discusses the growing role of digital information in the construction process, as well as the similar development in the infomediaries' information services. It analyses how the internet has evolved into a platform for electronic trade that is particularly versatile for digital goods and concludes with a description that points out possible solutions for infomediaries. The research questions were similar to those in Finne (1992): how does the emerging technology (electronic trade and the internet) affect infomediaries, and is it a threat. Others were the effort to explore the Infomediaries activities in order to explain where and how the new technology might be beneficial.

The next papers elaborate and deepen the areas raised by Finne (2003a), namely the value chain and its processes (Finne 2006) and the concept of value (Finne 2007). With the intention of showing how and where in the process customer value can be created, Finne (2006) uses a formal model of the value production process to analyse the problem. The model breaks down the process into numerous sub-processes partly for information production, delivery and partly for search and use of informationrovides an essential background to the latter processes and a more detailed understanding of the customers' processes. It breaks down the architect's work processes into sub-processes and illustrates how external information can be utilised and integrated into design work. Realisation of this position has lent support to the formulation of the contents of the information provided by infomediaries, which has been elaborated in Finne (2006 and 2007). The

research questions for Finne (2006) thus had to do with exploring the value chain, or net, of the infomediaries, answering questions such as what does the network look like?, where and how is value produced, delivered and received. Finne (2007) continued by exploring different sides of the question how can customer value of infomediaries' services be understood, and what is value in this context.

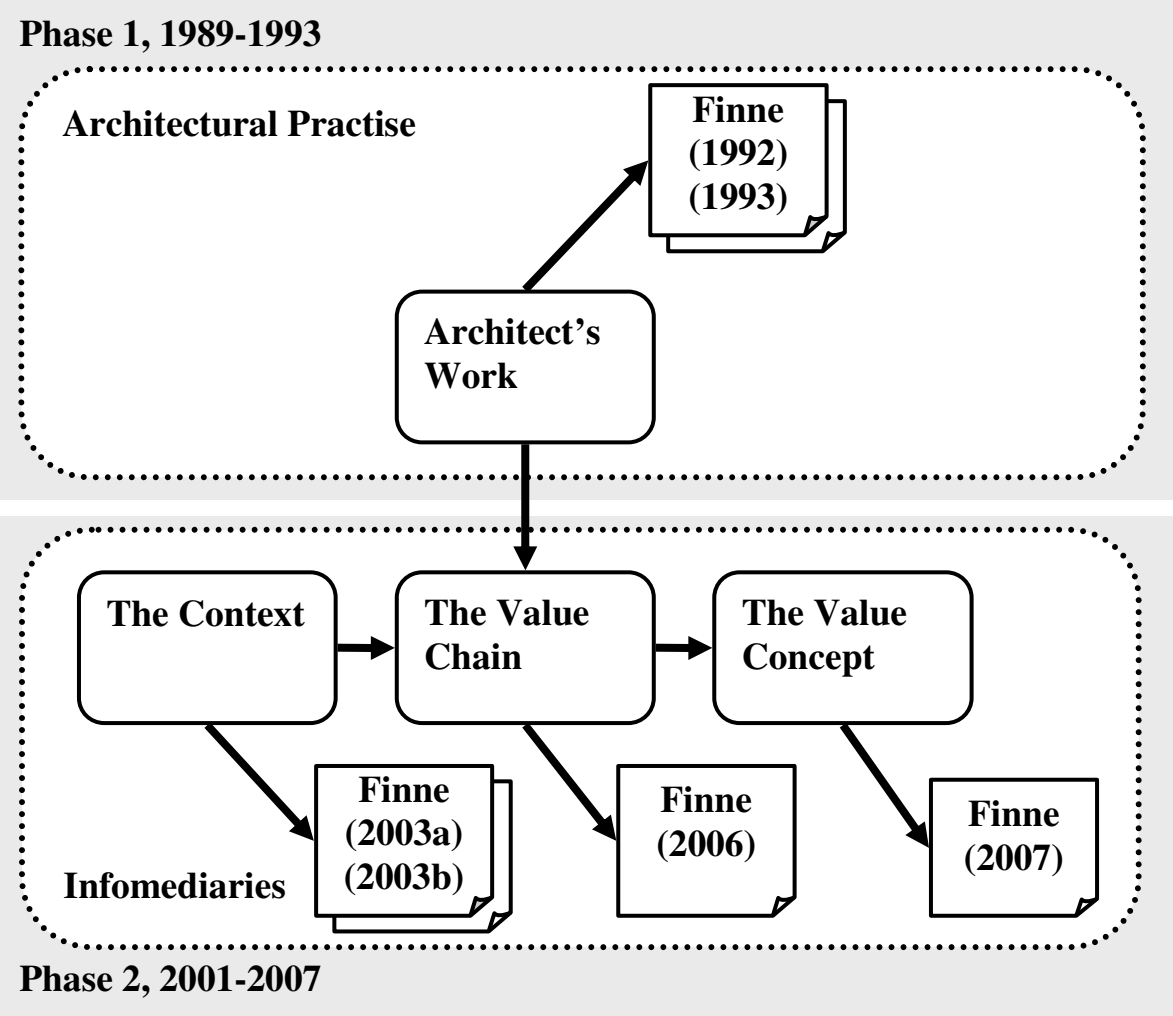

Figure 2: The outcome of the studies by the author, and the relative position of the papers that constitute the thesis

Issues such as research methodology, validity, testing concepts and evidence are reported briefly in the papers, but are instead elaborated in this summary.

1.4 The Research Gap

When a new technology enters existing processes and practises, opportunities a well as uncertainty arise. This thesis strives to bridge the knowledge gap in some of the issues that have arisen from ICT entering the construction value chain. It explores the use of information, with the emphasis on architectural practise, and the provision of information with the emphasis on infomediaries. The research questions are rooted solidly in the everyday work of the author.

The first paper chronologically (Finne 1992) is about the use of information and targeted architects and research involved in ICT and architects' work. It emanated from architectural practise at a time when ICT made its entrance in the form of CAD. Among the issues that arose was whether or not the use of CAD threatened creativity, i.e. the very core of the architectural enterprise. At the same time, there were expectations that CAD would bring along efficiency gains, reduce errors and improve quality. The outcome of the study was a theoretical framework with three levels (creative, combinatorial and registering) where on

each level the degree of ICT use was different. This framework enabled a structured discussion of the problem and made it easier to identify where the gains could be achieved without comprising creativity (Finne 1992 and 1993).

The latter papers (chronologically) (Finne 2003a, 2006 and 2007) are mainly about provision of information, but also about use. They targeted mainly infomediaries in construction, but also those involved in research and development of information services for construction. The knowledge gap arose from a situation where the internet and new internet start-ups in connection with the digitization of the information providers' production processes threatened the very foundations of established construction infomediaries. The first study (Finne 2003a) tackles the problem as a whole, looking for a way forward for the development of infomediaries' internet services, their contents and an ICT architecture. It also indicates a knowledge gap concerning the value chain of information provision (Finne 2003a). The second study (Finne 2006) then explores the value chain, via the use of a formal model. It also indicated a knowledge gap concerning the concept of value, which is then pursued in a third study (Finne 2007). Finally, all papers are tied together by this summary.

2 Research Methodology

This research has some particular features, or dimensions, which have influenced how the methodological choices have been made. One is that the research is undertaken in a position where a new technology has brought uncertainty as well as possibilities. The uncertainty arises from the novelty of the technology and the changes it imposes. It may be seen as threatening present skills and ways of working. Again, the opportunity exists for the technology to be beneficial if it is applied in the correct way. Thus, there has been a need to describe and understand what is happening and, from that description, create an understanding upon which measures for the future can be based. The other dimension is that the researcher himself has been both a privileged observer (Glaser and Strauss 1967) and a reflective practitioner (Schön 1991). A third dimension has been that of the employer of the author, who has been an early adapter of the technology. The methodology used strives to provide applicable answers to the practical concerns of people in an immediate problematic situation, and to make use of the researcher's opportunity to action taking and reflective evaluating, as well as to collaboration between the researcher and the client system

These criteria have directed the research towards mixed methods, qualitative research, constructivist and pragmatic assumptions, grounded theory, case studies and action research. The methodology used strives to produce a bridge between theory and practise (Argyris et al. 1985, Creswell 2003, Crotty 1998, Järvinen 2004 and 2005, Kasanen et al. 1993, Neumann 2000, Stake 1995, Strauss and Corbin 1998).

In the following sections, the role of the case company and that of the author are discussed. A methodology, which can utilise this starting point is presented, finally its validity and kinds of evidence are discussed.

2.1 The Case Company. its Sister Companies and the Significance of the study

Rakennustieto is the main information provider in the construction industry in Finland. In 2006 it had 120 employees and a turnover of over € 11 million. Whilst it comprises two parts, Rakennustietosäätiö RTS (The Building Information Foundation RTS) and Rakennustieto Oy (Building Information Ltd), it is hereafter referred to as one entity or company. The two of them are closely intertwined functionally and the R&D unit, of which the author is Director, is located in the Foundation although functions for both.

RTS is a private, not-for-profit body whose task is to promote good town planning and building practises as well as sound property management principles. The Foundation and its operations are managed by a Board and an Assembly representing the entire building and construction industry, through 47 member organisations and associations. RTS and its wholly or partly owned companies form an organisation referred to as 'Building Information'. The organisation consists of Building Information Ltd, wholly owned by RTS and the following companies, owned jointly by RTS and Building Information Ltd as majority shareholders: ET-INFOkeskuse AS (Tallinn), St. Petersburg Construction Centre Ltd, Moscow Construction Centre Ltd and Latvia Building Centre Ltd. RTS is also a minority shareholder in Haahtela-kehitys Oy, which has developed one of the largest cost management systems in Finland.

Basically, Rakennustieto could be considered a publisher, but its actions and services go far beyond that. It publishes books, journals, standards, regulations and guidelines, runs internet services such as a building product database (20 000 products), indoor air classifications, environmental declarations, standard contract forms, and it maintains building specification systems and classifications for construction and infrastructure engineering. It has a cost estimating system and publishes price books and has a physical and internet bookshop with the ambition of being the most comprehensive in Finland. Rakennustieto has a permanent exhibition for building materials which attracts 50 000 visitors per year. Production, storage and distribution of information today is mainly digital and during recent years Rakennustieto has systematically migrated towards an infrastructure for transferring its products and services more and more via the internet.

Internationally, Rakennustieto is a member of the two organisations of relevance: UICB and ICIS. UICB is the International Union of Building Centres – an international network of 20 local building centres in 14

countries. All its members are national focal points in the field of building information and experts in product information (Anon. 2007f). ICIS, the International Construction Information Society, has 18 members from 14 countries. It is a worldwide association of organisations that provides national master specification systems and/or cost information systems for the construction industry. Many of the members provide product information databases (Anon. 2007g). Both have good coverage and include most of the potential member companies known to ICIS and UICB. Through these organisations, Rakennustieto continuously benchmarks itself and monitors what happens in similar companies all around the world. The connections are close and the insight direct. As ofn late 2007, the Chairman of the Board of the Foundation remains as president and the CEO of Rakennustieto Ltd is Secretary of UICB, whilst the author is Treasurer of ICIS.

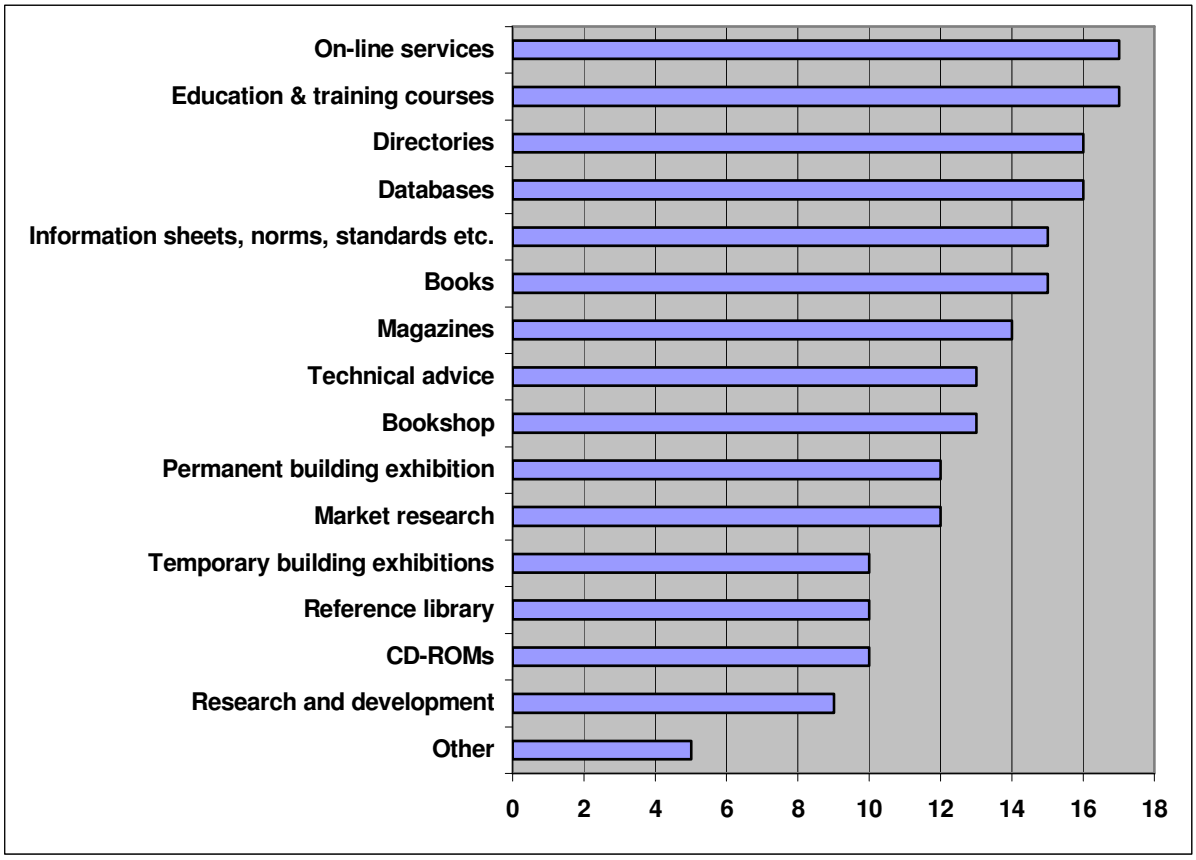

Figure 3: Services provided by infomediaries in the construction industry (Anon. 2003b)

Rakennustieto has a larger mix of services compared to most other members of the organisations mentioned, and most if not all services are represented. It makes the subject company, a satisfactory representative of its kind (Jones 2000, Anon. 2003b). A summary of services run by the members of UICB is presented in Figure 3.

2.2 The Role of the Researcher

A laboratory, or an outside researcher, is dependent on surveys, interviews, mostly non-confidential documents, and has thus access only to a limited set of data. In this thesis, the author has had a more far-reaching possibility. He has been both a privileged observer (Glaser and Strauss 1967) and a reflective practitioner (Schön 1991). A similar approach has been the one of Laitinen (1998) who assessed model based construction process management in one construction company, YIT.

The main sources of information have been documents and archived records (project plans, strategic plans, memos, proposals etc) observations (direct and participant), personal notes and discussions. Thus, the author has had access to more data and information (even tacit, if that is acknowledged) and the opportunity to

interpret and understand it, which would be difficult, even impossible, for an outside researcher. At the same time, this has brought some challenges concerning bias and methodology.

When the researcher functions as a primary data and information source or collection instrument, it is necessary to identify personal values, assumptions and biases, and how they might affect the results. Although every attempt to ensure objectivity has been made, there remains the chance that these traits may shape the way data and information are collected and interpreted (Creswell 2003). In this case effort has been made to ensure objectivity by shaping separate roles for the author in his different tasks, and by organising the work to be performed for different employers. This has helped in keeping the two roles as separated as possible.

Nonetheless, the way data have been collected and interpreted might have been coloured by the fact that the author has been an early adopter of the technology being examined. Also, his position as having responsibility for successful deployment might have had consequences. On the other hand, one prerequisite for successful deployment is identifying threats and drawbacks then recognising and reacting to them. Finally, the objectives for the research have been to pursue how new technology can be taken into beneficial use. Hence, it could even be argued that a positive bias in favour of the technology might be utilised as strength, since the objective of the research is to find sustainable strategies that utilise that technology. In addition, the author‘s position in the “real world” includes responsibility for successful solutions. The research has had to do with how to use the technology, not whether to use it or not.

The other challenge has been to construct a methodology that can maximise the benefits from such a potentially fruitful setting, and that of the author’s special position as researcher and practitioner. Here, in the latter connection, direct access to data and social networks has been possible, without compromising scientific rigorousness.

2.3 Methods Used

The study has been undertaken as a conceptual study and the methods have been chosen, and the methodology designed, in such a way that they strive to extract full benefit from the particular features of this research, the emerging implementation of a new technology, the researcher’s dual role and the employer of the researcher being an early adopter. The research derives from a situation in an area of real concern. It is based on a reality-conceived need to understand the present, on the need to react to that understanding and the need to construct a way forward.

Present positions in research approaches provide an abundance of alternatives, of which one is the way this study has been designed and undertaken. The traditional knowledge claims of mainstream science, i.e. what has been referred to as empirical science, the positivist/post positivist tradition or quantitative research has been accompanied by additional knowledge claim positions. These are such as constructivism, advocacy/participatory and pragmatism positions (Creswell 2003). Thus, besides quantitative research, qualitative and mixed methods are accepted by the scientific community, especially in the social sciences (Argyris et al. 1985, Creswell 2003, Crotty 1998, Järvinen 2004 and 2005, Kasanen et al. 1993, Neumann 2000, Stake 1995, Strauss and Corbin 1998). Methods are defined according to Strauss and Corbin (1998) as “a set of procedures and techniques for gathering and analysing data”. In a mixed methods’ approach the question is not either quantitative or qualitative, but a mix of both, although the mixture tends to be more of one than the other (Creswell 2003).

The research is thus positioned on the axis constructivism–pragmatism - see Table 1.

Positivism/ Postpositivism	Constructivism
Advocacy/Participatory	Pragmatism

Table 1: The knowledge claim position of the research

Characteristics along this axis, i.e. of constructivism and pragmatism, are listed in table 2 as described by Creswell (2003):

Constructivism, or Socially Constructed Knowledge Claims	Pragmatism
Understanding Multiple participant meanings Social and historical construction Theory generation	Consequences of action Problem centred Pluralistic Real-world practise oriented

Table 2: Positioning the research on the axis constructivism - pragmatism

Understanding is based on the assumption that individuals develop subjective meanings of their experience. The research relies as much as possible on the views of the participants being studied. Researchers are expected to recognise that they and their background shape their interpretation. He/she strives to interpret the meanings others have about what is being studied. Instead of taking a theory as the starting point, his/her intention is to generate or inductively develop a theory or a pattern of meaning (Creswell 2003, Neumann 2000). This is also how theory is derived in what is termed grounded theory (Glaser and Strauss 1967, Strauss and Corbin 1998).

A pragmatic approach (Creswell 2003, Neumann 2000) means that the researcher is not limited to any one system or philosophy. He/she needs to look to the 'what' and "how' questions, and research is based on its intended consequences. The researcher is free to choose methods, techniques and procedures depending on what will best meet needs and purposes. According to Creswell (2003) "Truth is what works at the time".

In addition to the knowledge claims and the research approach, additional methodological dimensions that can be used to position research are strategies for inquiry, data collection and sources of data. Concerning alternative strategies for inquiry, qualitative research offers various ways such as narratives, phenomenology, ethnography, grounded theory and case studies. In terms of data collection, there are closed-ended and open-ended enquiries, interviews and field observations. The position of this work is summarised in table 3:

Research approach	Knowledge claims	Strategy of enquiry	Methods	Sources
Qualitative research	Constructivist and pragmatic assumptions	Mixed methods design Grounded theory Case studies	Field observations Action research	Personal notes Documents Discussions Participation

Table 3: Summary of methodological positions

Defining issues is important (Stake 1995). The strategy of inquiry in this research draws on the principles of mixed methods design. It uses methods from grounded theory and case studies. The issues have been derived from practise. They have been what Stake (1995) refers to as 'emic' issues, i.e. issues arising from the inside, the people and actors belonging to the field. These have then been contrasted with findings from extensive reviews of relevant literature and screening results from previous research, where the measure of relevance has been whether the findings work or not (Stake 1995).

Literature findings have been chosen through a filter of experience and the question in focus. This makes it not just a typical review, but also the building of theoretical constructs or models of the parts that come from literature and those parts that come from observations (Järvinen 2005). For theory building, the principles of Glaser and Strauss (1967) and Strauss and Corbin (1998) have been a baseline. The theoretical constructs have been built rather than tested. They have been built from pieces of other theory derived from the literature. What pieces are chosen are based on observation in the field of research. The constructs have then been used to explain the observations. Importantly, the constructs can be used to not only to explain but also

to predict. Since one facet of the research problem is to aid strategy crafting, the ability to predict is also important (Strauss and Corbin 1998).

In the action research parts, results and proposed solutions have been taken from literature back into practice, proposed and tested, with some acceptance. Those parts, where a match could be established, were incorporated into a construct that constitutes the solution. The action research parts have followed what Kasanen (1993) or Kaplan (1998) describes as the innovation action research cycle. Kaplan divides the process into four parts
:
1. observe and document innovative practise
2. teach and speak about the innovation
3. write articles and books
4. implement concept in new organisations.

The process is cyclical or hermeneutic by nature. It starts as a base case, after which one circle becomes the initial implementation, the second becomes the intermediate and then those that follow become the advanced implementations (Kaplan 1998). Analogous cyclical processes are described by Susman and Evered (1978) and by Kasanen (1993). Figure 4 show the author's interpretation of Kaplan's circle as implemented in this research.

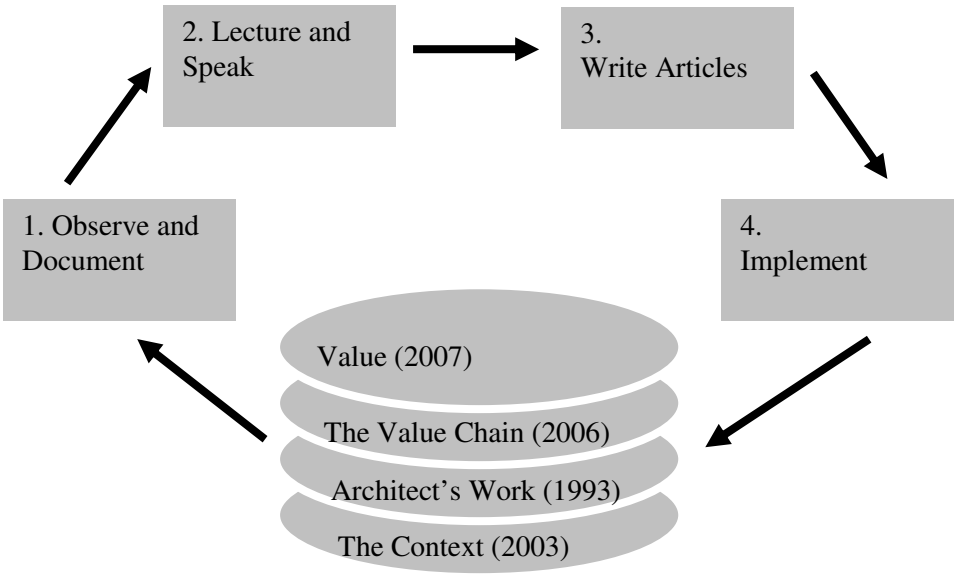

Figure 4: The Innovation Action Research Cycle, adapted from Kaplan (1998)

This thesis comprises four separate papers. Their chronological order differs from figure 4. The position of the first published paper (Finne 1992) is better described in figure 2, but has been placed on the second level in this figure for narrative reasons.

In practise, the cycle has been adapted in a pragmatic way allowing overlaps between its phases (the boxes in figure 2). The way the cycle has been utilised is illustrated in figure 4 and could be described as follows.

Each research cycle starts with the research problem, which has been derived from observations, documents and discussions in the case company. Additional support for the question being a central and important matter has been sought through discussions within branch organisations and seminars[1]. Simultaneously the

[1] For the papers Finne (2003, 2006 and 2007) the most important ones have been the annual meetings of the Nordic Building Centre managers, UICB and ICIS, and for Finne(1993) CAD-SAFA and ECAADE

scope within the research question has been narrowed down to some specific question(s) within the scope. This covers roughly boxes 1 and 2 in figures 4 and 5.

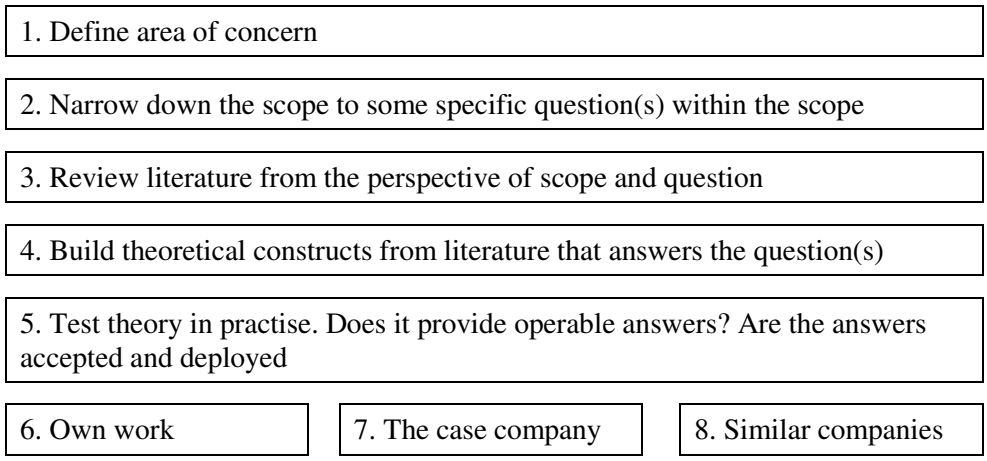

Figure 5: The work process

As a further measure, a relatively extensive literature study has been undertaken. During this, the author has simultaneously used both of his roles: the practitioner has sought answers to the question at hand, and the researcher has looked for whatever might emerge from within the scope, reflecting and writing about it. In adopting both of the roles, the literature findings and the observations have been mapped to construct an answer to the research question. Thus, the research and the work in practise have become intertwined in a braid where one could not have existed without the other in a manner of research utilising practise and vice versa. A general approach like this, first to develop a theoretical proposition and then to map it onto the focus area, has been recommended by Yin (1994). The proposition has been based on existing literature and the focus area has been chosen from needs derived in field studies, i.e. observations in the case company and its sister companies (Yin 1994). For the analysis, a mapping or pattern-matching technique has been used. According to Yin (1994), this kind of method is one of the most desirable strategies for a case study analysis.

In addition, the approach described by Glaser and Strauss (1967) and Strauss and Corbin (1998) stresses discovering theory from data or the building of theory more than verifying it. This part of the study covers roughly boxes 2 and 3 in figure 4, and boxes 3 and 4 in figure 5.

The outcome, or answer, and the reflections have been recorded in the papers that have been described in section 1.3 and figure 2. The writing-up process has continued alongside the author's day-to-day work where the results have been taken back into practise and proposed to the business. Those which have been accepted and taken into the routine business processes, or just otherwise 'worked', 'provided answers' or taken the process forward have been accepted as results. This covers roughly box 4 and the ovals in figure 4 and boxes 5-8 in figure 5. How the overall methodology is applied to each individual paper is illustrated in table 4.

Box in Fig. 4	Finne (2003)	Finne (2006)	Finne (1993)	Finne (2007)
1.	Infomediaries and ICT	Value production in the Construction Value Chain	Architects' design work and ICT	The concept of value
2.	The threat of the internet and new start-ups, what should infomediaries do to survive?	Model the construction value chain from the viewpoint of information provision. Where and how is value produced and delivered?	Does ICT threat creativity? How can the use of ICT be beneficial and provide additional value?	What is customer perceived value as a base for successful deployment of results from Finne 2003, 2006 and 1993
3.	Review of literature on infomediaries, internet and digital services	Review of literature on value chains, modelling, the construction process	Review of literature on the architects' work processes, creativity and ICT	Review of literature on value
4.	Develop digital goods and e-trade platform	Identify potential services	Develop a theoretical framework describing where use of ICT is beneficial	Connect value concepts to the results from Finne 2003a, 2006 and 1993
5.	Deploy digital goods and e-trade platform	Develop services based on the above	Deploy use of ICT according to the above	Deploy conclusions of a deepened understanding of value
6-8.	Practise supports the above	Practise supports the above	Practise supports the above	Practise supports the above

Table 4: How the overall methodology in figure 4 and 5 is applied to each individual paper

The results have been, once again, two-fold: (a) for the researcher, a licentiate thesis and five academic papers of which four academic papers constitute this thesis; and (b) for the practitioner, answers to questions abstracted from reality, which have subsequently been put into practise.

2.4 Validity and Kinds of Evidence

The general area of research is well established in other business areas such as marketing, management and strategy and in other areas of industry such as publishing and mechanical engineering. What is new and unique in this study is aligning this existing knowledge with the role of infomediaries working in construction (Finne 2003a, 2006 and 2007), and, in particular, architectural design (Finne 1992 and 1993).

The main purpose of this study has been to find answers to questions that deal with measures for success in the future. The ultimate validation would, of course, be sustainable business success over time, but such validation would come too late considering that the objectives of this study are guidelines for actions in the present, not the future. Consequently, validation has occurred in different ways, by seeking convergence between sources using several approaches: see boxes 5-8 in table 3.

The validation work has put more emphasis on the research process, the end-point of which is to produce a theoretical construct or a broad explanation (Cresswell 2003, Yin 1994). Generating the construct has gone hand-in-hand with its verification (Glaser and Strauss 1967). The measure of relevance has been whether it works or not (Stake 1995), or works at the time (Creswell 2003). This way of validation can also find support in pattern matching as described by Yin (1994). Validity is considered strengthened when the patterns of theory and observations coincide. Yin sees this as the most desirable strategy to adopt.

In this study, this means that the main measure of validity is if the results provide a functioning explanation in the case situation. The measure of this is that the results either have provided answers to the question of concern and/or that the results have been accepted and become a part of the case company's actions and strategies. Viewpoints, which have been approved by the committees, steering groups and boards and then incorporated into strategies, R&D projects, reports etc, have been seen as validation, i.e. when the observations converge, as described by Patton (1987) and Yin (1994).

The principles of pattern matching have been used in another way too. Using the findings from literature, a predicted pattern has been constructed, which has then been compared and matched to the observations from the case. In each case, areas have been found which are underexploited or unexploited. By underexploited or unexploited is meant that the areas fall within existing strategies, but that few or no products exist. Being able to use the results in such a way seem to support the validity of the results, since they have provided answers in a way accepted by the case company.

Even though the case company is a good example of its kind, making generalizations based on the direct outcome of the research is difficult. Stake (1995) even states that emphasis should not be put on generalization, but on particularization, meaning that, first, emphasis should be on understanding the case company itself. However, discussions within the case company and with managers in ICIS and UICB on results of this research indicate that, if not always the individual solutions, the process, and the way of thinking seems to be applicable also to a wider audience.

3 Summary of Published Papers

3.1 Paper I: The Building Process, CAD and the Core of the Architectural Enterprise

The background for this paper (Finne 1992) is somewhat different from that of the other three papers that constitute this thesis. The paper summarises the main points of the research that produced a licentiate thesis (Finne 1993). The research was finalized 1993, whereas the other three papers were written between 2001 and 2007 (Finne 2003a, 2006, 2007). The starting point of the paper is architectural design, whereas it is services of information providers in the later papers. Nonetheless, both sets of papers have some essential aspects in common. They explore the construction information process and the use of ICT (CAD) therein. This paper looks at the use of information; the others examine its provision. The model in Finne (2006) benefits from analysis of the use of information presented in this paper. The construction process is viewed in a similar way, with product modelling as a potential and beneficial platform for interaction between the actors in the process. Both are ultimately rooted in the Finnish RATAS project. The research reported in the paper is methodologically related to that of the later papers, using an extensive literature review as the basis for mapping to a case company and then action research in the pursuit of verification for solutions that work and help to move forward.

The time at which the research reported in Finne (1992) started was 1989. Computers had been in use among architects in Finland since 1984, the author being one of the first in Finland to use CAD for the day-to day-work of an architect. Even if the benefits and the potential to use of CAD was recorded in the case company (Finne 1993), and supported by literature (Mitchell 1977, Anon. 1985), there were prejudices towards the new technology and arguments that it might limit the creativity of the architect.

Based on a division of design in terms of ‘creative design’, ‘innovative design’, ‘redesign’ and ‘routine design’ made by Tong and Sriram (1989), the author proposes a triangular approach to the work of the architect where the edges of the triangle are: (1) creative design, which incorporates innovative design, i.e. design that produces something new, and does not incorporate any information as such; (2) combinatorial design, i.e. design which uses, for instance, model solutions and redesigns them to fit into the design at hand; where the outcome is to some extent new and to some extent re-used; and (3) registering design, i.e. tasks where none or very little redesign or adaptation is made (Figure 6). Typical examples are references to standards and routine production of drawings and text, such as tracing or drafting. In particular, category (2) has provided an understanding of the role of external information in the work of the architect, which has been beneficial in the later papers of the author.

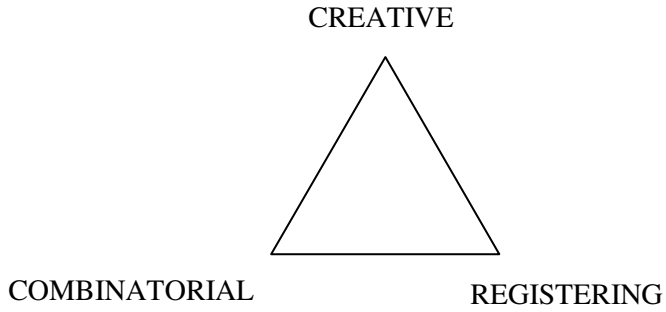

Figure 6: The relation between ‘creative design’, ‘innovative design’, and ‘redesign’ and ‘routine design’ (Tong and Sriram 1989) described as a triangle,

The prejudices and the fear of limited creativity seem to be connected mostly with what fall into the category creative design (Swerdloff and Kalay 1988, Archea 1987, Mark 1990). The paper, and in particular the research it is based upon (Finne 1993), elaborates the methodological issues of the architect’s creative work at some length. Consequently, the benefits of ICT can be found in the two other categories, i.e. those where infomediaries offer their services as described in Finne (2006 and 2007). The paper also concludes that a

fourth and neutral, area where benefits for the architect can be found is the storage and transfer of design data, and recommends an object based data modelling approach.

The results are combined into a model as shown in figure 7, where each of the aspects discussed has a position of its own in relation to the others thus illustrating where the potential benefits of ICT might be found.

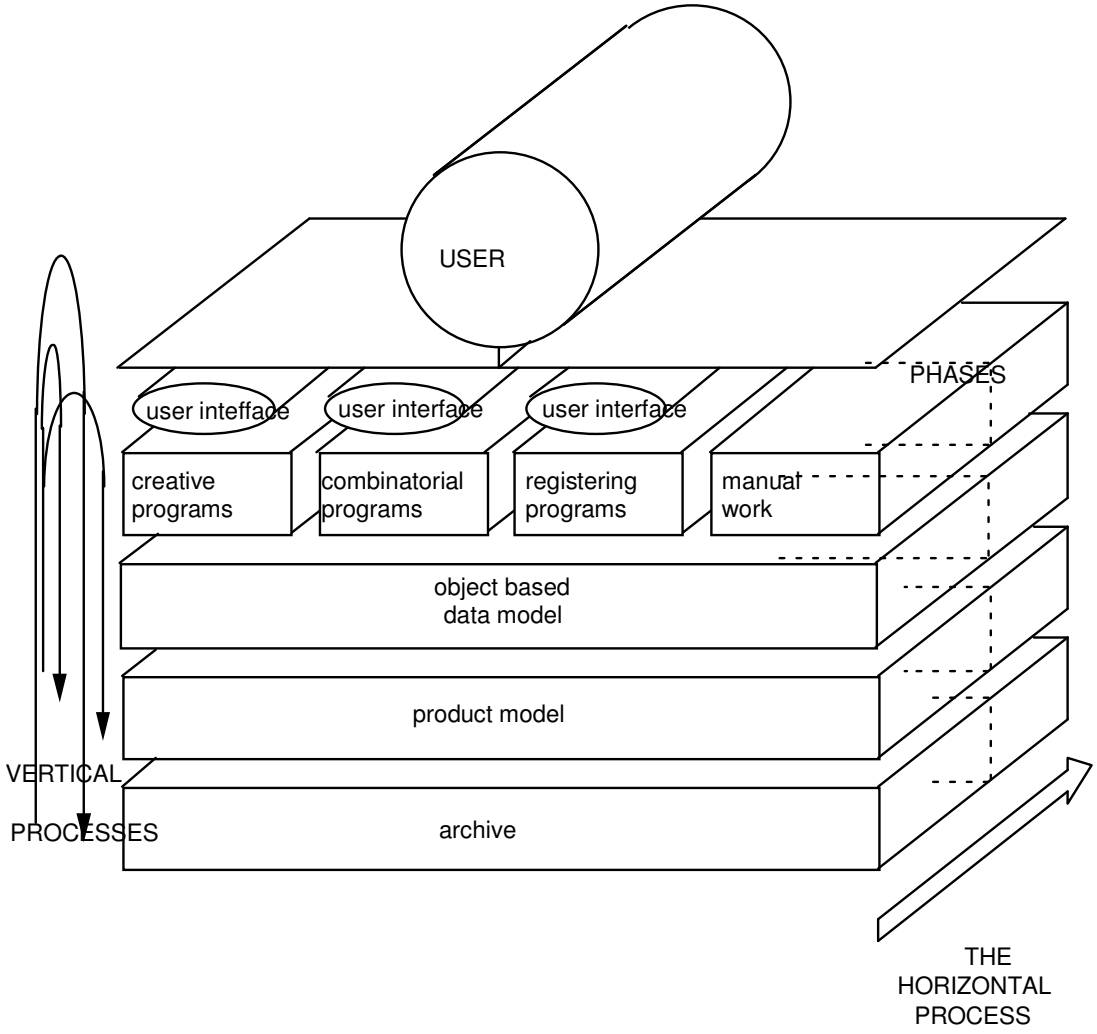

Figure 7: The results of Finne (1992 and 1993) described as a model

As a post paper remark since concluding the paper in 1992, it can be noted that many of the steps discussed in the paper, and captured in Figure 7, have now become a part of everyday practise.
Construction has taken many steps towards product modelling. To mention two examples from Finland, the Vera and Sara technology programs funded by TEKES, strongly supported the approach. Several ICT tools with modelling capacities exist, e.g. Archicad, Allplan and Revit, and they are made interoperable by the IAI/IFC standard. The ICT Barometer 2007 (Kiviniemi 2007) shows a strong inclination towards product modelling. The results of the ProIT project support product modelling by contractors, and the modelling guidelines of the biggest facility owner in Finland, Senaatti, were launched in 2007 (Kiviniemi et. al 2007, Anon. 2007c).

In 1984, computers had barely made their entrance in the case study office. The ICT Barometer 2007 (Kiviniemi 2007) shows that in 2007, 100% of architects' offices have computers, a figure which in a sense indicates that ICT has found its place.

In early 2008 the company of the author, Rakennustieto, launched a new product, a specification writing tool, and a second tool, a cost calculation system is about to be launched. Both are product model based and use external object databases, the objects of which are being provided by Rakennustieto and incorporated

into other modelling software (ACA, Archicad, Revit). In addition, there has been a growing customer demand for the type of information chunks that Finne (1992 and 1993) describe.

As a summarizing post paper conclusion it could be noted that the most important issues have been separating creative work from data storage and transfer. This has enabled the division of the architect's work into several parts of which the provision and integration of external information is one. The principle of integrated design and product modelling is another. Thus the results of the research the paper describes, have formed a basic understanding of one important customer's (the architect's) processes, thus providing an essential background for the preceding papers.

3.2 Paper II: How the Internet Is Changing the Role of Construction Information Middlemen[2]: The Case of Construction Information Services

The internet has radically changed the border conditions for infomediaries in most industries. It has created new business opportunities in the new, networked value chains that have evolved, and threatened the existence of companies who fail to re-engineer their operations (Coltman et al. 2002, Fingar and Aronica 2001, Jansson et al. 2001, Shapiro and Varian 1999a). The internet might present a severe threat to intermediaries. If customers start to deal directly with producers the intermediaries might disappear (Sarkar et al. 1995, Benjamin and Wigand 1995, Schmitz 2000).

The paper (Finne 2003a) examines how these changes affect infomediaries in construction. Three areas are defined as central and are elaborated: changes imposed by the internet, by the use of ICT in construction and in the production, storage and delivery of information

The emergence of the internet caused euphoric descriptions of a new economy where old rules would be overturned and an abundance of new internet-based companies would come into being (Kelly 1999). The descriptions, however, soon turned into views that are more careful. The turning point happened during 2000 when the value of, IT and internet-related companies, in particular, diminished to mere fractions of their highest value (Coltman et al. 2002, Fingar and Aronica 2001). The prevailing opinion was that although the very foundations of the economy did not change after all, some changes occurred in the prerequisites for business, in particular for digital goods. "Technology changes, economic laws do not". Focus should be on the value for the customer. Finally, the internet offers a totally new infrastructure to form networks and use them for transferring (digital) information between people, firms and software. When the three aspects, digital information, information networks and customer value are combined with existing principles for the economy, new patterns, business models and strategies evolve (Shapiro and Varian 1999a).

The interest of companies turned away from consumers to doing business with companies. It was also realized that internet-services had to evolve from mere web-publishing to supporting e-procurement in value networks (Coltman et al. 2001, Ravindra 2001, Fingar and Aronica 2001 Jansson et al. 2001). Soon it also became apparent that the internet was particularly suitable to digital products, or information goods, which could be delivered over the internet. An abundance of products provided by infomediaries, i.e. books, databases, magazines and web services, are all information goods (Shapiro and Varian 1999a, Kalakota and Robinson 1999, Coltman et al. 2001, Smith and Brynjolfsson 2001, Ravindra 2001, Öörni and Klein 2003).

However, this might not be the only case. The notion that electronic commerce will lead to the disappearance of intermediaries can be argued against (Sarkar et al.1995, Benjamin and Wigand 1995, Schmitz, 2000). One way is to seek support from Coase's transaction cost theory (TCT) as shown in figure 8, where I= Intermediary, P=Producer, C=customer and T= Transaction cost. An intermediary is needed when T2+T3 < T1. If T1 < T2+T3, it is more advantageous for the customer to deal directly with the producer. Coase (1988)

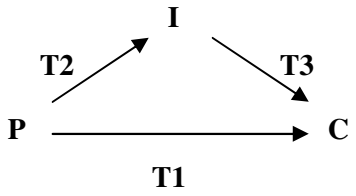

Figure 8: Coase's TCT as a triangle

stresses that transaction costs, or prices should be understood in the widest sense of the term, including not only monetary costs, but everything needed to carry out a market transaction for instance search and information costs, bargaining and decision costs (Sarkar et al.1995).

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[2] Although the name 'middlemen' was used quite correctly in the title of this paper, in this text the name 'intermediary' is used.

Further strategies, which might give intermediaries competitive advantage, have been presented (Coltman et al. 2001, Scott, 2000, Schmitz, 2000, Tapscott et al. 2002, Wielemaker et al. 2001, Willcocks and Plant, 2001):

The intermediaries reduce the amount of asymmetric information.
In a network abundant with information, attention becomes a scarce commodity. Intermediaries provide attention.
Proximity to the customers. An intermediary can affect the decisions of the customer, and thus gain bargaining power against the producer.
Reputation, trustworthiness and attention, which can be achieved by building brands. Despite what has been predicted, brands seem to continue to have a significant role on the internet. The brands of infomediaries are often well-known, i.e. 'RT', 'M1', 'RYL' in Finland or 'AMA' in Sweden.

In the construction industry, most of the information exists in one digital form or another, providing a promising foundation for e-business and computer-based communication. All mayor players use computer programs, produce, store and transfer their data in some digital format (Arif and Karam 2001, Dunt and Harper 2002, Anon. 2002, Anon. 2003a, Lim et al. 2001, Rivard 2000, Romo 2002a, Romo 2002b, Samuelson 2002).

The approach has become to take a life cycle perspective of the building and the information describing it as well as the process the process. Participants act in a value chain, producing, storing and delivering information digitally. The use of common data and product models, or Building Information Models (BIM), is spreading, and has gained considerable ground (Björk et al.1995, Sulankivi et al. 2002, Björk 2003, Eastman 1999, Kiviniemi 2007). The main standardisation initiative is IAI/IFC, International Alliance for Interoperability/Industry Foundation Classes (Tarandi 2003, Koivu 2002, Kiviniemi 2006). Existing digital models are not complete, so various mixed procedures are likely to coexist for some time (Romo 2002a, Romo 2002b).

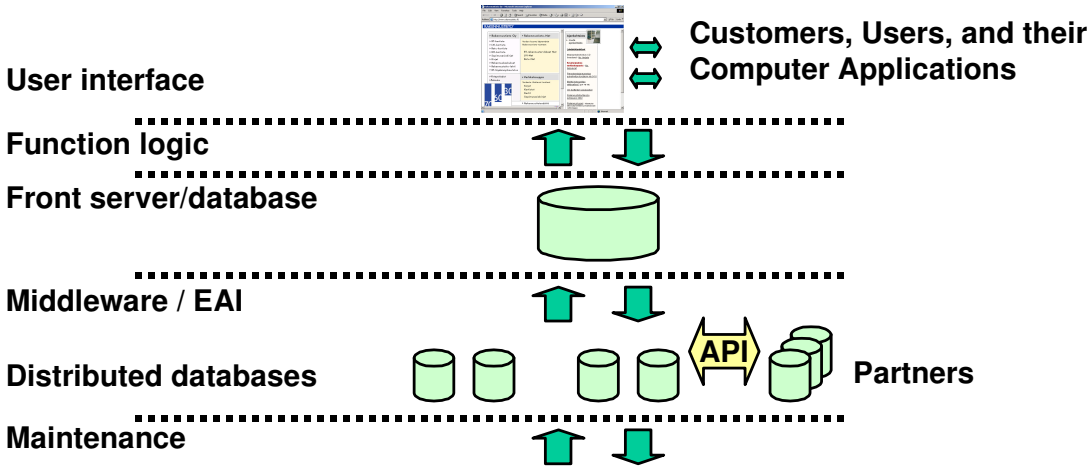


Figure 9: A proposed multi-tier architecture for infomediaries' web services

Some of the information, e.g. standards and product information is produced and/or published by construction infomediaries. They have two categories of customers: those who have information and need to have it distributed; and those who need this information. See figure 1. For customers who supply information (e.g. the product industry), the intermediaries add value by effective distribution. For customers who need need information (e.g. architects) intermediaries add value by providing the right information at the right time in the right format. The information provided can be either passed on from the previous group of customers or produced by the intermediary. As a technical solution for the construction infomediaries to support e-procurement in value networks, the paper proposes internet-based services on a multi-tier architecture as shown in figure 9.

The services comprise a multitude of digital products, such as building product databases, indoor air classifications, environmental declarations, general quality reference databases and specification systems.

As a post-paper conclusive remark, it can be noted that in the case company in 2007, there is an ever growing belief in the concept, with the company continuing to develop it and in the process launching new products.

3.3 Paper III: Publishing Building Product Information – A Value Net Perspective

In this paper, the role of infomediaries – essentially information intermediaries – in the construction industry in producing and delivering value for their customers is explored. Infomediaries have two groups of customers: those who need and use information and those who supply it. See figure 1. Infomediaries provide information to those who need it and they share information from those who have it and want it distributed. They also produce information themselves. Typical examples could be categorised as extended publisher activities such as books, catalogues, standards building product databases and data sheets. Today, virtually all major participants in construction use and produce their data in some kind of digital form. The same is true of infomediaries, who provide them with digital information services. The emergence of the internet has radically changed the boundary conditions for enterprising infomediaries, creating new business opportunities in the networked value chains that have evolved and threatening the existence of those infomediaries who fail to re-engineer their operations (Finne 2003a).

The construction industry is often described as a value chain that produces buildings. However, there is another aspect, which is often overlooked, i.e. the construction value chain also produces information (Björk 1997). Some of this information is produced and/or provided by the infomediaries, and the internet has become a serious competitor (Finne 2003a). When a customer chooses between services, he/she tends choose the one that has the lowest transaction costs, alternatively the one that maximises value (Coase 1988, Sarkar et al. 1995). One of the prerequisites for success for infomediaries is that they understand and utilise the value chain, or value network, of construction and publication and that they, based on that understanding, offer services to their customers at lower transaction costs or that give better value than then their competitors (Finne 2003a, Porter 1999, Shapiro and Varian 1999a, Tapscott et al. 2002, Parolini 1999).

In order to provide a better understanding of the value network the paper presents, through the medium of an IDEF0 model, parts of the construction value chain relevant to the pursuit of customer value.

The need for modelling derives from the nature of the construction value chain. The construction process is ambiguous and fragmented, and involves a significant number of participants: building owners, designers, constructors, building material producers, local authorities, building users, tenants and facilities managers. All are engaged in projects that are most often one-off in nature and carried out under the twin pressures of limited money and time, whilst subject to demand for high quality (Karhu 2001, Björk 1997).

The main reason given for using the IDEF0 method is that it associates closely with processes, as does the study this paper discusses. The method has been used extensively internationally and there is a growing familiarity with IDEF0 as a common means for communication (Karhu 2001, Karhu et al. 1997, Karstila 2003, Laitinen 1998). Many applications of IDEF0 modelling to the construction domain have been attempted. One of the first models to use IDEF0 is that of Sanvido et al. (1990). Others are that of Messner and Sanvido (1994) and the Process Protocol (Kagioglou et al. 1999). Other forms of modelling have been undertaken by Karhu et al. (1997), Laitinen (1998), Karhu (2001) and Karstila (2003): all have modelled the Finnish construction process.

The focus of the model described in this paper is not on the physical building, but on the production of information and of product information in particular. The viewpoint is that of the infomediary and is based on the case of a national enterprise. The model is used to explore in detail how value is aggregated, how it is delivered and how it is received. The activities of users other than architects have been given relatively little attention. The model's perspective is that of the infomediaries. Two separate information flows have been modelled – those of the manufacturers and those of the infomediaries. It compares the creation of product information by manufacturers with that of infomediaries and proposes transaction cost theory as a tool of analysis.

The model is presented in more detail in the paper by Finne (2006) and can be downloaded in its entirety from www.finne.fi. It shows how product information is produced and provided in one breakdown of diagrams, and how it is retrieved and used in another. Value is generally produced in box A1 (left) and its child diagrams and perceived in box A2 (right) and its child diagrams)

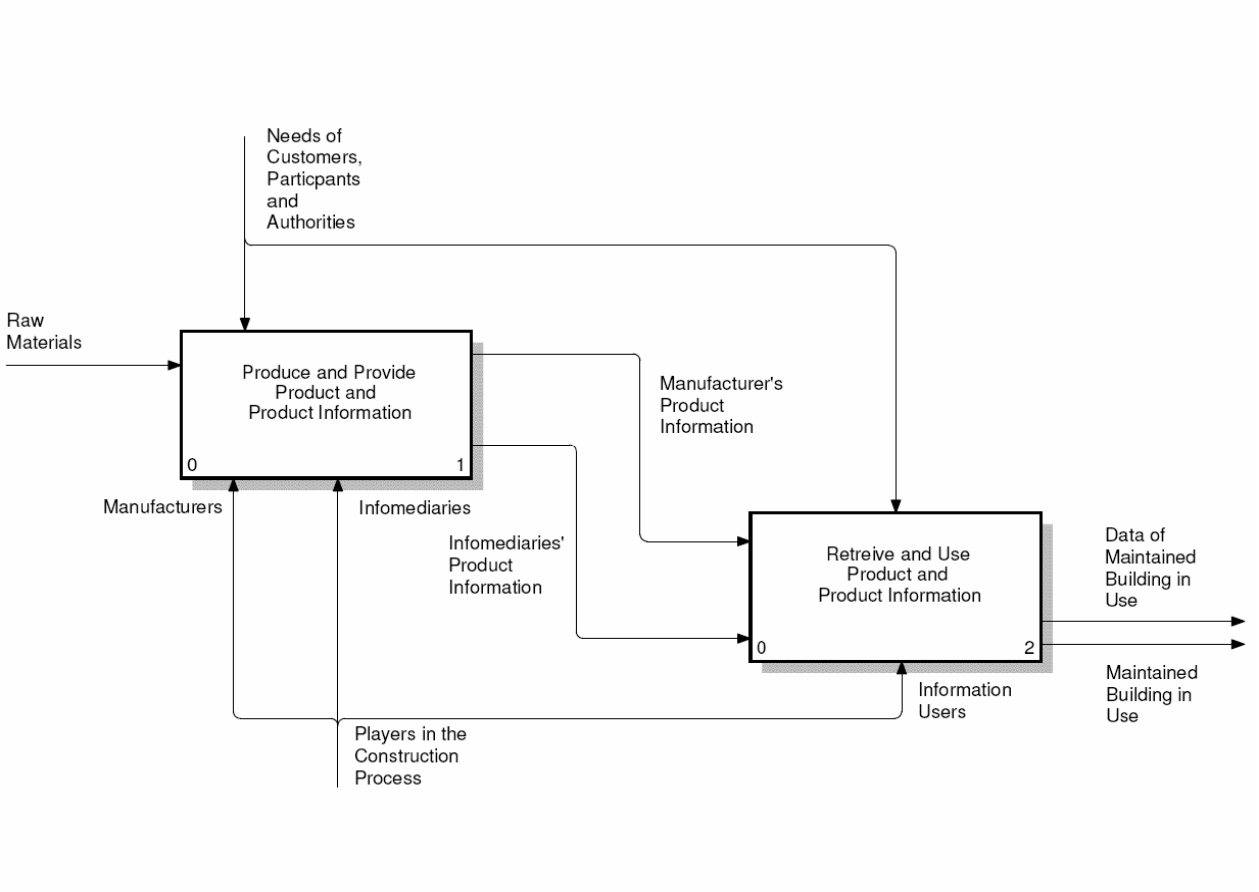


Figure 10: Value is generally produced in the box to the left and its child diagrams and perceived in the box to the right and its child diagrams

The processes modelled by the sub-diagrams in the leftmost part of the model deal with how building product information is produced and how value is added to it. Some dimensions are discussed in more detail, using results from other research, e.g. that brands continue to be important, also on the internet, despite predictions to the contrary (Wimmer et al. 2000, Smith and Brynjolfsson 2001, Coltman et al. 2001). Figure 11 shows an example of a diagram modelling how value is produced. It illustrates how value is added to product information.

The rightmost part of the model describes how the information from infomediaries is used, via a breakdown of the user's work into numerous sub-processes. These are then coupled to the corresponding processes of the infomediaries, showing where it is perceived, and when and how their information is or could be used. Figure 12 shows an example of this.

The model has proved useful in gaining a deeper understanding of customer needs among information providers as well as users. The model has been validated through action research and has helped to strengthen existing strategies and led to new insights. It has also had an impact on existing and proposed services of the enterprise being studied. Several new products are now in the production pipeline of the case company.

The model also reveals the need for a deeper understanding of the concept of customer value. This issue has been further pursued in the chronologically subsequent paper (Finne 2007).

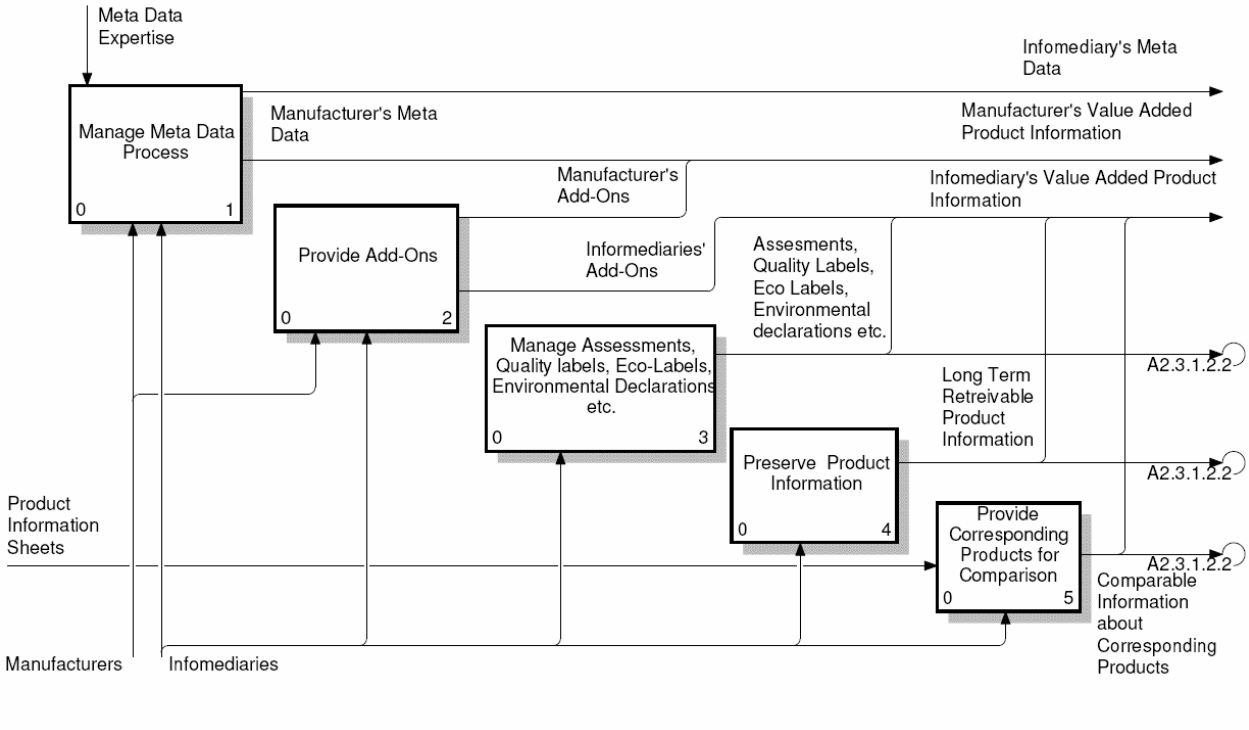


Figure 11: How value is added to product information

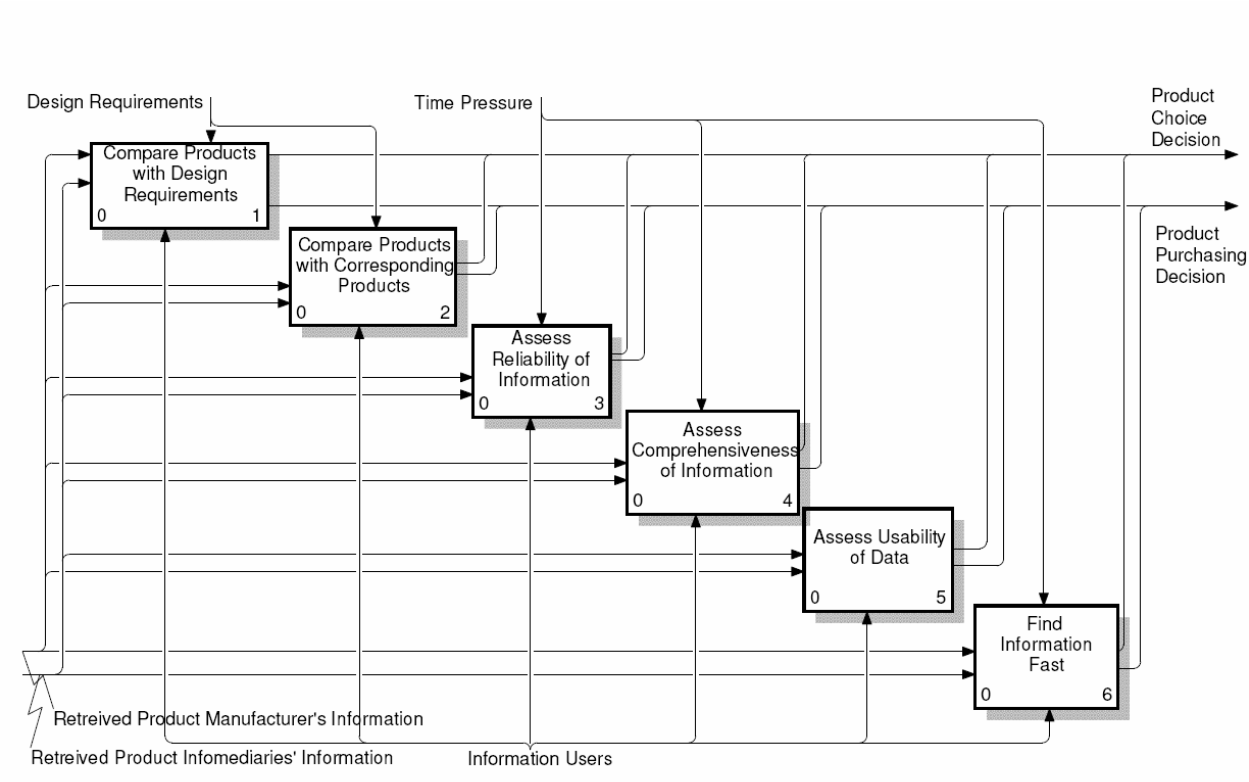


Figure 12: How value is perceived

3.4 Paper IV: Perceived Customer Value in Construction Information Services

Significant benefits may be achieved in the use of computers and computer programs, integrated design and product modelling (Mitchell 1977, Gielingh 1988, Björk 1989, Turner 1989, Eastman 1999). The architects' work too, if divided into parts with different levels of need for creative freedom and viewed separately, could benefit significantly from computer use, in particular when combined with a product model approach (Finne 1992, 1993). In a recent questionnaire, 93% of the responding architects were using product models, representing 33% of their work (Kiviniemi 2007).

The greater part of the information needed to design, construct and manage a building has become digital. The information is produced partly by the design process and is thus unique for each building. Part of it is produced elsewhere; the design and procurement documents only contain references to this external information, not the information itself. Another essential part of external information is product information, some of which is eventually integrated into building documents, while some serves as a basis for comparisons, evaluations and decision making. This kind of external information is provided by service providers such as Rakennustieto in Finland, Svensk Byggtjänst in Sweden, or STABU and CROW in the Netherlands, i.e. typically one or two providers per country. They are infomediaries or information intermediaries as well as information producers and provide standards, general specification systems, standard contract forms and product directories. Digitization in combination with the emergence of the internet has changed the prerequisites for their success in business. A whole range of new business possibilities has emerged as digital customer processes, such as product modelling, specification writing and finding products, need support. The infomediaries meet new competition and need to rethink their products as well as their business processes in order to sustain and enhance their competitiveness (Finne 2003a, 2006).

In previous papers, the author has discussed how infomediaries might structure their information systems, in order to enable the information to be provided in different combinations for different purposes throughout the process and the whole lifespan of the value chain (Finne 2003a). The importance of recognising and understanding the value network in which the participants of the construction value chain function in an inter-related way, has been put forward, and the network has been modelled and explored (Finne 2006). The importance of producing products with superior customer value compared to competitors has been investigated (Finne 2003a, 2006).

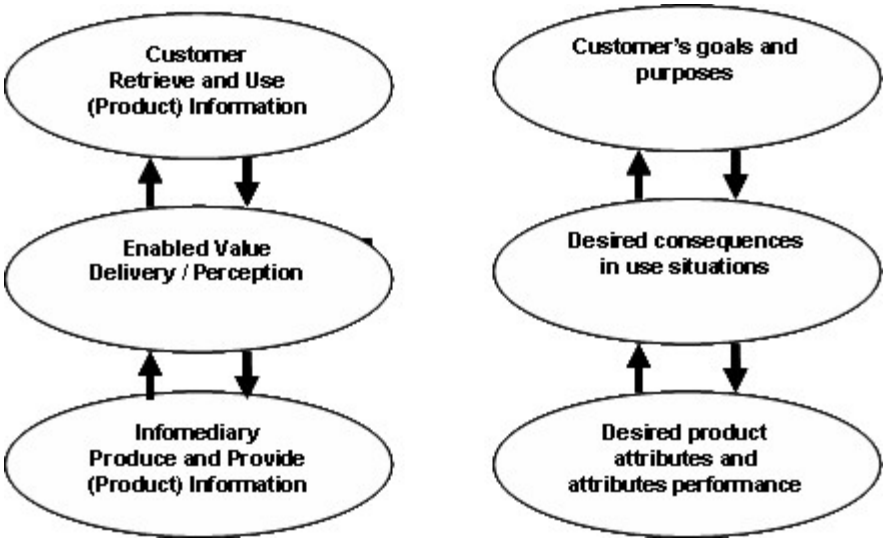
The research reported in this paper describes a way of tackling the issue of customer value from construction infomediary services. Even though no common agreement or mutual understanding exists about how to define customer value (Woodruff 1997, Saliba and Fisher 2000, Sweeney and Soutar 2001), many agree that perceived value can be derived from a correlation between benefits and costs (Sinha and DeSarbo 1998, Saliba and Fisher 2000, Johnson and Weinstein 2004, Holbrook 2006). Thus, it becomes necessary to maximize benefits and minimize costs. Costs, as something to be minimised, can consist of, for example, exchange costs, which include transaction and transportation costs and taxes; transaction costs which include time and effort to search out, negotiate and consummate an exchange; and out-of-pocket costs (Saliba and Fisher 2000, Johnson and Weinstein 2004, Keeney 1999).

Traditionally, value is dealt with as something that is inherent in the product; it is often seen as a part of brand building or the efforts of marketing, and can be produced and delivered as part of the product and its attributes then handed over to the customer who pays a price for it. This kind of approach is discussed on a general level by, for example, Langley and Holcomb (1992), Holcomb (1994), Sinha and DeSarbo (1998), Pohlman et al. (2000), Han and Han (2001), Sweeney and Soutar, (2001), Johnson and Weinstein (2004), Holbrook (2006), Underwood et al. (2000), Berry (2001), Wilson et al. (2001). The last three authors deal directly with aspects of customer value in construction.

Later research goes beyond this. It argues that value cannot be pre-produced. It treats value as something co-produced by the customer throughout the relationship, partly in interactions between the customer and the supplier or the service provider. Value is produced and consumed simultaneously. Products (or services) can only be facilitators of value. Customers use the inputs the sellers provide in their own value-generating processes. Value springs out of the use of the inputs of sellers to realize more revenue or decrease costs

(time, money, inconvenience and frustration). This also implies that all firms are, in fact, service firms. A service perspective is thus adopted (Woodruff and Gardial 1996, Woodruff 1997, Goodstein and Butz 1998, Grönroos 2000, Saliba and Fisher 2000). This has far-reaching implications for the strategy, as well as the organisation, of the firm or company (Crosby et al. 2002, Grönroos 2000). The service provider must gain a thorough understanding of the customer's value generating processes and the customer's goals: he or she should determine how to improve those processes by his/her activities. The focus is on the outcome the customer seeks and value derives from the ability to achieve the customer's goals (Grönroos 2000, Saliba and Fisher 2000, Goodstein and Butz 1998). There is a need to gain a deeper understanding of the customers' latent needs and to extend beyond regular customer surveys (Kano 2001, Mello, 2001, Salz 2001, and Wilson et al. 2001).

The consequences are illustrated by the following two figures. In figure 13, the service perspective is illustrated as a hierarchy by Woodruff (1997) and Finne's (2006) model is interpreted in a similar way.



Figur4 13: Finne's (2006) model (left) compared with Woodruff's (1997) schema (right)

Finne's model originally describes the customer's processes as targets for the service providers' products and as a means for understanding what products the customer might need. If a service perspective is adopted, the model might be interpreted as a description of processes where the aim is to maximize benefits and/or minimize costs.

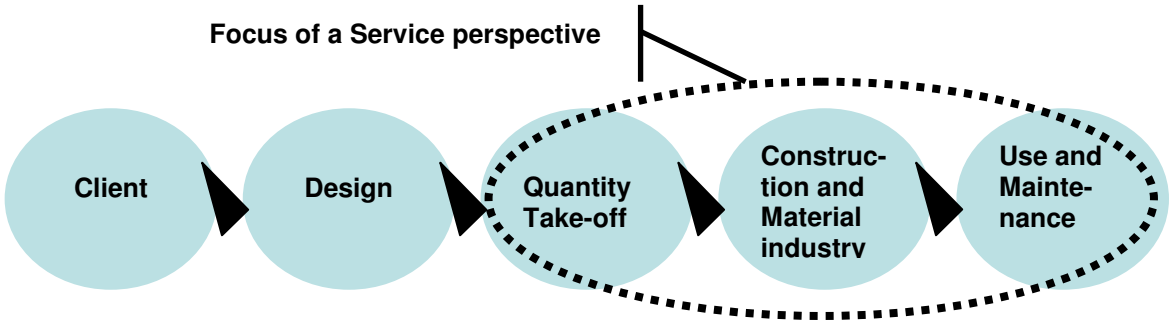


Figure 14: A service perspective extends and moves the focus of value production forwards in the value chain

When the focus on value creation moves from products to what customers do for their own customers, the potential for value creation moves forward in the value chain (see figure 14) (Ullberg et al. 2002).
The conclusions, elaborated in the paper by examples, are that it is not enough for infomediaries to produce books, standards, product sheets etc. They need to gain a thorough understanding of their customers' business processes. Instead of producing products (or services), they should become facilitators of value for their customers.

4 Results, Discussion and Conclusions

4.1 Overview of the results

The research reported in this thesis has been undertaken in a situation where new technology has imposed changes on the day-to-day working of the participants in the construction value chain; primarily, CAD for architects, and web-publishing and electronic business for infomediaries. The aim and objectives of the research have been elaborated in section 1.2, but as a brief summary, the broad aim has been to provide a platform for orientation in a new and strange situation. The objectives have been to explore, clarify and understand what is happening, and to explain where and how this new technology might be utilised; in short, to indicate a way forward.

The thesis comprises four different papers (Finne 1992, 2003, 2006 and 2007), unfolding different aspects of use and provision of ICT tools, information and information services in construction. As an outcome, there are four sets of results, which are partly intertwined. Altogether, the results point towards a picture of an ever-more computerized, or digitized, construction value chain.

In this value chain, a lifetime perspective is often taken, which means that all participants from project initialization through to use and maintenance become part of it. These actors use, produce, store and deliver information, and they do it in some digital format. Product modelling, or BIM, has been proposed as approach to the data format, a trend that has gained in strength after the afore mentioned papers have been written (Froese 2002, Kiviniemi et al. 2007, Anon 2007d, Anon 2007e). In addition to buildings, the process now additionally deals with information about the buildings. In this increasingly digital process, information providers are required to adjust their own value adding processes accordingly. Those that do not adjust, face the risk of becoming redundant. The proposed solution is to provide information digitally and to deploy a platform for electronic business that integrates customer information, economic information and product data, and to do this utilising the concepts of value chains (Finne 2003a).

Once information providers, or infomediaries, take a digital value chain approach they face new challenges, if their actions are likely be successful. The establishment of a thorough understanding of the value chain and their position in it is proposed. One way forward, which seems to offer a solution, is to widen the concept of the value chain towards the concept of value nets. A detailed description, or rather a formal model, of the value net seems to offer a fruitful way to find almost an abundance of business processes where customer value is, or could be produced. The breakdown of the model into numerous value producing and value receiving (sub-) processes can be undertaken for service providers' own business processes as well as for those of customers. Using the breakdown, the service offer and customers' needs can be assessed (Finne 2006).

Within the value chain, there is a particular worry: architects' concern for creative design. Many architects fear that the use of ICT might put limitations on creativity of their design. However, if the architects' work is analysed in more detail, parts may be found where information provided by, for instance, information service providers, can be utilised without the creative parts becoming threatened. Typical examples are product information, standard solutions, standards and archive services. Furthermore, the use of standards, which enable participants in the value chain (including the architect) to exchange information is expected to be of increasing benefit (Finne 1992, 1993). An approach, which has been of growing relevance, is product modelling (BIM) (Froese 2002, Kiviniemi et al. 2007, Anon. 2007d, Anon 2007e).

Even if a relatively simple understanding of the concept customer value seems to offer useful results, the study indicates that a more thorough understanding might lead to more far-reaching results. Service providers need to go beyond customer (satisfaction) surveys. The study supports the notion that in construction information services, customer value cannot be fabricated in advance, but springs out of each contact between the service provider and the customer. The proposed way forward is to adopt a so-called service perspective, and to acquire a deep-understanding of the customer's business processes. The intention

of the understanding thus gained is to enable development of new or enhanced products, which meet and even exceed customer expectations (Finne 2007).

4.2 Discussion of the results

The aims, objectives and results have been elaborated in the previous section. They were to establish an understanding of the present and to indicate a way forward. Since this has occurred and the proposed way forward has gained acceptance, or even to some degree been carried out, the objectives have been met to that extent. The individual papers deal with different aspects more in detail. Their outcome will be discussed in the following section.

Finne (2003a) deals with the situation for infomediaries in the construction industry. It discusses the internet as a platform for information delivery and e-business, arguing that those who provide value to their customers will survive and thrive. It also elaborates activities of those providing information services and describes an ICT architecture for information production, storage and delivery, as well as establishing a need to connect to the networks where information is delivered. The argument builds on the assumption that customers will increasingly move towards a growing compatibility and use of standards. Full electronic commerce, or the full use of product models, might still be some years off, even if the momentum exists (Koivu 2002, Froese 2002). It could also be argued that standards should be avoided, even fought, because they prevent differentiation and create lock-in, and thus premium pricing (Shapiro and Varian 1999a and 1999b). There are, however, no observations up to the present from the field of the case company, which would give support to these claims.

Another question not addressed is the need in general for information intermediaries. It could be reasoned that if, for instance, there were only very few architectural offices and very few building product firms, it seems unlikely that these would need an intermediary to find each other. However, the present trend has been the reverse. The amount of building products in the product database of the case company has been steadily increasing over the course of this study.

A third question, for which there is still little evidential support, is the willingness of the infomediaries' customers, who are used to tangible products which can be kept on a desk or put into a shelf, to pay for the less tangible services on the internet. At present, experiences from the case company are encouraging when it comes to products that have been transferred from paper to electronic format. Another encouraging issue is that the internet offers possibilities such as interactivity, enhanced functionality and personalized products, which are not even possible in the old paper-based environment, thus making totally new services possible.

Finne (2006) elaborates the value chain or network where the infomediaries function. By the use of a formal model of the processes, the points where value is produced, delivered, received and consumed can be shown. A model always has a purpose and a viewpoint. If these are altered, the model will be different. In this case, the model was limited to building product information and architects, and the model's viewpoint is that of the infomediary. Even with these limitations, it has been possible to use the model of the value chain (value net) to identify new services. There is an abundance of areas, which could yet be explored using the model. Civil and structural engineering, installation engineering, interior design, use, maintenance and management could be mentioned as examples forwards along the value chain. Backwards along the value chain might be participation in the production of building product catalogues, although this is not pursued or elaborated.

As a means for dealing with the potential for success of a particular product, Transaction Cost Theory (TCT) has been used. The TCT was originally conceived as a price mechanism but can be used for value as well. The idea is that customers choosing between alternative, competing products choose the one with the lower transaction costs, i.e. higher value. Cost and value should be understood in a very wide sense of the word (Coase 1988, Sarkar et al. 1995).

Finne (1992) is based on the licentiate thesis of the author (Finne 1993). It is an analysis of the core of the architect's work in order to explore how the use of ICT, or CAD, might receive benefit without comprising creativeness. It describes areas of the architect's work where the use of IT (i.e. CAD) might be beneficial and indicates product models as a means of data storage. It also indicates the need for external databases, like those the Building Centres provide and shows how they might fit into the process.

As mentioned in section 1.1, the position of Finne (1992) is slightly different from Finne (2003a, 2006 and 2007) in terms of scope and age. It views the construction information process from the architects' perspective and there is a time-gap of eight years between the finalisation of the licentiate thesis and the re-start of the research in 2001, which is now considered from the viewpoint of construction infomediaries. At the time of writing, 15 years have elapsed since the licentiate's publication. Of the conclusions, most have been fulfilled. Computer programs are now a commodity in architectural practise and the use of BIMs is growing rapidly The Finnish ICT Barometer 2007 shows that 100% of all architect offices have computers, internet, e-mail connection and 2D CAD drawing. 93% use BIMs and 83% share BIMs. 84% saw the trend in using BIMs as growing (Kiviniemi 2007). In Sweden, there has been a clear increase in the use of IT too (Samuelson 2007). In addition, electronic information services now exist. Visits to the websites of members of UICB and ICIS reveal an abundance of information services, i.e. document repositories, product databases, specification writers, schedule tools and even support for BIMs (Anon. 2007f, Anon. 2007g). However, programs that are aimed explicitly at assisting, or even doing, creative work are scarce if not non-existent. In looking at the topics of conferences or journals, it seems as if the issues of artificial intelligence and knowledge engineering have almost disappeared.

Finne (2006) concluded that customer value was an area to be explored further. The next paper (Finne 2007) takes up that theme. The scope is on perceived customer value in architectural design and the use of external databases with an emphasis on the use of product information. Since it is the most recent paper, published in June 2007, there is still quite scarce long-time documentation of its proof-of-concept in the day-to-day-practises of the case company. There are some positive early indications. ICIS chose 'enhancing customer value' as its theme for its annual assembly in 2006, in-depth team interviews gained ground as a source of customer knowledge, recent web services have been designed around customer tasks and the strategy during 2007 focused on how the organisation could be redirected towards customers instead of products.

4.3 Generalization of the results

Not all methodologists argue for the need to have large generalizations. In qualitative research, generalization play a minor role (Cresswell 2003) and in case studies the real focus is not on generalization but on particularization, i.e. to learn to understand the case company really well. According to the constructivist view, it can even be left to the reader to make generalisations of his/hers own (Stake 1995). Nevertheless, some attempts will be made.

The research focus lies within the construction value chain on infomediaries, architects and building product information. Thus, generalization can happen on several levels:
within the company between different product or customer groups
between other similar companies
between other companies

Observations from the case company over the period of the research indicate that generalisation between product or customer groups is possible and has in fact been done systematically. One example is the that product palette includes four sets of information binders, traditionally published on paper. During the period of 2006-2008, they are being transferred to an internet platform following the principles described in Finne (2003a). Furthermore, the first contains features based on the customer's sub-processes as described in Finne (2006). The actual model itself has not been used, but the principle of identifying key customer processes has, and the pilot service has been for HVAC engineering, whilst the paper describes architectural design.

When it comes to generalization between similar companies, the indications are of limited cases. On the other hand, the members of UICB and ICIS have provided some of the observation material, so it becomes difficult to recognise which one has been the source and which one is the consequence.

5 Conclusions

5.1 Final conclusions

It is the hope of the author that this work might contribute to the accumulated knowledge and understanding about the use of ICT in construction insofar as:

The first paper (Finne 1992) might show that use of CAD/ICT can be beneficial in the architectural enterprise and that part of the benefit can come from the use of external databases offering chunks of information for the design task at hand. The second paper (Finne 2003) could do this by elaborating on the role of the internet and that of infomediaries who provide the external databases that provide the chunks of information mentioned above. The paper focuses on product information and points towards how they might do this successfully.

The third paper (Finne 2006) might provide a helpful description /model of the value net/chain where information is delivered. This might help to pinpoint where and how value is produced.

The third and fourth papers might provide insights in that the construction process does produce not only buildings but also information, and that it might be important to realise that it is not enough to produce a building efficiently with good quality utilising e.g. concurrent engineering, total quality management, life cycle calculations and life cycle assessments. It might also be essential for the customers to receive data about the building.

The fourth paper might provide a useful elaboration of what is meant by 'value' in the construction process with focus on architects' work and product information.

The entirety might help infomediaries in particular to draw and implement their strategies, and any participant in general to understand what value is, and how it is produced, delivered and received in the construction value net/chain.

As a conclusive remark, observations from the case company and from discussions with managers of companies in UICB and ICIS support the notion that more than the individual results, the general approach, i.e. the TCT, the value net model, the service perspective, and value receiving seems to be useful. The approach includes assessing the internet as a service delivery platform, gaining a deep understanding of the value chain, providing better value than competitors, and doing this from a service perspective.

5.2 Need for Further Research

When needs for further research have been identified, this has been mentioned in each individual paper. In many cases, an identified need has served as a basis for the following next paper. These will not be repeated here. There are, however, two separate issues to which no or few indications have been found during the literature reviews and the observational parts.

The first issue is that of the end customer or the construction value chain, or rather whether or not there is an end customer. It is important to identify customer needs that go beyond the immediate next customer in the value chain (Porter 1999, Grönroos 2000, Prahalad and Ramaswamy 2004). If an end customer can be established, the participants in the value chain can focus on him/her, otherwise they might benefit from some guidance about how far up or down the construction value chain customers might be considered.

The other one springs from the proposed solutions in Finne (2007), where a service perspective is recommended following the principles described by e.g. Goodstein and Butz (1998), Grönroos (2000) and Prahalad and Ramaswamy (2004). The idea of taking a service perspective are still in their infancy in the case company. No indications of how the organisation should adapt to a service perspective in practise, have been observed, even if the need has been recognised.

6 References

Anon. (1985): CAD-projektering, en utvärdering, Bollnäs, kv. Älgen, Byggnadsstyrelsen, Stockholm

Anon. (2002): eEurope, An Information Society for All, An Action Plan to Be Presented in View of the Sevilla European Council 21/22 June 2002, Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions, COM(2002) 263 final, Brussels, 28.5.2002, http://europa.eu.int/comm/enterprise/ict/policy/e-bus-snfsme.htm, accessed 31.5.2007

Anon. (2003a): ITBOF, IT Bygg och Fastighet, (Swedish development programme for IT Construction & Real Estate), Result report on CD and http://www.itbof.com/, accessed 15.1.2003

Anon. (2003b): UICB, The International Union of Building Centres. Information leaflet, Helsinki

Anon. (2007a): B-Webs: Strategic Business Networks in Electronic Markets, Research Joint Project at Svenska handelshögskolan (HANKEN), Helsinki, http://apps1.sordino.fi/db/hanken/crisuk.ns5/bd5b1eb679b764f142256719003c6a8d/cf5b03f19b5c5b0ac2256b40005bd4ff?OpenDocument, accessed 31.10.2007

Anon. (2007b): FoundIT - Taking E-collaboration Techniques into Productive Use in the Construction Industry, Research Project at Svenska handelshögskolan (HANKEN), Helsinki, http://apps1.sordino.fi/db/hanken/crisuk.ns5/033d817fb1ba6571422566fe00413417/7ccaf636ac92070bc22570b300252b28?OpenDocument, accessed 31.10.2007

Anon. (2007c): The ProIT project home page, http://virtual.vtt.fi/proit/, accessed 2.11.2007

Anon. (2007d): Byggherrekravene, Det Digitale Byggeri, http://detdigitalebyggeri.dk/fundament/bygherrekravene.html, accessed 30.9.2007

Anon. (2007e): U.S. General Services Administration 3D-4D Building Information Modeling, http://www.gsa.gov/BIM, accessed 30.8.2007

Anon. (2007f): The UICB Website, http://www.uicb.org, accessed 11.5.2007

Anon. (2007g): The ICIS Website, http://www.icis.org, accessed 11.5.2007

Archea J. (1987): Puzzle-making: What Architects Do When No One Is Looking, Computability of design, pp. 37.52, ed. Kalay Y.E., Wiley Interscience, New York

Argyris C., Putnam R., and McLain Smith D. (1985): Action Science: Concepts, Methods, and Skills for Research and Intervention, San Francisco, California, http://www.actiondesign.com/action_science, accessed 11.5.2007

Arif A. and Karam A. (2001): Architectural Practices and their Use of IT in the Western Cape Province, South Africa, Journal of Information Technology in Construction, Vol. 6, pp. 17-34, http://www.itcon.org, accessed 31.5.2007

Benjamin R. I. and Wigand R. T. (1995): Electronic Commerce: Effects on Electronic Markets, Journal of Computer-Mediated Communication, Vol. 1, No 3 http://jcmc.indiana.edu/vol1/issue3/wigand.html, accessed 18.2.2003

Berry L. L. (2001): The Old Pillars of New Retailing, Harvard Business Review, April, pp. 131-137, http://www.sap.com/industries/retail/pdf/CS_Old_Pillars_New_Retail_HBR.pdf, accessed 7.9.2007

Björk, B.-C. (1982): Tietokoneavusteinen rakennussuunnittelu - nykytilanne ja kehitysnäkymät tutkimusselostus, Rakennus-CAD esitutkimuksen osaselvitys no 7, The Technical Research Centre VTT, Rakennustalouden laboratorio, Espoo

Björk, B.-C. (1989): Basic Structure of a Proposed Building Product Model, Computer-aided Design, Vol. 21, No 2, pp. 71-78

Björk, B.-C. (1997): INFOMATE: A Framework for Discussing Information Technology Applications in Construction, Construction Informatics Digital Library, http://itc.scix.net/cgi-bin/works/Show?w78-1997-5, accessed 31.5.2007

Björk B.-C. (2003): Electronic Document Management in Construction - Research Issues and Results, Journal of Information Technology in Construction, Vol. 8, pp. 105-117, http://www.itcon.org, accessed 7.9.2007

Björk B.-C., Johansson C., Lindgren N., Löwnertz K. (1995): Datorstödd hantering av dokument i bygg- och förvaltningsprocessen, Royal Institute of Technology, Stockholm

Björk B.-C., Penttilä H., Karstila, K. (1991): Rakennuksen tuotemallin teoria ja sen soveltaminen, The Technical Research Centre VTT, tiedotteita 1278, Espoo

Creswell J. W. (2003): Research Design, Qualitative, Quantitative and Mixed methods Approach, (2nd ed.), Sage, Thousand Oaks, California

Coase R.H. 1988: The Firm, the Market and the Law, The University of Chicago Press, Chicago

Coltman T., Devinney T. M., Latukefu A., Midgley D. F. (2001): E-Business: Revolution, Evolution, or Hype?, California Management Review, Vol. 44, No 1, pp. 57-85

Crosby L. A., Grönroos, C., and Johnson S. L. (2002): Who Moved my Value?, Marketing Management, Vol. 11, No 5, pp. 10-11

Crotty M. (1998): The Foundations of Social Research, Meaning and Perspective in the Research Process, Sage, London

Dunt E. S., Harper I. R. (2002): E-commerce and the Australian economy, Economic Record, Vol. 78, No 242, pp. 327-342

Eastman C. M. (1999): Building Product Models – Computer Environments Supporting Design and Construction, CRC Press, Boca Raton, Florida

Enkovaara E., Salmi M., Sarja A. (1988): RATAS-järjestelmä, Rakennuksen tietokoneavusteinen suunnittelu, Rakennustieto, Helsinki

Fingar P. and Aronica R. (2001): The Death of "e" and the Birth of the Real New Economy, Business Models, Technologies and Strategies for the 21st Century, Meghan-Kiffer Press, Tampa, Florida

Finne C. (1992): The Building Process, CAD, and the Core of the Arcitectural Enterprise, Nordisk Arkitekturforskning (Nordic Journal of Architectural Research), Vol. 5, No 4, pp. 69-79

Finne C. (1993): Arkitektarbetets väsen, datorstödet och planeringsprocessen, en analys och kravbeskrivning, (The Core of the Architectural Enterprise, CAD and the Design Process, an Analysis and Description of Requirements), Licentate Thesis, University of Technology, Department of Architecture, Espoo, Finland

Finne C. (2003a): How The Internet Is Changing the Role of Construction Information Middlemen, Journal of Information Technology in Construction, Vol. 8, Special Issue eWork and eBusiness, pp. 397-412, http://www.itcon.org, accessed 21.12.2006

Finne C. (2003b): Information Services for Life Cycle Knowledge Management in the Construction and FM Industry, Proceedings of the European Conference on Information and Communication Technology Advances and Innovation in the Knowledge Society eSM@RT 2002 in collaboration with CISEMIC 2002 Conference, Salford

Finne C. (2006): Publishing Building Product Information – A Value Net Perspective, Construction Innovation, Vol. 6, No 2, pp. 79-96

Finne C. (2007): Perceived Customer Value in Construction Information Services, CIB W78 Conference 2007, Bringing ICT knowledge to work, conference proceedings ed. Daniel Rebolj, University Library Maribor, Maribor, pp. 125-133

Froese T. (2002): Vera – Information Networking in the Construction Process, a TEKES Technology Programme, Final Programme Evaluation Report, University of British Columbia, Dept. of Civil Engineering, Vancouver, Canada, September 2002, http://cic.vtt.fi/vera/Documents/Froese_Final_VERA_Evaluation_020926.pdf, accessed 30.9.2007

Gielingh W. (1988): General AEC Reference Model, ISO TC 184/SC4/WG1 doc. 3.2.2.1, TNO report BI-88-150, Delft, Netherlands

Glaser B. and Strauss, A. (1967): Discovery of Grounded Theory, Aldine, Chicago

Goodstein L. D. and Butz H. E. (1998): Customer Value: The Linchpin of Organizational change, Organizational Dynamics, Vol. 27, No 1, pp. 21-34

Grönroos C. (2000): Services Management and Marketing: A Customer Relationship Management Approach, John Wiley & Sons, Chichester

Han J., and Han D. (2001): A Frameworks for Analyzing Customer Value of Internet Business, Journal of Information Technology Theory Application, Vol. 3, No 5, pp. 25-38

Holbrook M. B. (2006): Consumption Experience, Customer Value, and Subjective Personal Introspection: An Illustrative Photographic Essay, Journal of Business Research, Vol. 59, pp. 714-725

Holcomb M. C. (1994): Customer Service Management: A Methodology for Increasing Customer Value Through Utilization of the Taguchi Strategy, Journal of Business Logistics, Vol. 15, No 1, pp. 29-52

Jansson K., Karvonen I., Mattila V.-P., Nurmilaakso J., Ollus M., Salkari I., Ali-Yrkkö J. and Ylä-Anttila P. (2001): Uuden tietotekniikan vaikutukset liiketoimintaan, teknologiakatsaus 111/2001, Tekes, Helsinki, (The Consequences of Information Technology upon Business Activities, Technology Review)

Tarandi V. (ed.) (2003): Journal of Information Technology in Construction, A special issue on IFC - Product models for the AEC arena, http://www.itcon.org, accessed 7.9.2007

Johnson W. C. and Weinstein A. (2004): Superior Customer Value in the New Economy, Concepts and Cases, (2nd ed.), CRC Press, Boca Raton

Jones A. R. (2000): UICB Web Site: NEW --- LINKS, presentation at the UICB 2000 conference in Helsinki 14.6.2000, unpublished

Järvinen P. (2004): On Research Methods, Opinpajan kirja, Tampere

Järvinen P. (2005): Action Research as an Approach in Design Science, D-2005-2, Department of Computer Sciences, University of Tampere, Tampere

Kagioglou M., Cooper R., and Aouad G. (1999): Re-engineering the UK Construction Industry: The Process Protocol, Second International Conference on Construction Process re-Engineering – CPR99, July 1999, http://www.processprotocol.com/pdf/cpr99.pdf, accessed 31.5.2007

Kalakota R. and Robinson M. (1999): e-Business; A Roadmap for Success, Addison Wesley, Massachusetts

Kano N. (2001): Life Cycle and Creation of Attractive Quality, Proceedings of the 4th International QMOD Conference, Linköping, 12-14 September

Kaplan R. S. (1998): Innovation Action Research: Creating New Management Theory and Practice, Journal of Management Accounting Research, Vol. 10, pp 89-118

Karhu V. (2001): A Generic Construction Process Modelling Method: A Model Based Approach for Process Description, Doctoral thesis, Stockholm: The Royal Institute of Technology (KTH), Industrial Economics and Management

Karhu V., Keitelä M. and Lahdenperä P. (1997): Construction Process Model, Generic Present-State systematisation by IDEF0, The Technical Research Centre VTT, Research Notes 1845, Espoo

Karstila K. (2003): ProIT Process Model (In Finnish), Version 097, the ProIT-project, unpublished

Kasanen E., Lukka K., and Siitonen A. (1993): The Constructive Approach in Management Accounting Design, Journal of Management Accounting Research, Vol. 5, 243-264

Keeney R. L. (1999): The Value of Internet Commerce to the Customer, Management Science, Vol. 45, No 4, pp. 533-542

Kelly K. (1999): New Rules for the New Economy: 10 Radical Strategies for a Connected World, Penguin Books, New York

Kiviniemi A. (2006): Ten years of IFC development. Why are we not yet there? Keynote presentation at the CIB, ISCCBE, ASCE and DMUCE Joint Conference on Computing and Decision Making in Civil and Building Engineering, June 14-16.2006, Montreal Canada

Kiviniemi A. (2007): ICT Barometer 2007, http://www.buildingsmart.fi, accessed 31.5.2007

Kiviniemi A., Rekola M., Kojima J., Koppinen T., Belloni K., Kulusjärvi H., Hietanen J. (2007): Senate Properties' Product Modelling Requirements 2007, http://www.senaatti.fi/document.asp?siteID=2&docID=517, accessed 30.8.2007

Koivu T. J. (2002): Future of Product Modeling and Knowledge Sharing in the FM/AEC Industry, Journal of Information Technology in Construction, Vol. 7, pp. 139-156, http://www.itcon.org, accessed 7.9.2007

Laitinen J. (1998): Model Based Construction Process Management. The Royal Institute of Technology (KTH), Industrial Economics and Management

Langley J. C., and Holcomb M. C. (1992): Creating Logistics Customer Value, Journal of Business Logistics, Vol. 13, No 2, pp. 1-27

Lim Y. M., Rashid A. Z., Ang C.N., Wong C.Y., and Wong S.L. (2001): A Survey of Internet Usage in the Malaysian Construction Industry, Journal of Information Technology in Construction, Vol. 7, 259-269, http://www.itcon.org, accessed 31.5.2007

Mark E. (1990): The Design Automation Paradox, Conceptual Modelling of Buildings, CIB W74 + W78 Seminar, Lund 1988, Conference proceedings, Stockholm

Mello S. (2001): Right Process, Right Product, Research Technology Management, Vol. 44, No 1, pp. 52-58

Messner J.I. and Sanvido V.E. (1994): An Organization Based Information Architecture to Support Upper Level Construction Organization Decisions, Preproceedings, CIB W78 Workshop on Computer Integrated

Construction, Espoo, The Technical Research centre VTT, http://itc.scix.net/cgi-bin/works/Show?w78-1994-22, accessed 31.5.2007

Mitchell W. (1977): Computer Aided Architectural Design, John Wiley & Sons, New York

Neumann W. L. (2000): Social Research Methods: Qualitative and Quantitative Approaches, (4th ed.), Allyn and Bacon, Boston

Parolini C. (1999): The Value Net: A Tool for Competitive Strategy, John Wiley & Sons, Chichester

Patton M. Q. (1987): How to Use Qualitative Methods in Evaluation, Sage, Newbury Park, California

Pohlman R. A. and Gardiner G. S. with Heffes E. M. (2000): Value Driven Management: How to Create and Maximize Value over Time for Organizational Success, Amacom, New York

Porter M. E. (1999): Competitive Advantage, The Free Press, New York

Prahalad C. K. and Ramaswamy V. (2004): The Future of Competition, Co-Creating Unique Value with Customers, Harvard Business School Press, Boston

Ravindra K. (2001): Surveying the E-Landscape: New Rules of Survival, Information Systems Management, Vol. 18, No 4, pp. 22-31

Rivard H. (2000): A Survey on the Impact of Information Technology on the Canadian Architecture, Engineering and Construction Industry, Journal of Information Technology in Construction, Vol. 5, pp. 37-56, http://www.itcon.org, accessed 7.9.2007

Romo I. (2002a): ICT in the Construction Industry Technology Strategy, IAI ITM Evening April 23rd 2002, http://cic.vtt.fi/vera/Seminaarit/2002.04.23_IAI_ITM_seminar/RT_ry.pdf, accessed 31.5.2007

Romo I. (2002b): Rakennusklusterin teknologiaohjelman sisältötyöryhmän raportti, (Final report of the contents work group for the Technology Programme for the Construction Cluster 2003-2007) Tekes PM 10.12.2002

Saliba M. T. and Fischer C. M. (2000): Managing Customer Value, Quality Progress, Vol. 33, No 6, pp. 63-69

Salz N. (2001): Engaging the Entire Organization in Delivering Customer Value, The Journal for Quality & Participation, Vol. 24, No 1, pp. 52-53

Samuelson O. (2002): IT-Barometer 2000 - The Use of IT in the Nordic Construction Industry, Journal of Information Technology in Construction, Vol. 7, pp. 1-26, http://www.itcon.org, accessed 31.5.2007

Samuelson O. (2007): The IT-Barometer – A Decade's Development of IT Use in the Swedish Construction Sector, CIB W78 Conference 2007, Bringing ICT knowledge to work, conference proceedings ed. Daniel Rebolj, University Library Maribor, Maribor, pp. 247-253

Sanvido V.E., Khayyal S.A., Guvenis M.M., Norton K.J., Hetrick M.S., Muallem M.A., Chung E.K., Medeiros D.J., Kumara S.R.T., and Ham, I. (1990): An Integrated Building Process Model, Technical Report No. 1, CIC Research program, Pittsburgh, PA: The Pennsylvania State University, Department of Architectural Engineering

Sarkar M.B., Butler B. and Steinfield C. (1995): Intermediaries and Cybermediaries: A Continuing Role for Mediating Players in the Electronic Marketplace. Journal of Computer-Mediated Communication, Vol 3, http://jcmc.indiana.edu/ vol1/issue3/sarkar.html, accessed 10.10.2002

Schmitz S. (2000): The Effects of Electronic Commerce on the Structure of Intermediation, Journal of Computer-Mediated Communication, Vol.5, No.3, http://jcmc.indiana.edu/vol5/issue3/schmitz.html, accessed 7.9.2007

Schön, D. A. (1991): The Reflective Practitioner, How Professionals Think in Action, Arena, London

Scott J. (2002): Emerging Patterns from the Dynamic Capabilities of Internet Intermediaries, Journal of Computer-Mediated Communication, Vol.5, No.3, http://jcmc.indiana.edu/vol5/issue3/scott.html, accessed 7.9.2007

Shapiro C. and Varian H. R. (1999a): Information Rules: A Strategic Guide to the Network Economy, Harvard Business School Press, Boston, Massachusetts

Shapiro C. and Varian H. R. (1999b): The Art of Standard Wars, California Management Review, Vol. 41, No 2, pp. 8-32

Sinha I. and DeSarbo W. S. (1998): An Integrated Approach Toward the Spatial Modeling of Perceived Customer Value, Journal of Marketing Research, Vol. 35, No 2, pp. 236-249

Smith M. D. and Brynjolfsson E. (2001): Consumer Decision-Making at an Internet Shopbot: Brand Still Matters, The Journal of Industrial Economics, Vol. 49, No 4, pp. 541-558

Stake R. E. (1995): the Art of Case Study Research, Sage, Thousand Oaks, California

Strauss A. and Corbin J. (1998): Basics of Qualitative Research, Techniques and Procedures for Developing Grounded Theory, Sage, Thousand Oaks, California

Sulankivi K., Lakka A., Luedke M. (2002): Project Management in the Concurrent Engineering Environment, The Technical Research Centre VTT, Publications 470, Espoo

Susman G. I. and Evered R. D. (1978): An Assessment of the Scientific Merits of Action Research, Administrative Science Quarterly Vol. 23, No. 4, pp. 582-603

Sweeney J. G. and Soutar G. N. (2001): Consumer Perceived Value: The Development of a Multiple Item Scale, Journal of Retailing, Vol. 77, pp. 203-220, http://www.nfh.uit.no/dok/sweeney&soutar-2001.pdf, accessed 7.9.2007

Swerdloff L. and Kalay Y. (1988): An Object Definition Language for Architecture, Knowledge-Based Design in Architecture, TIPS-88, Otaniemi 15.-16.1988, Pre-proceedings ed. Gero J. S. and Oksala T., Helsinki University of Technology, Espoo, pp. 69-81

Tapscott D. Ticoll D. and Lowy A. (2002): Digital Capital, Harnessing the Power of Business Webs, Harvard Business School Press, Boston

Tong C. and Sriram D (1989): Overview.PS, MIT project Athena, unpublished

Turner J. (1989): AEC Building Systems Model, ISO TC184/SC4/WG1 Document N363, 25.8.1989

Ullberg E., Rodriguez E., and Stormby N. (2002). “Risk Man-agement: From Portfolio Strategy to Value-creating Systems Strategy“, The Geneva papers on Risk and Insurance, Vol. 27, No 3, pp. 467-476

Underwood J., Alshawi M. A., Aouad G., Child T., and Faraj I. Z. (2000): Enhancing Building Product Libraries to Enable the Dynamic Definition of Design Element Specifications, Engineering, Construction and Architectural Management, Vol. 7, No 4, pp. 373-388

Wielemaker M. W., Elfring T. and Volberda H. W. (2001): How Well-Established Firms Prepare for the New Economy, International Studies of Management 6 Organization, Vol. 31, No 1, pp. 7-29

Willcocks L. P., Plant R. (2001): Pathways to e-Business Leadership: Getting from Bricks to Clicks, Mit Sloan Management Review, Vol. 42, No 3, pp. 50-59, http://www.carig.co.uk/pages/userdata/bca/articlesmrwillcocksplanPathwaysEbusiness.pdf, accessed 7.9.2007

Wilson C., Leckman J., Cappucino K., Pullen W. (2001): Towards Customer Delight: Added Value in Public Sector Corporate Real Estate, Journal of Corporate Real Estate, Vol. 3, No 3, pp. 215-221

Wimmer B.S., Townsend A.M., and Chezum, B.E. (2000): Information Technologies and the Middleman: The Changing Role of Information Intermediaries in an Information Rich Economy, Journal of Labour Research, Vol. 21, No 3, 407-419

Woodruff R. B., and Gardial S. F. (1996): Know Your Customer, Blackwell Publishers, Malden

Woodruff R. B. (1997): Customer Value. The Next Source for Competitive Advantage, Journal of Academy of Marketing Science, Vol. 25, No 2, pp. 139-153

Yin, R. K. (1994). Case Study Research Design and Methods, Sage, London

Öörni A., and Klein S. (2003): Electronic Travel Markets: Elusive Effects on Consumer Behaviour, working paper, The Swedish School of Economics and Business Administration, Helsinki

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