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Knowledge as a business opportunity – knowledge transfer practices in Finnish AEC industry networks

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Facing an increasing competition from their foreign counterparts Finnish Architecture, Engineering and Construction (AEC) industry is utilizing value networks in their operations and trying to make the most of their knowledge about the end users and the life cycle management of buildings. However, the knowledge management practices in the industry are still in its infancy in many respects and this creates possibilities for competitive advantage and new business opportunities. The focus of this paper is on the knowledge creation and transfer as a source of business opportunities in AEC industry. This paper is based on literature review and the viewpoints of the companies operating in different parts of the life cycle of buildings. These viewpoints were collected in 20 in-depth interviews during August 2005 and May 2006. A broad coverage of all the important interest groups, in the field of construction and maintenance of buildings, were fairly included in the interviews to construct comprehensive picture of the knowledge transfer practices and possible business opportunities related to them.

Keywords—knowledge transfer, value networks, AEC industry, emerging opportunities.

I. INTRODUCTION

The Finnish Architecture, Engineering and Construction (AEC) industry is facing an increasing competition from their foreign counterparts in the competitive bidding of construction projects. Facing this fierce competition, some of the companies working in this industry are trying to incorporate value adding services to their products or make the most of their knowledge about the end users and the life cycle management of buildings. These operational improvements usually require networking between construction companies and service companies operating in different parts of the life cycle of a building. However, according to literature, AEC companies have been slow to adopt new business models, working methods and technology in these respects [1]. Also practitioners have become aware that the industry does not – in terms of technological solutions for example – evolve as fast and flexibly as other industries. Especially the lack of efficient networking and knowledge management practices in the AEC industry has raised concerns among researchers and practitioners alike.

The focus of this paper is on the knowledge creation and transfer in interorganizational networks as a source of new business opportunities in AEC industry. This paper is based

on literature review and on the viewpoints of the industry representatives. These viewpoints were collected in 20 semi-structured interviews, conducted in two separate stages during the year 2006.

This paper is a part of an ongoing research project called DESNET that is a collaborative effort between VTT (Technical Research Centre of Finland) and TKK (Helsinki University of Technology, BIT Research centre). The research problem of this research effort is formulated in the following way: To identify the most advantageous model of networking, in respect to possibilities to support new information and communication solutions for the product specific knowledge management along the life cycle of a building. This paper reports the findings of these interviews that are related to knowledge transfer practices in interorganizational networks and knowledge driven business opportunities in this field.

This paper is structured in the following way:

- “Knowledge as business” paragraph places this paper within the broader research streams in knowledge management, network analysis and strategy,
- “The characteristics of the Finnish AEC industry” section describes the business and knowledge management environments the industry is facing according to literature,
- “The knowledge creation and transfer in AEC networks” section narrows the focus even further to the knowledge management issues in the context described in the previous sections.
- After the literature review sections, the viewpoints from the literature are contrasted with those of the practitioners (11 interviews), in order to construct new business opportunities in the networked AEC industry.
- As a conclusion this paper reports the results of the second round of interviews, in which these new business opportunities and the knowledge transfer practices related to these opportunities, were presented to practitioners (9 interviews).

II. KNOWLEDGE AS BUSINESS

Interest by social scientists in the firm as an institution has been stimulated by the question of why firms exist at all. The highly popular transaction cost theory focuses upon

the relative efficiency of authority-based organization (hierarchies) with contract-based organizations (markets). The resource-based view (RBV) perceives the firm as unique bundle of idiosyncratic resources and capabilities – and can be seen as a step towards institutional research stream from industrial organization and transaction cost theory [2]. RBV views the primary task of management is to maximize value through optimal deployment of existing resources and capabilities, while developing the firm's resource base for the future [3] - [5].

RBV emphasizes the fact that most products require the services of several resources (information, money, power, or material aid) and most resources can be used in several products. The emerging knowledge-based view is not, as yet, a theory of the firm, but to the extent that it focuses upon knowledge as the most strategically important of the firm's resources, it is an outgrowth of the resource-based view of the firm [4]. The greatest downfall of the knowledge-based view so far can be said to be the difficulties researchers face when trying to estimate the impact of knowledge on performance. However, looking outside single firm, and combining the ideas of resource-based view with those of transaction theory, situations where it is preferable to share knowledge resources in inter-organizational networks in contrast to building in-house resources can be described.

When broadening the perspective outside single firm, this paper takes the connectionist stream of network studies [5] as a starting point. In this perspective an actor is successful, because she or he can draw on the knowledge that is controlled by different networking parties - in contrast to structural viewpoint, where the emphasis is on the position the actor has in the network. Both these viewpoints in network studies can help the present discussion by providing a relative measure of the impact of knowledge resources. However, since knowledge isn't as easily warded as other resources [6] and effective knowledge transfer, especially from outside sources, is build on trust [7], connectionist stream of networks studies portrays more realistic view of the current knowledge markets as systems based on human interaction.

Another critically realistic ontology [8] is taken in the discussion of knowledge management. The length of this paper doesn't allow thorough discussion about different layers in knowledge transfer systems [9], but it is noteworthy that this ontology was present in the interviews conducted in this study. As a summary, this paper takes knowledge based view as a starting point and describes knowledge markets as social networks, where knowledge is transferred with dynamic processes and underlying structures shaping the transfer.

III. THE CHARACTERISTICS OF THE FINNISH AEC INDUSTRY

The Architecture, Engineering and Construction (AEC) industry in general creates and maintains the facilities for

every day living and economical activities – for example all the buildings and the infrastructure needed to support them. In Finland the products of this single industry comprises over 70% of the national assets and also the industry employ 500 000 workers, which is about 20% of the whole working force in Finland. [10]

However, at the same time AEC industry in Finland is also very heterogeneous group of companies in respect to resources available and specialized knowledge they possess and use [11]:

- Of the roughly 27 000 companies operating in this industry, only 157 can be considered large (over 250 employees or turnover over 43 MEUR) in Finland.
- Companies are usually highly specialized with workers usually belonging to equally specialized crafts (architects, structural engineers, consultants, contractors, facility managers, etc.).

The AEC industry on the whole has been criticized for inefficiency and for the lack on innovativeness in the construction process. Some of the characteristics of the industry act as underlying reasons for these industry-wide problems – for example, mainly due to the mandatory bidding of the projects, the AEC industry is highly competitive in nature and it is consequently characterized by low levels of trust between different actors [12]. This low level of trust affects horizontal networking in the industry, but also the development of long-term relationships between main contractors and key suppliers [13]. Together with the project-based nature of the industry, this lack of trust and lack of networking hinders standardization, innovation, and organizational learning in the industry [14].

At the same time the environment, where companies operate, is changing quite rapidly in Finland. According to industry's own analysis there are four trends shaping the environment and the industry operating in this environment [10]:

A. Companies and their customers have become international even faster than anticipated, which has affected in many ways the market structure, business concepts and also the every day life of the local actors.

Customers operating globally expect that Finnish AEC companies follow them abroad to support their activities – as an example, experts predict that the export of knowledge intensive design services double in ten years. As the markets converge in this industry, EU directives are increasingly affecting companies operating in different countries, but also the local actors in Finland. And of course, this trend is not one-way transition only – while Finnish companies go abroad, foreign companies and work force increases their presence in Finland. Especially international investors have increased their share in Finnish real estate trade to almost 50% in recent years.

B. The whole economy in Finland is turning into service economy – the increasing importance of networked services is one of the strongest trends in AEC industry.

Services constitute already 70% of the GNP in Finland today. Services and service business require different kinds of knowledge, competences and infrastructure than traditional industrial activity and this means that AEC industry is facing strong transformational forces. Companies in the AEC industry are focusing on their core competences. This has led these companies to outsource much of their supporting activities, and has increased the importance of network economy, partnerships and close interaction. Public sector is facing strong demands for increasing the productivity of their own services and this has also increased the use of networked service providers in the industry.

The new competences and knowledge needed in this transition has lead into a birth of a whole new business: service integrators or managers that manage the operational service procurement for their customers in this industry. Especially in the office building sector, the new found interest on user services and the increase in foreign investors in the sector have together increased the use of these service providers. This trend has also enforced the in-house development of competencies and knowledge associated with network management and with the life cycle management of a building.

In house building sector, especially facility management companies have reacted quickly and many knowledge and competence related development efforts have been initiated among these companies. This trend in house building sector has been strengthened by the increase in customer needs both in the building of new houses and renovating old houses. Entirely new knowledge and competences are needed within all the actors when customer base is segmented and targeted more precisely. At the same time, the share magnitude of future need for renovation in housing sector increases the need for networking between different actors.

C. The importance of knowledge management and knowledge transfer in the improvement of the service capabilities, quality and productivity increases. The digitalization of information management creates new possibilities to offer even better service solutions to customers.

Internet has changed the way procurement is done – products and services are offered and bought internationally and in real time. Also improvements in information and communication technologies (ICT) have changed the way work is done nowadays and so ICT have influenced the office building sector in AEC industry with increased user needs in this sector.

ICT is no longer seen as a driving force of the needed change in the industry, but as a tool and service instrument facilitating that change. Basic ICT technology is well used

in the sector and in the use of computer aided design and building information models (BIMs) Finland is one of the leading nations. However, the challenge is still to get the right information to right place at the right time – knowledge management and transfer practices have remained relative undeveloped, especially when networking between companies has become necessity for companies to stay in the leading edge of the progress. There are technological solutions for information and knowledge transfer in the form of technological standards and common product / project libraries, but even in this respect the picture is incomplete – only recently have actors in the industry started to think about the value that information and these technological solutions add to process and who actually pays the bill when developing these solutions.

D. The significant rise in the price of energy has increased the urgency to found new solutions, service concepts and business models that lower the life cycle costs and the environmental impact of the buildings.

As the price of energy rises, energy efficiency is increasingly important part of the eco-efficiency, which is about producing services, products and well-being with minimal use of natural resources. When thriving for long term cost improvements and eco-efficiency, the suitability and proper functioning of the buildings is one of the most important factors in AEC industry. This means yet another need to improve knowledge management and networking practices in the industry.

The incentives for change in these environmental issues have come so far mainly from outside of the industry, but there are indications that initiatives from inside the industry are also increasing. The interest of the public authorities on the matter can be explained with the fact, that built environment constitutes 40% of the total energy consumption in Finland. 20% of this energy consumption is produced during the building phase and the rest is produced during the operational phase of the building life cycle. International agreements oblige AEC industry to improve energy efficiency in, for example, heating, production and transportation. In addition, EU energy efficiency directive requires a special energy efficiency certificate to be created when houses are sold or rented – since the existing building base is mainly responsible for energy consumption, this energy efficiency certificate is hoped, in the longer run, to change attitudes and behavior of users and companies operating in the AEC industry. In any case, these regulations demand for new knowledge management and competence improvements from all the actors in this industry.

These four trends have awakened the companies operating in this field and several joint development projects have been initiated recently to answer these industry-wide challenges [10]. These development efforts focus especially on networking and knowledge

management practices in the industry, which are looked into next.

IV. KNOWLEDGE CREATION AND SHARING IN AEC NETWORKS

The construction industry is basically a knowledge-based industry which relies heavily on the knowledge input of different participants in the project team [15]. In this respect it is quite surprising, that information and knowledge management is still in its infancy in the AEC industry and there is need to understand how different industry sectors are devising and implementing knowledge management systems in order to learn from their experiences. The AEC industry is well-known for repeating costly mistakes because they have not leveraged knowledge held in other parts of the organization [15].

As noted before, a project in the AEC industry usually requires knowledge and competencies from specialists that belong to different professional backgrounds. Also, there is a desire and a need for originality and creativity in proposing design / construction solutions among the AEC companies. These tendencies are usually in odds with the need to reuse knowledge from past projects [16], [17]. Longer-term partnering between clients and suppliers is beginning to create a basis for the effective capture and reuse of project knowledge. However, there is often a lack of technological infrastructure within the companies and within the industry [18] and the lack of technological fit between existing solutions [19] may act as a barrier for this improvement in knowledge management practices.

In addition, it is common that a construction project consists of several phases, including bidding, planning, design, construction, commissioning and facility management. These phases require usually different competencies and the work done in one phase or by one party is normally the input for another phase or another party [20]. If the transition between phases doesn't go smoothly, there may be breaks in knowledge transfer during the life cycle of building [21]. Usually there is a larger construction company managing the process [22] and acting as an intermediary between different parties in different phases during construction, but after the building is assigned some of the information is usually lost and regenerated, in the worst case, many times during the rest of the life cycle of the building.

One example of systems that have been tried to implement in the AEC industry in response for these differing needs, is building information modeling (BIM) systems. Building information modeling integrates all the geometric model information, the functional requirements and capabilities of the building and product specific information into a single interrelated description of a building over its life cycle - including the design, construction and facility management stages of a project [23]. In addition to life cycle management of knowledge,

the visualization applications related to BIM can help designers, for example, work collaboratively and communicate ideas more efficiently during conceptual design, or can be used as marketing tools with clients [24].

It is already agreed upon by the different actors in the AEC industry, that BIM is inevitable, but there are conflicting views on how long the mainstream adoption will take - some estimate that widespread use of BIM is still 6-7 years away [1]. So far, the ideal case of a single building model that contains all information for all stages of the design and building process has given way to more limited applications [25]. Some researchers have gone so far as criticizing BIM as too rigid-structured schema to satisfy all AEC disciplines with specific needs [26].

One important aspect in the knowledge management in the industry is the ownership of the BIM or product specific data. For example, due to integrity and security reasons the main repository of BIM information is usually centralized. But as the AEC industry is comprised of disjoint disciplines and companies, distributed project databases are much more desirable than in many other industries. Furthermore, a centralized BIM database often requires a single organization to have control over the management of that database – a scenario that is quite confusing in most of the AEC projects given that the facility owners and the major companies involved would like to have control over parts of the information throughout the various phases of the life cycle [26]. The confusion as to who will own, distribute and take legal responsibility for the building data is lowest when architects and engineers work for the same company, when a building owner values the building model for proprietary use and when liability is shared in construction projects [23].

One of the challenges for future technological development and usage is to combine the so called “passive” and “active” knowledge. Much of the information about standard components provided by manufacturers for various AEC disciplines is now available in electronic format. These parts libraries represent “passive” information in contrast with the “active” information created and communicated throughout an AEC project [16], [26]. Also, the standard types of components found in product libraries have property values in the final design (actual dimensions, material, etc.). Such attributes are not represented in most of the current construction management solutions. Thus a realistic construction process model must use these detailed but otherwise disparate construction management data and link them to each another to form a comprehensive entity [27].

As a summary of the literature reviewed, it can be said that even though new systems and technologies for knowledge management and sharing have been slow to spread into wider use, they have been seen as holding future potential. The industry has already seen a birth of an entirely new business potential in “Service integrator” activities and also knowledge-based services are expected

to strengthen their position both abroad and in domestic markets. The biggest stumbling stone towards maximum utilization of knowledge management and sharing solutions in the AEC industry might not be technology, but rather the willingness of the AEC professionals to revise existing procedures [28]. The industry also needs to improve its practices in knowledge transfer and capturing tacit knowledge, if the companies are to prepare themselves for the loss of knowledge when employees leave the organization [17], [29].

V. INITIAL VIEWPOINTS FROM THE PRACTITIONERS

The first round of interviews was conducted between August 2005 and January 2006. The interviewed professionals (Table 1) were selected based on the suggestion of their networking partners or based on active contribution to industry related publications or seminars. Each interview was recorded, transcribed and later analyzed to construct a comprehensive picture of the knowledge transfer practices and possible business opportunities related to them.

TABLE 1
COMPANIES INTERVIEWED IN THE FIRST ROUND

Company	Division (if any)	~ Line of Business	~ Position of interviewee
SKH Kiinteistöhallinta		Facility Management	Director
Senate Properties	Office Premises	Property Management	Director
RAK systems Oy		Consulting	Director
NCC Construction Ltd	House building	Construction	Manager
Coor Service Management		User services	Director
Finnmap Consulting	Development	Consulting	Director
Ramboll Finland	ViaFM Facility Management	Facility Management	Director
Rautaruukki Oyj	Ruukki Construction	Building products	Specialist
Skanska Oy	Development and Marketing	Construction	Director
YIT Construction Ltd	Office Premises	Construction	Director
Parma Oy		Building products	Manager

In this initial round of interviews, representatives of selected companies were asked during semi-structured interviews about:

- Challenges and changes the industry is facing in the foreseeable future and the drivers behind these changes.
- Challenges and possibilities of value networks in the Finnish AEC industry. Topics included, for example, challenges related to the management of value networks and possibilities related to life cycle management of buildings and product specific information.

- Knowledge creation and transfer practices during and between different stages in the building's life cycle. Topics included possible pitfalls in current practices, promises of the new and old information technology solutions and interplay of different actors in value networks.

From the interviews it became clear that for example house-building sector is facing major changes in the future. In the words of one of the interviewee: *"Without a doubt the needs of the residents, or clients if you like, increases ... quality of buildings is at good level in here, but we could do much better ... and as the importance of home increases in the values of people, their needs [concerning residential building production] increase. And it is clear, that the renovation of building increases [especially pipe line renovations]. These are the two mega trends that make networking more and more important in this industry."*

Value networks were seen by the interviewees as more and more important aspect when knowledge required to design, construct and maintain buildings is becoming more complex. These value networks face difficult challenges, since knowledge intensive work is hard to value – or as one of the consultants said: *"Facility management will face big changes as good managers leave the markets – fees are quite low in the market and industry is facing difficulties in attracting new professionals. Already facility managers are managing considerable amount of properties and now that the amount of these renovations is going to be ten fold, they will face considerable turmoil ... there surely will be new operational models in there ... in my opinion, the big challenge in the industry is how to raise the valuation [of these knowledge intensive services]. For example, how to get the value of proper renovation visible and that way get our chin and morale up, and how to be able to commercialize the know-how [we have]."*

Concerning knowledge creation and transfer practices in AEC industry, interviews relieved quite surprising characteristics: *"There are many interruptions during the life cycle [of a building] and during construction projects. Custom is that information is given to customer only when that customer persuades - and sometimes not even then, but only after customer demands it ... it should be understood [by us], that what is self-evident to an engineer isn't necessarily self-evident to a customer ... and if you think about the life cycle of a building, too little knowledge is transferred from these different liability inspections and renovation projects back into new building construction."* *"Constructions firms have this practice that before the building is assigned, the general superintendent, responsible for the construction of the building, disappears from the construction site and is replaced by superintendent responsible for the assignment – many of the firms have this kind of system. These superintendents are specialized in customer complains ... assignment probably goes more smoothly for them, but they don't necessarily learn anything from the process."*

As a summary for the initial round of interviews it can be said that the industry's own analysis [10] has captured all the same challenges and trends that came up in this study. The only difference was that the professionals interviewed in this study emphasized the possible loss of expertise as more people are retiring every year. This is, of course, an important aspect from the knowledge management point of view. In addition, value networks were seen important and increasingly important in the future. But when the company representatives were asked to describe value networks they were participating (according to schematics presented in the interview), even companies in the same value networks described these networks differently. This implies that management of these networks is still quite vague, although companies in AEC industry have traditionally relied quite much on outside resources. Also the lack of model agreements and established knowledge transfer practices hindered knowledge sharing between companies. These problems with knowledge transfer practices were amplified even more when knowledge and information was transferred between parties operating in different parts of the life cycle of building - especially the transition from the construction project into maintenance of the property constitutes a major barrier in the transfer of life cycle knowledge. Current information technology solutions, build around BIM and IFC -standard, weren't seen as a feasible solution for these knowledge transfer problems, but they remain a promise for the future.

VI. TOWARDS KNOWLEDGE SHARING NETWORKS IN FINNISH AEC INDUSTRY

Combining the different needs and viewpoints we can construct a picture of different aspects of networking and knowledge transfer practices in the near future (Figure 1).

First, looking at the characteristics of AEC industry in Finland:

- Two different market sectors can be identified. Customers, who possibly lack the expertise for procuring services, will utilize the services of a specialized integrator, such as facility or property managers providing service packages to their customers ("Outsourcing" in Figure 1). Examples of such customers includes the housing sector, buildings owned by foreign investors in the office building sector and some of the municipalities in the public sector. Customers, who have in-house capabilities for service procurement or service production, will combine the services of specialized service providers to match their needs. Their interaction with service providers is characterized by more formal knowledge transfer from the BIM they own to the network of service providers from the BIM they own to the network of service providers ("Filtering" in Figure 1).
- BIM and IFC standard will be at the heart of the knowledge management in the future, and
- Life cycle perspective is an important aspect.

Looking at the possible networking practices in the industry, we can say that:

- The magnitude and importance of networking will increase, and
- The most efficient way of networking during the life cycle of the building is probably mixture of different network configurations (see [30] for full description). There should be an external organization providing product specific information to different actors (RaSi / RT in Figure 1), and depending on the capabilities of the customer, a service integrator may be needed.
- "Local networks" characterized by joint

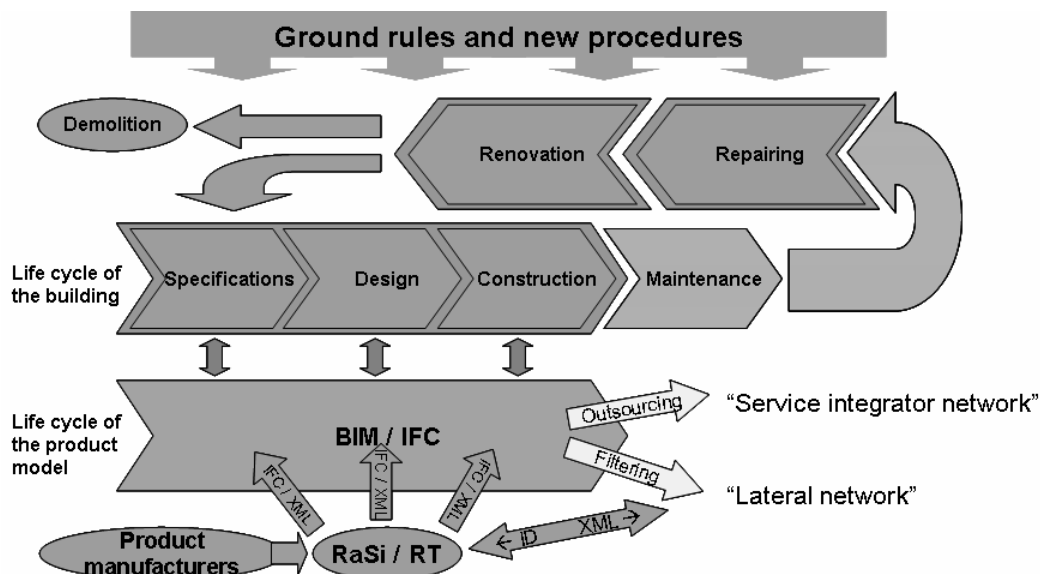


Figure 1 Different aspects of networking and knowledge transfer practices in AEC industry

geographical activities, common interests and common product- or resource pool will continue to exist – however, as a industry wide networking model they are less efficient than configurations described above.

Turning into knowledge creation and transfer practices, it is probable that:

- Specialized ICT solutions are still needed during the life cycle of the building (especially during maintenance), and it is not economically feasible to throw existing solutions to the waste bin. These solutions may or may not support IFC standard,
- The most efficient way of networking during the construction phase is based on common knowledge management technology (BIM), which enhances the interaction of different companies / disciplines, and
- Legal ownership of the BIM will be an important issue.

Looking at the different business opportunities of the situation presented above, a non-profit organization such as RaSi (Finnish Hardware Association) or RT (The Confederation of Finnish Construction Industries) is probably best suited for taking care of the product information libraries. However, commercial solutions may emerge if they add sufficient value to already initiated non-profit services. If neutral information representations (IFC / XML or similar) are used in knowledge transfer, existing technological solutions can still be used in the construction phase and especially later on in the building's life cycle. This, however, enhances new business possibilities too, according to the interviewees, as facility owners aren't restricted any more to legacy solutions and/or single service provider. In the commissioning phase of the building, as-built information or BIM is handed over to the owner of the building just like before, but the industry will probably see more and more outsourcing of the maintenance of BIM to specialized service providers.

SECOND ROUND OF INTERVIEWS AND CONCLUSIONS

The second round of interviews was conducted between May 2006 and June 2006. The interviewed professionals (Table 2) were selected based on the suggestion made by professionals in the first round of interviews or based on active contribution to industry related publications or seminars. Only one of the interviewees forbade the recording of the interview – all other interviews in this round were recorded, transcribed and later analyzed. Results of the first round were sent beforehand to interviewees as a food for thought and representatives of these companies were basically asked to disprove our findings or tell us additional insights regarding value networks and knowledge transfer practices in this industry.

TABLE 2
COMPANIES INTERVIEWED IN THE SECOND ROUND

Company	Division (if any)	~ Line of Business	~ Position of interviewee
The Association of Finnish Architects' Offices (ATL)		Architectural services	Director
Suomen Asumisoikeus Oy		Property Owner	Director
Olof Granlund Oy	Research and development	Consulting	Director
ISS Services Ltd		Facility Services	Director
Lujapalvelut Oy		Facility Services	Director
Hartela Property Development	Development	Construction	Director
City of Espoo	Technical and Environment Services	Property Owner	Director
Optiplan Ltd	Nonresidential design	Consulting	Director
Oy Halton Group Ltd	Office segment	Building products	Director

During the interviews it became clear that the clear cut market segmentation in the maintenance of the building, as it was presented in the picture 1, doesn't represent the market situation too well. "Service integrator networks" (Figure 2) are expected to become more and more popular / important in the future, but it's not the type of network that is important in the life cycle of product model – it is the sense of ownership and development responsibility of these building information models that supports the use of life cycle knowledge more than use of any particular networking practice.

Future: coordinating KIBS

multi-sectoral KIBS branch-specific KIBS and their networks

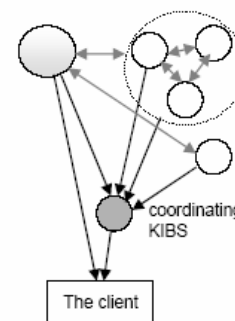


Figure 2 Development towards a two-layered structure in the knowledge intensive business service (KIBS) sector: specialists and coordinators / integrators [31]

The combination of "active" and "passive" information during the whole life cycle of buildings interested

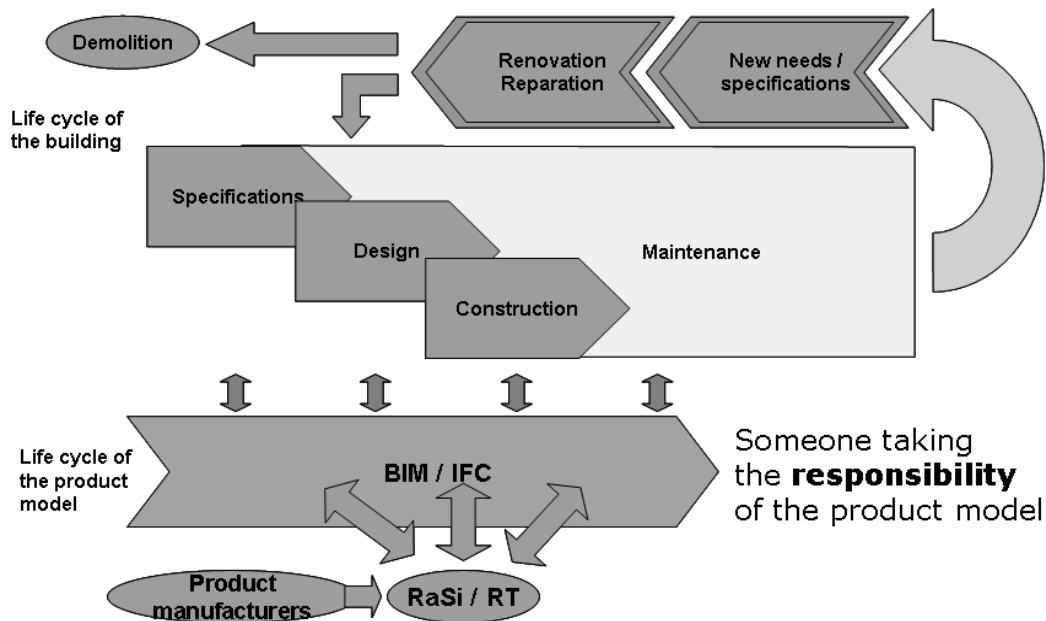


Figure 3 Updated picture of the different aspects of networking and knowledge transfer practices

professionals (RaSi / RT on-going project or other). Especially the possibility to store information about discontinued products was seen as important and feasible feature and possibility to collect feedback from the maintenance in the same information repository for the product manufacturers to use was seen as valuable feature if only it could be done somehow.

Some of the construction companies in the second round expressed growing interest in the end users and towards maintenance as a means to get more information about these end users. Lack of this feedback mechanism was considered the most serious flaw in picture 1. This tendency can also be seen from the industry's own Visio 2010 report [10], where the development in the common vision (related to trends such as described in chapter III) was estimated using expert panels and different competencies as dimensions. Competences related to customership and end users were estimated to have been developed the least in almost all of the vision targets since year 2002. Clearly there is a consensus in the industry that competencies and networking practices that address these issues should be developed. Figure 3 presents the picture of different aspects of networking and knowledge transfer practices updated according to these remarks from the second round.

As a summary from these 20 interviews it can be said that attitudes towards BIM and IFC -standard can be divided into two groups – technological believers and skeptics. BIM and IFC standard will be at the heart of the knowledge management – sooner or later. Concerning networking practices and business opportunities, “service integrator networks” presented as a possible future trend in Toivonen's thesis [31] can be found already in AEC industry. From the knowledge management perspective it is

interesting that these service integrators seem to utilize mainly knowledge and development of that knowledge as a business opportunity. Also networking partners serving the whole industry may emerge to facilitate the use of life cycle related knowledge. It is noteworthy that the situation presented in Figures 3 is based on the assumption that non profit organizations and governmental actors, as such facilitating actor, are successful in their supporting roles – if a dominant design or de facto application emerges as a commercial solution, either to the storage and sharing of product specific life cycle information or to the way services are produced in some part of the life cycle then this situation needs to be revised.

Current regulations in Finland and processes used in the industry don't support networking practices very well, but they allow networking to happen. Currently networking companies use free form ground rules or contract forms in situations where normal business contracts don't apply. According to the interviewees, these ground rules and contracts don't remove the need to build trust between different players in the network, but they act as nice safeguards and can help companies come to mutual agreements on the division of risks and rewards of the collaboration.

DISCUSSION

As a concluding remark for the future of networking in AEC industry, it may be necessary to refer to Gulati [32], who claims that firms enter new alliances more readily if more network resources become available to them rather than less. The only feasible way to courage the forming of AEC networks may be by ensuring that AEC companies are acquainted with the network approach and given

opportunities to engage in long-term strategic alliances – you cannot just tell the AEC companies to start networking and building trust in collaboration, since networking is established between people and only over longer periods of time. Having said that, this study shows that the magnitude and importance of networking will probably increase throughout the industry and especially “Service integrator” companies to become more and more common in the customer interface. In addition, while there is always a chance that truly new and radical innovation (product or service innovation) changes the business landscape, we anticipate that an external player, who stores and disseminates product specific life cycle information, is needed while waiting for the necessary IFC –standards to come true.

This study has several limitations – 20 interviews is very limited number, especially since this study tried to take into account all the different players in the life cycle of buildings. In addition, this study focuses closely on the situation in Finland and networks in AEC industry and can’t be generalized to other markets or industries too well. However, AEC industry being a knowledge intensive industry, we think that there is much to learn from the observed knowledge creation and sharing practices in other contexts as well. Based on the experiences from this study, a future step that could help AEC industry, along with all other knowledge intensive industries, could be a research effort focused on the valuation of knowledge work and expertise.

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