Services in Digital Design: new visions for AEC-field collaboration

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The objective of this paper is to describe contemporary digital building design from a service provider aspect. The constrained framework of this work is digital architectural design practice. When design is seen in the context of the AEC field, a process oriented approach is commonly used in describing collaboration and evolutionary progress of the design work as a project. Design projects are scheduled chains of activities which result in design delivery or actual physical buildings as the end products of the project. Recently developments in building information modelling (BIM) have presented fundamentally new ways for collecting, exploring, and sharing design information. This study develops the novel digital approach: BIM as design services. The key finding of the study is that parts of the design domain can be described as services in the changing digital environment. The scientific contribution of this paper is in describing contemporary digital design practice with an alternative service approach. A framework for such services is also presented. This work will expand the authors' contribution to research on preliminary architectural design using building information models.

1. Introduction

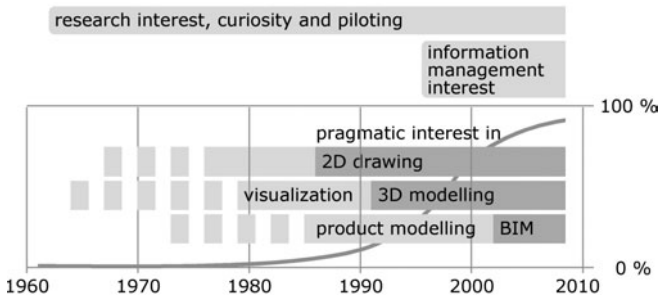
The roles within the *building design discipline* are constantly changing. Despite the existence of skillful designers, often traditional architects, project managers, team leaders and technology-oriented ICT-specialists are also needed in the contemporary design and construction process. Design organizations have noted the changes and have reacted by publishing strategies to implement these changes to their domains.

Digital design is commonly understood as an essential and inseparable part of the design profession and part of the building production process in the AEC-field.

The first 40 years in digitally-enabled design are briefly categorized by identifying a few distinguished periods, as presented in figure 1. These are:

- The pre-history of early research and prototypical stand-alone design systems 1960's to mid 1980's.
- The expansion of CAD to design practice with two-dimensional drafting systems (2D-CAD) from the mid 1980's to late 1990's.
- The development of information management techniques.

Three-dimensional modelling has been used throughout the history of digital design, most often descriptively in presenting and visualizing the designs but also in managing and coordinating design data and building information.



► Figure 1. Major trends and interests in digital building design. The line graph (curve) illustrates the verified volume of building related CAD in practice.

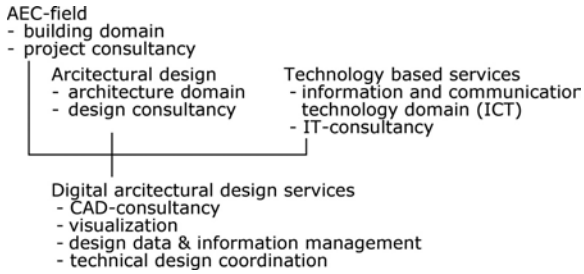
The growing contribution of the *service sector* in the western civilization has been remarkable. Based on reports in several common news sources, the service sector is currently the most important segment of global economy in middle and high income countries. Service related activities and systems are undertaken through people and technologies, and they essentially change the value of knowledge when performed.

Recent service systems related research emphasize that people are clearly the most essential and critical factor in formulating contemporary services [1]. Spohrer et al claim further that organizing technical issues such as information sharing, or managing and executing the service palette, becomes of secondary importance.

One of the early leaders in defining technology related services has been IBM, the world's largest and oldest IT-consultancy provider, who started to systematically develop IT-services in the late 1980s. Even though information technologies have been practiced for decades within the design field, the systematical research context of IT-related design services is still in a fairly premature phase [2].

Since the advent of architectural computing and CAD, technical activities have been noted to be supplied in the form of simulation, energy evaluation, 3D-modelling, visualizing and technical assistance, but this latter domain has not been regarded as a major service discipline.

This paper defines the foundations for digital architectural design services. These services can be classified as a sub-category of technology based services [3] but usually not without the influence of design. Digital architectural design services provide service products for architecture and, as an essential part of building design, also for the larger domain of the field of AEC. (figure 2).



◀ Figure 2. Digital architectural design services combine IT-based services with building knowledge supplying design and construction.

2. Methodical foundations – objectives, hypothesis, focus

The framework for this service study is a research project on preliminary building design and contemporary information technologies. The research methodology is based on methods from action research and case studies. The elementary research technique is empirical research.

The first phase of the work was performed as an extensive literature review on architectural design, related ICT and building modelling material. Research material has also been collected via a pre-interview of construction field professionals, to illuminate the scene of preliminary design. Several case examples have been used in this presentation to illustrate the service aspect approach within design and construction and also to present the possibilities for potential building project related services.

A starting point for this study is the hypothetical assumption that the application of digital techniques in the architectural profession, which has happened during the last 40 years (figure 1), has created new and useful but still somewhat underestimated potential within the design profession. This is development potential, which could economically be utilized by the aid of the service aspect.

The research objective of this paper is to search for, describe and classify new topics and enterprise areas within architectural design and related information and communication technologies, to clarify and promote digital design service concepts. It should still be emphasized, that the objective is not to transfer the whole design domain to services, but to test whether ICT-related design tasks can be regarded as services, and if so, what would be the consequences of this.

One key motivator for this work has been a desire to define the modern foundations of architectural practice within digitally enabled design. Architectural foundations, which are still based on traditional and proven architectural virtues, are augmented, now, by new methods, tools and available contemporary technologies.

The research emphasis of this study is in building design, more particularly architectural design. Architectural design is usually considered to cover two main design areas, namely building design and more wider and society-related urban planning. Building design is the focus of this study, whereas the planning domain is not included, due to its different foundations, nature and project structures.

3. Framework definitions

Due to the multidisciplinary nature of this research approach on architecture, digital technologies and service sciences, the various related discipline domains are first presented as the foundations.

3.1 Architectural design

Architectural design is traditionally considered as being a design domain to associate various aspects of the building in process integrating artistic, aesthetic, functional and technical issues. Architectural design combines theoretical design issues, adapting them to fit with construction practice. This pragmatic aspect of architecture derives from Ancient Greek philosophy, the Aristotetlian "praxis", a term for action oriented activities. Dana Cuff is one of the few modern researchers who has considered architecture by concentrating more on pragmatic design work and process [4].

"Design is often described to be an iterative and integrative process, where all those various aspects of a design task will be merged to form a beautiful, functional as well as buildable wholeness, the building" stated Brian Lawson, who included entirety and buildability as important objectives of architectural design.

One of the virtues of good architectural design involves a broad and multidisciplinary understanding of the design task. The constantly increasing complexity of contemporary construction [5] requires an overall control of buildings, rather than just deeper and deeper discipline oriented technical differentiation within various design tasks. Or to put it into different words,

since emergent specialization in numerous building details is evident what is needed is a holistic and unifying architectural design capability.

3.2 Computer-aided architectural design

Computer-aided design CAD, has played an important role in pragmatic and design processes in architecture. The theoretical foundations for CAD were laid in the 1970s and expanded through to the 1990s when the working environment of the architects, the "working table", could be thought of as totally digital [6]. Traditional architects' pencils and paper were replaced with CAD-systems for digital drawing and 3-dimensional modeling. Often the term computer-aided architectural design CAAD is used when architectural use of CAD is emphasized.

When design related co-operation and communication is discussed more fundamentally, it doesn't only consider design tools such as CAD, but the whole communicative design working environment has faced remarkable changes caused by email, digital document management, network-based collaborative tools and environments. Computerization and digital new media has even been described as a comprehensive foundation for the contemporary architectural profession [7].

3.3 Computerized building modelling

Wider contexts of comprehensive digital building and building process frameworks have been presented since the advent of computing. The topic became known as computer-integrated construction CIC [8] or computer models of buildings CMB [9]. Recently the area has been renamed virtual design and construction VDC and virtual building environment VBE. VDC means the use of multidisciplinary performance models in design and construction projects [10] and VBE is a physical place or location where virtual buildings can be created with an integrated set of various software tools [11].

Bo-Christer Björk defined a building kernel model as being the common data repository; and building aspect models as being the participant dependant content repositories [8]. Lam et al calls the unifying model a shared object model SOM, and the discipline specific models domain object models, DOMs [12]. A common for these various building modelling definitions is, that the models should form a comprehensive and consistent model of information related to a building.

A popular recent buzzword BIM, building information modelling, is defined a data management domain within these larger frameworks. Eastman's definition is closely related to the associated digital tools [13] and Bazjanac defines BIM being an instance of a certain building, implemented into software applications. A joint Erabuild-report defines BIM an object-oriented digital representation of a building, facilitating interoperability [14]. Moum has noted that there are currently several, slightly disconnected

definitions with various emphases [15], concluding that contemporary BIM is almost used like a brand in present discussons. Succar's extensive BIM-definition attempts to form a unified description of contemporary BIM [16].

Nevertheless, building modelling has mostly been concerned with the representative description of the buildings' form; emphasizing how the building looks and generally the actual modelling work has been performed using CAD-tools, which have largely dominated the discussion on building modelling. Modelling the functional aspects of buildings then, rather than building form, gives a different approach to building modelling. Although the topic of so called performance based building modelling has also existed conceptually for 10 years [17], building performance and behaviour has not been very popular within pragmatic designers, where representational form in building modelling has dominated [18].

A building project is considered a continuum of processes, tasks, management but also content issues. Building project management aims in controlled efficiency of design and construction process. Scherer states that although product models are well developed and applied in design, they are not yet mature with production processes [19]. Howell and Koskela are pessimistic when they evaluate contemporary theories within construction production, hence, they propose a reform called lean construction management [20]. Khazode et al have recently connected the lean construction methodology, theoretically, with the VDC-concept [21].

3.4 Foundations for technology based services

"Service" is a well used, and commonly known term, to describe an economic business concept for non-material goods or products; but a scientific description about information technology related services has only emerged just recently. The field of service activities was proposed to be a research domain by a IBM in 2004 [22] and information technology related services have been around for a few decades. The domain is called service science, management and engineering (SSME). ICT-services are described as being the exchange of money, time or effort to obtain value from access to goods, labour, professional skills, facilities, networks or systems, without actual ownership of the physical elements [23].

One elementary service concept in the domain of business and management, is outsourcing; meaning sub-contracting a part of business, usually non-core activity, to a third party. Outsourcing was originally introduced as a business theme in the 1980's [24]. A service business related term multisourcing describes the blending of business and IT-services [25].

Within the ICT-service sector, as everywhere in business, a common objective is to grow and enhance effectiveness. A rather new and service related theme is also to gain certain agility, which Cohen has described being one objective for business multisourcing [25]. Incorporating agility, flexibility and speed and thus anticipating new service possibilities, or even

products for the design and construction disciplines, is the challenge for this research exercise.

4. Constituting digital design services

The proposed framework for digital design and construction is first described generally, then illustrated with related case examples.

4.1 From project and process oriented design to services

Recent AEC-field practice has been often referred to as a *project oriented approach* to work. The process chain of building projects is familiar, and proven for the construction field phases from design through construction to the completion of the building.

Constituting unique building projects with almost always individualized project teams are the common method in designing and construction. In actual on-site construction though, existing networks of contractors and sub-contaractors are common. Integrated design teams, which are coalitions of companies with shared and tested working methods, have also proven to be effective [26].

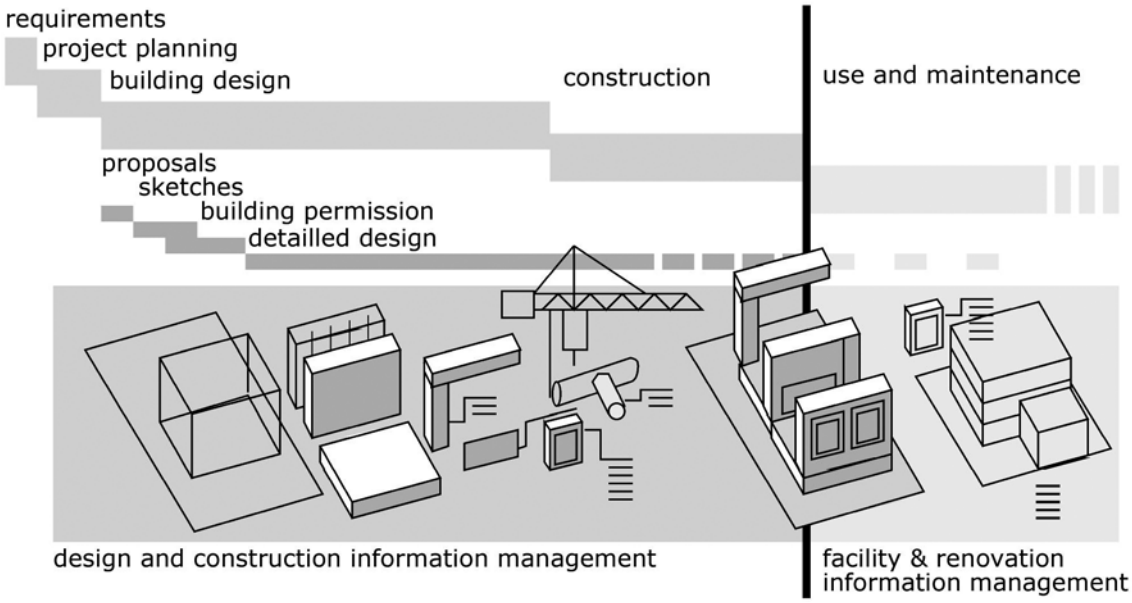
Because of the numerous project participants, with the perpetually changing combination of actors, the concepts of customers, services, service chains and creating value for the customers, should be rather easily accepted within building project, phases and deliverables. Actually service concepts are seemingly rather well understood within building design, although they are not well defined or understood as services nor well commercialized within design and construction. Thomas Froese has underlined the importance to first define the project information management framework, which then is a necessary pre-condition to more complex ICT-implementations such as for instance BIM [27].

Differing from the first phases of a building project – design, engineering and construction – the facility management sector on the other hand has adopted service concepts earlier. Recent service related national Finnish technology programmes by TEKES (national funding agency for technology and innovation) introduced a service oriented approach in several of their development programmes which highlight clearly the intention in supporting service related intentions, business models and activities. The most active branch in adopting the service aspect has been the property and real estate sector and facility management services (figure 3).

4.2 AEC-field

Management, coordination, collaboration and integration

It is obvious that when designers are connected with the design process, design activities have to be guided and managed as well as the whole design and construction process has to be managed. Kruus's research on design as



▲ Figure 3. The AEC-domain, building process phases before the building is completed, constitutes the scope for the services in this exercise. Facility management sector is excluded from the study.

a managed part of the construction process developed methods to enhance coordinated building design; for instance as procurement packages [28]. He suggests dividing designs, on the one hand, into solid and fixed parts, and on the other hand, transformable parts. For instance design content guidelines, formal contracts and assignments with the clients are currently rather demanding in contemporary design practice. A novel area referred to as architectural design management, has now appeared and management issues are very likely to influence the architectural profession even more in the near future [29].

Recently *collaboration* has been one of the most used buzzwords in discussions within the AEC-field. Here the word is defined to mean teamwork; the horizontal integration of various design disciplines, which act simultaneously at a certain defined phase of a building project.

An important quantitative objective of design collaboration, seen from service aspect, is simply to offer more for the customer, or the client, or the end user of the building. Integrated multidisciplinary design teams can offer more functionality, more variety, greater perspective or, quite often, more effectiveness. Production volume can be achieved with collaboration so that one can produce design solutions simply faster and quicker.

A qualitative objective, how to offer better design solutions, cannot be separated from quantity. Although sometimes the initiative in establishing collaboration is only to acquire size, the results of working collaboratively can produce better searched, wider based and more deeply discussed design solutions.

Vertical integration is regarded here as the coordination of building information within time. Related with collaboration, the desired project time

span defines how widely digital information is supposed to be used during the building life cycle. The sustainability aspect suggests managing building data over the whole life-cycle of a building [30]; connecting also a global socio-political issue of modelling for long term building design [16].

The *interoperability* issue has been one of the most discussed topics within BIM [31]. Amor claims, that although interoperability has been the major requirement for BIM, it still has not been fully realized in commercial BIM-practice.

Case example: Information delivery services

A value based approach to design and construction sector information delivery services was presented recently by Finne [32]. Finne, acting as the research manager in Finnish Building Information Foundation, has used the foundation's commercial counterpart Building Information (Rakennustieto) as a case company for his research in the constantly changing information delivery environment.

According to Finne, "the construction sector can often be described as a value chain that produces buildings" although the concept of value is still very rarely used within the field. Of the most obvious, traditional and measurable values, time and money, also more complex, comprehensive and measurable value-concepts should be searched, defined and marketed to building process participants. Furthermore he claims, that the value of digital information, for instance design documentation, is created in the design process and especially when using the information. Digital information itself is insignificant but it becomes valuable only through usability.

When seen as a commercial service, added value from delivering building information can be found for instance from the agility and speed to find correct and accurate data, or from tailoring the required data for various individual or project needs. Another potential for this kind of information delivery service is in synthesizing various information sources and thereby constituting and creating new information.

Case example: Multidisciplinary building design

Large building design related companies, such as Ove Arup and Partners have a multidisciplinary approach to building design. Recently more traditional engineering companies in Finland, have also been reformulating their foundations by strengthening their building engineering mix by also including architectural design to their profiles. Large companies can offer more comprehensive in-house solutions to customers.

Despite the ability to offer more comprehensive and more effective building design services in larger and demanding building projects, this integrative building engineering may also be a reaction to contemporary dispersion, differentiation and specialization of the design domain. The more various niche specialists are involved, the more heterogeneous and complex

the entirety of the building project becomes. On the other hand,large contractors' tendency to compile larger projects from fewer and larger multidiciplinary service sources, to better manage the projects [33].

For instance parametric 3D-modelling has been reported as representing a pragmatic method in coordinating and managing the collaborative work in multidisciplinary teams [34]. Forgues et al warn about differentiating discipline specific information in a way that is too detailed because of the fragmentation of information, which furthermore leads to inefficient collaboration [35]. They raise the question of carefully defining the boundaries between modern computerized design teams.

Case example: BIM-model evaluation

Quantity take off and cost estimation has been one of the earliest benefits gained from building product modelling and still it has been reported being one of the most important objectives for implementing BIM [14]. Most often the quantities are used in various volume based cost estimations.

When BIM-models are to be used as a quantity source, they require reliability evaluations before the information can be used. Despite traditional manual cross checking of design information, model evaluations and conformance testing can also be performed with automated software applications, such as Solibri, which has based its business strategy solely on BIM-model evaluation and optimization.

Since BIM-models and related IFC-standard for model based data delivery are structurally rather complicated, Amor remarks that model checking requires special expertise [31] hence, a potential framework to perform this kind of evaluation is to base it on services.

Case example: Building simulations

Early applications in using building models were used to simulate various energy behaviour aspects. Since the 1970's and Stratchclyde's Abacus experiences [36] integrated building simulation has proceeded both theoretically [12] and also in design practice. Buildings thermal and climate conditions can be evaluated from the models. Granlund building services has based their business strongly on BIM but also on related tool development. In addition to energy, the acoustical behaviour of can be evaluated model based [37].

In a similar way to BIM-model evaluation, model based simulations do require technical expertise, thus they would also be a suitable domain for services.

Case example: BIM-model maintenance

In order to perform multidisciplinary coordinated building design technically, it is obvious that novel ICT-experts are needed in construction projects

[38]. The role of a digital project coordinator was introduced in the Finnish ProIT-guidelines [39] to technically manage the content of the building information as a delegate of the project owner. All those definitions, specifications and integrative actions which are needed to proceed the project, are proposed to be assigned to the digital coordinator.

Interoperability and data exchange have most often been mentioned being important criteria for BIM [14]. So called BIM-model servers are presented to save model data to real time BIM-repositories, i.e. not as files. Servers have been described theoretically and as pilots and prototypes, but they have not yet appeared in wider commercial use. Ku et al note that such repositories have not been used in complex form projects [xi]. Moum on the other hand reports moel servers being used in pilot projects [15].

Liability issues in using model based data, instead of traditional drawings, may cause conflicts between information providers (i.e. designers) and information users (i.e. builders) who have traditionally been separate contract partners according to Ku et al [40] and continue, that despite geometric form finding, model-based approach may also facilitate radical changes in future project practice and business models.

4.3 Architectural design

Even if the design domain is not regarded as a service, the concept is not unfamiliar within design and construction. All building designers have supplied their clients or customers with design information for decades. Architects' patrons, today better called customers, can be categorized to a few different groups. Private customers have been persons, such as historical monarchs and seemingly wealthy people. Public customers, such as cities, communities and organizations as ell as commercial companies have needed architectural service, since the industrialization of the western society. The final end users of buildings can also be regarded as architects' customers. A new and therefore a potential customer group for architects are the property and facility owners and managers. This new customer group appeared during the 1990's, when facility management (FM) and construction economy in fact was identified as an independent domain.

Despite the economical approach in modern design and construction, customer confidence and sometimes even unselfish "architectural advocacy" are still valid approaches when defining a more modern contemporary professional profile for the architects.

Another crucially important topic for architects is the value perspective, especially multiple values. An architectural designer is usually hired to supply, not only impressive designs, but a comprehensive value based understanding of the design task. Versatility is one of the core competencies of an architect.

Complexity

Architects will, it seems, be serving wider audiences and more heterogeneous customer groups in the future. Larger entireties, more complex contexts and more numerous affiliations will require the engagement of designers, hence, they have to be educated to manage complexity [41].

The external requirements for arctitectural practice are constantly changing. Design tasks have become more complex, hence they are more difficult to manage. The technical content of the buildings has increased, transformability requirements have grown; not to mention the constantly evolving environmental demands for construction.

On the other hand contemporary digital technologies have made it possible to manage more complex designs and more complicated projects which would not perhaps have been even possible without digital technology [40]. Architect Frank Gehry's recent buildings have often been referred as examples of model based complex design [42].

Valuable personal skills

An important personal requirement for an architect is often identified as unique individual skills, therefore individualism and personality are highly appreciated. Thus architecture has often been regarded as art: art rather than business, although the business aspect within the profession has also been recognized during the last century as well.

A traditional approach for a designer is based on *confidence* between the designer and the client or the customer. A trusted professional can first supply the customer with well considered alternative solutions for the needs, then perform various design evaluations and finally deliver detailled solutions.

An architect is usually the first construction field professional to work with building related tasks. The architect is an agent who is hired to run customers errands, and who finally takes care of customers desires and needs.

One well stated reflection from the history of architectural practice by a Finnish architect Birger Brunila in 1910 [43], who describes the architectural working environment as follows:

"The architect is an artist who has to manage a large domain area; he has to be a constructor, a thinker, he represents the builder and project manager in technical and legal issues, he is the concierge of patron's wealth, and finally he also has to be a business-man."

Defining, describing and visualizing the design content and by this documenting customers' wishes and thoughts and materializing still premature building related ideas, is a rather traditional topic within architectural design. It is also an area where architects usually perform well and produce real novelty value for the customers.

The importance of preliminary design

The most meaningful and cost effective project decisions are made in the preliminary project phases, in project planning, conceptual design and in early design [44] and the architect is often the first construction field professional helper for the customer, hence the emphasis in this presentation concentrates first on architectural design, and extends it more widely to design in general.

A design professional is needed in a building project also to challenge the customer, and question whether the customer's needs and requirements during the preliminary design are correct.

Policy issues are crucially important in the preliminary phases of a building project planning, i.e. before the project launch. This was well addressed in the pre-interviews performed in the early of this research study. Also Succar claims decision making and policy being one constitutive field for building information models [16].

Case example: Strategic workplace planning

A rather new trend of strategic workplace planning offers companies future strategic facility management and planning, rather that just more traditional architectural office layout design. Haahtela Kehitys Oy, originally a Finnish project management & cost estimation firm, these days coaches companies, cities & communities to workplace planning. Workplace planning is said to add new value to the organizations with facility management by controlling & steering their working environment. Haahtela is basing the service concept on Ari Pennanen's research work on activity modelling [45].

Another Finnish company, an architectural service provider Respace Oy, offers workplace planning through more traditional architectural design services. Customers for their service are top operative company managers, and the service concept is based on organizatorial management.

Early building project phase requirement management, is an issue between the customer and the architect [46]. Requirement definition in the preliminary building project phases and further requirement management in the following phases, can constitute a service, which needs both management and architectural skills.

Workplace planning can be technically performed for instance with spatial design tools, which are a novel area within CAD and BIM-applications, although it has been stated, that there are still inadequately tools for this available [47].

Case example: Digital visualization services

The users possibilities to virtually visit designed buildings during the design phases enhanced rapidly together with the expansion of CAD-systems, which became the architects' master tools during the 1990's. The 3D-

modelling phenomena grew up several service oriented companies like Adactive and 3DRender in Finland, who offer virtual visualizing and modelling services for construction practice. Visualizing is most often considered as extra services to actual design content providers, the architects, and it is seemingly a rather competed service sector.

Customers for visualizing services are designers and also project owners. This service concept is based on the assumption, that visualizing can be outsourced, and service providers can therefore offer superior quality and technical skills, which the designers can not reach.

Case example: Technical computing support

Technical computing and CAD-support, which started to develop already during the late 1980' together with the expansion of CAD-systems, has been regarded as services. This service support has been offered by software distributors and vendors, but also by CAD-experts as commercial service providers. An educational aspect, CAD-teaching, has often been an essential part in this service.

This service concept is based on the assumption, that customers (designers) who have to use more and more complex, but still inevitable CAD-tools, need assistance in managing their digital tools & working environment. The concept parametric modelling has often been used referring to automating product and form production [13][15].

Digital modelling and customization of modelling tools is reported being a supplementary design service by Kaijima & Panagiotis [48]. Personal digital customization has often been used in creating flexible, free and imaginary forms. Digital tool customization may well be a method to adapt, modify and tailor design software applications, to better match desiners' personal intentions and further, to better match original project goals.

5. Conclusions

Clear recognition is meaningful in defining building design related ICT-based services. "Radical new services can be improved by creating a clear product identity and offering tangible clues to help customers visualize and evaluate services" stated Candi [3]. Hence, novel services have to be marketed.

When constituting services, Zhang & Tao describe the process of defining services as being in three phases: conceptual service characteristion, actual service development and finally pragmatic service delivery [49]. This view serves, first of all, in characterizing and formulating the notion of services.

The service case examples presented are analyzed to examine their usability in contemporary construction. The potential need for proposed services can, consequently, be anticipated (table 1).

	Usability in contemporary digital design and construction	Anticipated potential and need in contemporary digital design and construction
AEC-field related case examples		
Information delivery sercices	Implementation is based on extensive data repositories. Has to be implemented to various working, application and system platforms.	Growing with the growing need for digital information.
Multidisciplinary building design	Is more a business strategy than service. Almost a requirement in larger projects. Includes feasible potential for various in-house collaboration and integration services: - [internal] project data management - [internal] model inspection	
BIM-model inspection	Implementation requires technical expertise in BIM and IFC.	Possibly growing with the expansion of BIM.
Building simulations	Despite technical computing expertice, needs also deep HVAC/MEP engineering knowledge.	Possibly growing with the expansion of BIM.
BIM-model maintenance	File based maintenance can be performed like web-hotels or project web providers. Easily and quickly applicable in contemporary document management platforms & project webs.	Already available in contemporary practice.
	BIM model servers or on-line model repositories, require technical expertise in BIM and IFC but also in databases and file-sharing.	Potential "next wave" in BIM-based data management.
Architectural design related case examples		
Strategic workplace planning	Targetted to company management, strategic and functional business planning. Spatial design is close to traditional architectural design and feasibility studies.	Digital implementation is potential new domain for architects.
Digital visualization services	Already widely available in contemporary practice.	Potentially growing with the expansion of designers modelling skills.
Technical computing support	Already available in contemporary practice. Implementation requires software-specific technical expertise.	Potentially growing with the expansion of designers modelling skills.

▲Table 1. Evaluation of presented service case examples.

The anticipated consequences of these kinds of digital design and construction related services may alter the roles of construction process stakeholders and it quite obviously has already generated new actors and operators to the field. In actual ICT-service implementation legal and liability aspects of the intended services have to be redefined, because traditional building process boundaries have been regulated by existing, often document based, agreements between project stakeholders. If the project roles should be redistributed when implementing services, the participatory contracts have also to be adjusted.

Crude business logic will in the end take care of the success of these constituted novel services. Service providing is precisely targeted at those who actually need digital services. If there is no need, there is no service either.

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