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User Driven Innovation in the Building Process

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Abstract: During the late years there has been an ever-increasing focus on the possibilities to change the building process to raise quality on the final building products as well as the activities of actors involved in the building process. One reason for this interest is the new opportunities evolving due to introduction of advanced information and communication technology (ICT). The paper focuses on creative changes of the building process powered by user driven innovation activities. An overview of existing user driven innovation methodologies is given as well experiences from the ongoing Virtual Innovation in Construction (VIC) project. One important driving force for change is the opportunity for users to develop and articulate real needs concerning for example different functionalities of a building and its parts, but also on artifacts supporting the actual needs capture and requirements formulation during building design. A general methodological framework and meta ontology for Virtual Innovation in Construction is presented as well as findings from implementation of the method.

Key words: innovation; user driven; needs; requirements; creative design; construction; system development

Introduction

It is noticed that end-user involvement in design and creation of new products has great beneficial influence on the product creation process and product quality both for involved companies and end-users of the products. The building design and erection process is all about creation of a product that within established budget lives up to the expectations of the end-user and owner. The modern product end-user is participative, creative, self organizing and community oriented. These facts motivate us to also involve the problem generating end-users in the building process. There is thus a great need to investigate and develop enhanced methods and work processes for end-user involvement in the building process to meet the future end-user needs and to produce better buildings.

Buildings are important ingredients in optimizing quality of our lives whether we talk about buildings for living, work, or different kinds of social services. Buildings are not ordinary products like mobile phones or cars. They are often produced as one of a kind by organisations existing only during the building project. There are great opportunities for innovation in this open environment but also challenges caused by the intra-organisational setting, entailing that much knowledge on how innovation is carried through within companies are not directly applicable. Furthermore the networked business models supporting innovation and distributed value growth are under continuous development and assessment.

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Late development within information and communication technologies (ICT) supply us with possibilities to create new services to assist us in the user driven innovation process but also in introducing new adapted services in buildings. These new services must be designed to be effective, efficient and provide user satisfaction during use[1].

The virtual building (VB) plays a central role when we simulate, test, evaluate and refine services during building design. A VB may be defined as "a formalized digital description of an existing or planned building which can be used to fully simulate and communicate the behavior of the real building in its expected contexts"[2].

The paper presents results from the on-going project User Involvement in Construction - Virtual Innovation in Construction, VIC, financed by the Danish Enterprise and Construction Authority and the Program for User Driven Innovation. Project participants are the two main engineering and architecture companies in Denmark, Arkitema A/S and Rambøll A/S, and Aalborg University, Civil Engineering department.

1 User Involvement

It has long been known that the discovery of unrevealed needs or untapped markets is a possible source of innovation, and for many years, focus groups, questionnaire surveys, etc., have been utilised in order to gain a better understanding of the needs and wishes of consumers. However, such surveys have certain limitations in relation to innovation, inasmuch users and consumers are frequently unaware of their needs and wishes, often do not possess sufficient innovative visions or ideas, and sometimes display a certain lack of consistency between what they say in response to surveys and their actual behaviour.

Methods have been developed, particularly in the design industry, to uncover such needs, which cannot be revealed with the help of the prevalent methods. These methods are of an anthropological nature, and go under such terms as user-centred design, user-driven innovation, empathic research, and applied ethnography. The methods are concerned with studying and observing people in their daily routine, in order to understand what *underlies* their actions and behaviour. What are the underlying, unrecognised desires, needs, expectations and longings that motivate people to act as they do? If, for example, you aim to develop a new type of meeting-room for a knowledge enterprise, you should examine not just the meeting situation, but the entire organisational life of which the meeting-room forms a part. The aim of the methods is thus to acquire knowledge about people and their behaviour in a broad perspective, as well as about their feelings, values and inner driving forces. This knowledge can then be applied as a starting-point for producing future-oriented products, and new services that the users did not know they could get, and did not even believe they needed.

Often, consumers value the actual process of obtaining a product just as much as the product itself. We can clearly see this in the "Build-a-Bear" concept, in which the user/consumers happily pay a lot of money for the experience of helping to make their own teddy bears; a teddy bear, which, as a finished product, could be acquired for half the price in a traditional toyshop. They have become a prosumer, *pro*ducer and cons*umer*.

By involving users in the development process of, for example, a new domicile for a company, you can help to ensure their sense of ownership of the changes that the move will entail.

2 User Needs and Requirements on the Building

Before a client end-up with a requirements specification on a building, we have to recurrently traverse the end needs capture and consolidation process. The end-users of a building are typically building inhabitants, external service providers, operation and maintenance personnel, and building administration. They may on many cases have conflicting wishes and expectations on building performance, optimizing from their world of discourse. Wishes and needs on the functionality of the final building have to be formulated with common mutual understanding in a collaborative process we can call *co-creation*[3,4]. The needs have to be weighted/ordered to yield ordering of alternative solutions produced in the light of building life time cost and different construction solutions.

We require some kind of metrics to describe our needs. Needs-requirements metrics with special regard to workspaces are exemplified below[5]: adaptability (to suit different building users changing needs), capability (providing the potential to introduce, replace and

change building elements, services and systems), compatibility (ensuring that all aspects of the building are wholly coordinated and integrated and can be none selected without influences from other elements), controllability (providing users with the means to maximise their use and operation of the workspace, its services and facilities), and sustainability (ensure that the workspace and its facilities are operated and maintained to enhance individual and corporate productivity, and their health and wellbeing at all times).

Cases studied in the VIC project focus on office buildings, but the method should be general and even useful outside the building sector.

3 User Driven Innovation Methods

We describe user driven innovation as a 'systematic approach to develop new products and services, building on investigation or adoption of users life, identity, praxis, and needs including unrevealed needs' (http://www.ebst.dk/brugerdreveninnovation.dk/tilskud).

In connection with user driven innovation, as mentioned before, we are concerned with innovation processes performed in inter-organizational settings. Most innovation methods used today focus on how a single company can be more innovative in product development and retailing through radical, incremental, modular, architectural, and disruptive innovations.

Complex business models with temporary partners in building projects together with external product providers may lead to less pressure from competitors on participating companies. This can be good (openness, in the long run the end-users will benefit high quality products) and bad (shortage of economic incitements).

Below are some methods to support user driven innovation listed and commented on. Some of the methods were used in connection with user needs capture for the Arkitema A/S and Rambøll A/S new offices.

Interviews and questionnaires (Rambøll A/S outsourced user involvement process planning to an external consultant)

Focus groups the interaction in the group is the basis for knowledge creation (used by Rambøll A/S with handpicked users with lead user characteristics).

Self observation The purpose of self-observation is not to answer questions, but to raise them[6]. Photo and video shots (taken with simple digital cameras) may be commented on with text or sound. Self observation supports anthropological studies.

Story telling Set a *scene* (landscape, Turkish bazaar, etc.) and *theme* (stroll, finding facilities and services) (Arkitema architects could stroll through the building to meet colleagues and share knowledge). Stories can be meta marked during collection. If time is too limited for self studies, story telling could be an alternative. Story telling may be a means to motivate users to participate in a co-creation process.

Scenario writing Arkitema used an activity cards system (representing building facilities) thereby forcing end-users to consider realistic scenarios (prioritize their personal time and what facilities to use).

Lead user involvement A toolkit for lead user innovation is presented[7]. Lead users are characterized by being extreme users who modifies and further develops products and concepts.

Behavioral mapping Behavioral mapping is a type of systematic observation research that tracks behavior over space and time. The tracking may focus on a particular place or be based on an individual's movements.

Contextual inquiry is an applied ethnographic study (is also part of the contextual design methodology[8])

Commented VB model walkthroughs users should comment experiences during walkthrough. Users could also be observed during walkthroughs.

Appreciative inquiry was used by Arkitema for innovations generation in the development of the company organization and to trigger ideas and needs formulations.

4 Virtual Innovation in Construction-VIC

The project goal of the Virtual Innovation in Construction (VIC) is to create an ICT supported methodology VICMET to involve building end user in a creative innovation process together with building designers, to capture and formulate end-user needs and requirements on buildings and their functionality. An open dynamic innovation space VIC-SPACE is created with access from WWW.

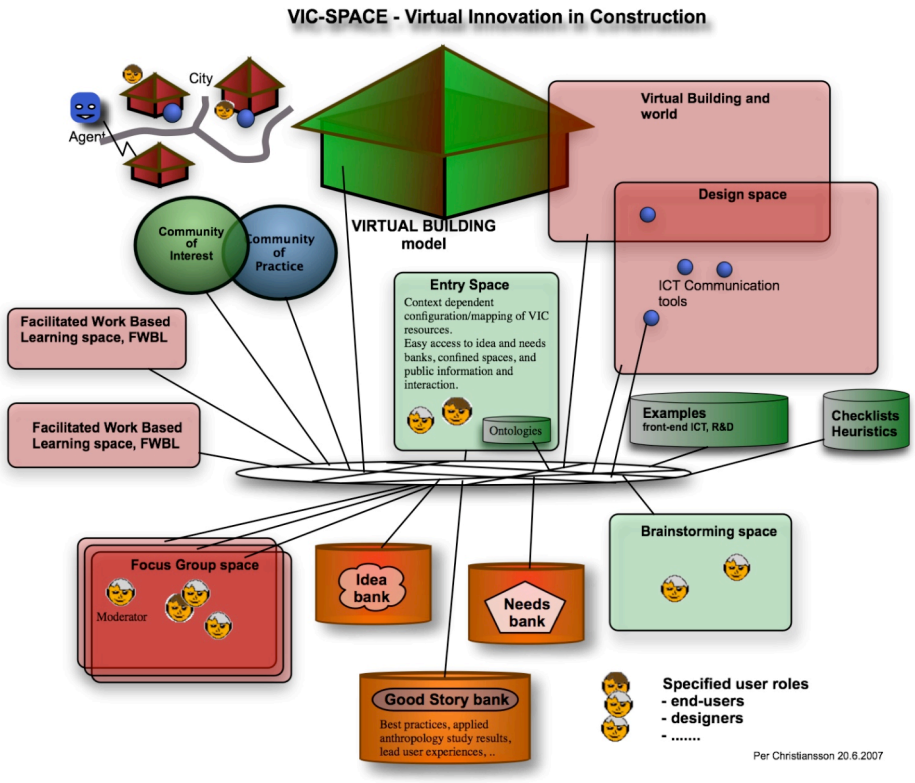

Fig. 1 The VIC methodology, VICMET, will house a number of spaces suited for different activities

The project (1) identify trends in the users' behaviour, values, needs and motivations, and thereby enable the collection of knowledge which will form a foundation for the development of new and valuable architectural, constructional, technical and functional services solutions, (2) give users the opportunity to participate actively in the development of the buildings that provide the backdrops to their lives, and thereby enhance their experience of quality and their sense of ownership, through participation in a social and creative process. This implies (3) development and evaluation of VICMET itself in an innovative and creative design process. The VIC-method is expected to be useful outside the building sector.

The VICSPACE is an *innovative meeting place* to collect and in common agreement formulate realistic needs and requirements on the functionality of buildings. It will support efficient and effective *cross disciplinary interaction* (information exchange) between end-user with diverse backgrounds, clients and designers/architects/engineers for exposure, clarification, consolidation, and formulation of end-user needs in a innovative process.

Experiences and results from work in the Danish National Digital Construction (Det Digitale Byggeri, DDB) are planned to be made available from VIC-SPACE, e.g. through use of digital building models in all phases of a buildings life cycle, as well as new collaboration methods based on use of digital virtual building models[9]. VB models generated by CAD-systems can be accessed from the design space as well as physical models and combinations in a mixed reality environment[10].

The development of VICMET is as mentioned above in itself an innovative and creative design process. Gero and Maher mention design paradigms classified as creative, innovative (combining known elements in new ways) and routine[11]. The contextual design (CD) method[8] is giving inspiration in the VIC system development. Initial needs and requirements on the system are consolidated from Arkitema A/S and Rambøll A/S respective design of their new offices in Copenhagen as well from projects participants general experiences. The CD method overall contains the steps 1) contextual inquiry, 2) interpretation sessions and work modeling, 3) consolidation and affinity building,

4) visioning (how will VICMET make design more innovative), 5) storyboarding, 6) user environment (UE) design i.e. the functional layout of the new system, and 7) interviews and evaluation on paper prototypes and mock ups.

It was observed at Arkitema that internal personal frustrations might arise if roles are not clear for the persons participating in the process. Tacit knowledge (i.e. beyond formally documented during process) on needs, common values, overall views, was often lost due to participants entering (often too late) and leaving the process.

Arkitema emphasize that they would have needed a more structured way to handle the consolidation and optimization of needs in the innovative design of their new office. VICMET will support collaboration between end-user and design specialists to avoid situations of sub-optimizations and ineffective waiting on input for design. The project strives to establish a *co-creation* environment.

Arkitema documents that the activities were very different, depending on whether the purpose of the activity was to create insights into unidentified needs of the organization, to find common ground and develop common understandings of the development of the project, to explore new future related possibilities and opportunities, or to explore the possible role of the building in the city area. It was also emphasized that it is very important to communicate achieved results in formats adapted to different user categories. VICMET is continuously evaluated during development and in the early stage through simple cooperative evaluations.

5 Ontologies and Metrics

An ontology is an explicit specification of a conceptualization[12]. The VICMET, as any functional level system description, needs a basic meta (business level) ontology with concepts definitions and their relations. Figure 2 shows a first VIC ontology.

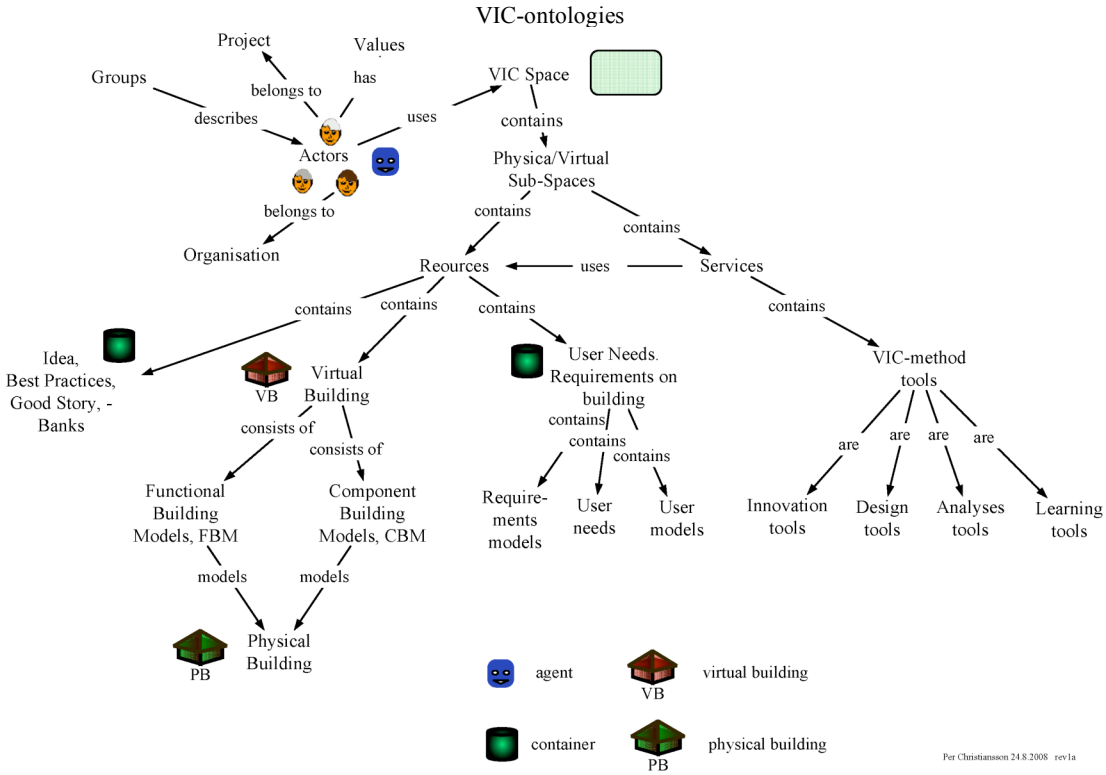

Fig. 2 The first version of a VIC meta ontology

Needs and requirements formulation from end users leads to specific requirements on functional building systems (FBS), and their implementation as a physical building consisting of component building systems (CBS). A FBS may be a comfort system to provide personal living and working quality, a personal trans-

port system, a load carrying building system, an escape system, or a communication systems (collaboration, knowledge transfer, mediation, virtual meeting). Functional building systems may be improved through embedded ICT-systems to help in making the building more intelligent and responsive to end user needs, usage context and surrounding constraints[1]. FBS ontologies are today not even de-facto standardized. The ongoing work on developing IFC exchange formats and building information modelling (BIM) models[13] and dictionary frameworks[14] will contribute in the VIC ontology development.

Ontologies can be augmented by users tagging input data during e.g. a self-observation process creating so called folksonomies[15].

6 The VIC Method

Figure 3 shows the first version of VICMET expressed as a sequential work model.

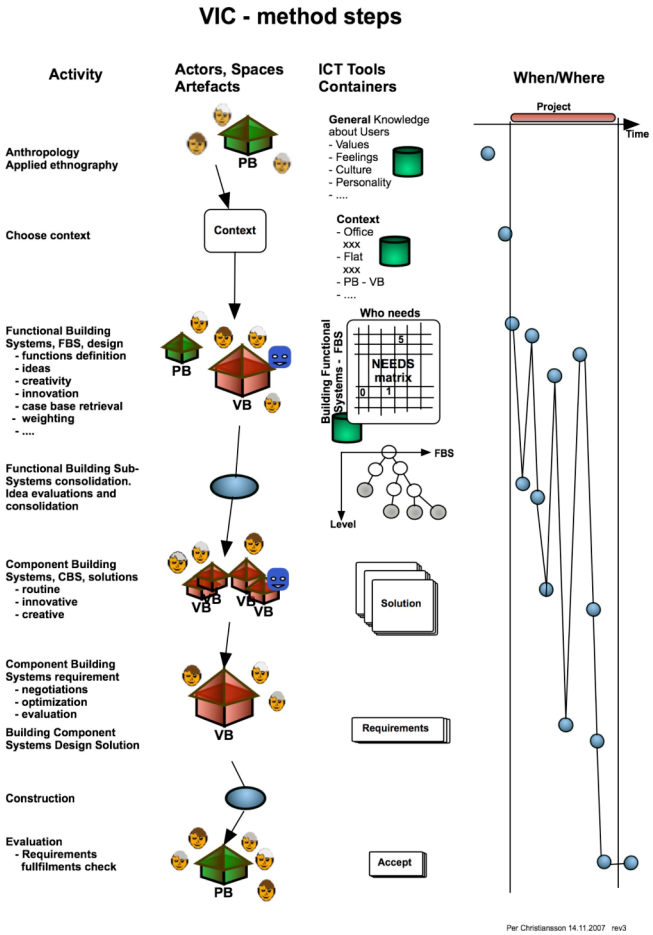

Fig. 3 The main steps in the VIC-method (VICMET)

Findings, from Arkitema and Rambøll performed innovative designs of their respective offices, have already influenced the design of the VICMET model. It is for example very important at the third and fourth level of the model to further develop the definitions and handling of needs and their relative importance in relation to FBS, which also to some extent have to be newly defined.

The FBS with sub-systems will in a many-to-many relation be connected to the CBS and its sub-systems. In other words there exists intricate relation between FBS and CBS in that one building component (e.g. a window) can be part of many FBS, in this case the comfort system (such as indoor climate, and lighting), escape system, security system etc.

The ambition is to make and test virtual prototypes of the building so the physical building will not be the only prototype. VICMET will not offer a total solution

but the fundamental building blocks and dynamics for further developments. A central innovation use case is defined in the VICMET development, namely the 'meeting space/knowledge sharing' case.

We do not always know what business model outside the specific project that will be the setting. This means that VICMET should be open to support different business models and settings. The success criterion is that new services and products have high quality defined in terms of usability, effectivity and efficiency. VICMET therefore have a *community* of *interest* and *practice* that can support a wider co-evaluation, co-creation process supported by continuous ontology development.

All innovations in VICSAPCE do not have to be part of the next new product. They can also be stored as ideas or partly evaluated innovations stored with rationale, evaluations, and feedback views and from real experiences. Context should be specified when feedback is given otherwise it is hard to use the information.

VICMET will support both the program phase and early design as well as detailed design and innovations in buildings under construction.

The Confluence system is used as a VICSPACE container (http://www.atlassian.com/).

7 Conclusions

The first version of a user driven innovation method in connection with building design is presented. It is concluded from the work that there is a need to further develop ontologies, functional building descriptions, and sequential methodology to support a creative design in an open innovation environment.

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