FUTURE INTEGRATED DESIGN ENVIRONMENTS

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ABSTRACT

We are facing a probable great change in the way we carry through design in future ICT supported environments. The main driving forces are the digitalization of information handling leading to a paramount paradigm shift when information storage and access media are separated, building process and product systems are formalized in digital models, user environments are provided with rich multimedia access to virtual models, virtual collaboration rooms established, and new efficient and effective ICT tools defined and implemented.
There are though some barriers putting strains on the development. Among the most important are missing ontologies both on business and Web/Internet service levels as well as their interrelations, poor user involvement in needs and requirements formulations on new ICT tools and continuous user involvement in design and evaluation of new user environments, and lack of interoperability within building process/product models. The general competence level and preparedness for organizational and work change due to global paradigm needs to be increased.
The paper presents a system development approach to future development of Integrated Building Design Systems (IBDS) with efforts to specify needs and wishes on future system and resources to support system development. Examples are picked from ongoing global efforts as well as finished and ongoing research at Building Informatics, Aalborg University.

KEYWORDS

Integrated building design, future, ontologies, models, user driven, innovation.

1. INTRODUCTION

We are facing a probable great change in the way we carry through building design in future ICT supported environments. The main driving forces are the digitalization of information handling leading to a paramount paradigm shift when information storage and access media are separated, building process and product systems are formalized in digital models, user environments are provided with rich multimedia access to virtual models, virtual collaboration rooms established, and new efficient and effective ICT tools defined and implemented.

There are though some barriers putting strains on the development. Among the most important are missing ontologies both on business and Web/Internet services levels as well as their interrelations, poor user involvement in needs and requirements formulations on new ICT tools as well as continuous user involvement in design and evaluation of new user environments and ICT tools, and lack of interoperability within building process/product models. The general competence level and preparedness for organizational and work change due to global paradigm shift going from the art of writing via art of printing to the art of communication needs to be increased. There is also a need for better methods and environments to establish a more user driven innovation process and capture of user needs and requirements on future building functional systems.

We are entering a very complex society where competences typically are distributed among people in problem solving efforts. For example the old Building Master is now a team of collaborating building design specialists. We need partly new fundamental human values, tools, and methods to effectively and efficiently act in these complex settings. A general competence level raise and preparedness for organizational and work change due to global paradigm shift is also needed.

The paper presents a system development approach to future development of Integrated Building Design Systems (IBDS) with efforts to specify needs and wishes on future system and resources to support system development. Examples are picked from ongoing global efforts as well as finished and ongoing research at Building Informatics, Aalborg University. Most research results are achieved in beneficial collaboration with building industry companies.

2. HISTORIC DEVELOPMENT AND ENABLING ICT

Information and Communication Technology (ICT) tools have been a powerful driving force in development of the way we work and handle information. During 1950-60 large computers were used typically for batch processing over night in custom made applications, and the results presented on heavy-duty line printers. Classification systems were used to structure documents. During the 1970s building models with abstraction hierarchies were introduced as well calculations on 3D models. The relational databases were introduced, CAD(/CAM) systems were deployed on main frame or mini-computers, and the time sharing operating systems were implemented. During the 1980s the personal computer was launched (1981) and the terminal rooms were slowly substituted with desktop accessible (not portable) computers. We got high-resolution raster graphics and windows in operating systems. Object oriented building modeling systems (mid 1980s) became available as well as the Internet and practical use of email. It became popular to develop Knowledge Based Systems. As a follow-up to the Initial Graphics specification (IGES, 1979) the Product Data Exchange Specification/Standard for Exchange of Product Model Data (PDES/STEP) work commenced in 1983, see also (NBS-DATA, 1988). 1989 the first version of a global operating systems, namely the World Wide Web (WWW), was formulated. During the early 1990 we could efficiently share applications on personal computers over the Internet, and video communication over the Internet was also possible, Figure 1. The first demonstrations had been made already 20 years before when Doug Engelbart 1968 demonstrated distant collaboration over the net with document sharing and video communication. http://vodreal.stanford.edu/engel/17engel200.ram. Biographical Sketch. Douglas C. Engelbart. Bootstrap Institute.

Figure 1: Left; Experimental set-up at KBS-Media Lab, Lund University, 1991, with video communication and screen sharing using Timbuktu from Farallon. Right; A hypermedia workstation developed 1988 at KBS-Media Lab, Lund University with video display of images and films stored on video disk integrated with the hypertext based program HyperCard from Apple computer. From (Christiansson 2001b).

It started to be meaningful to talk about virtual workspaces as complement to meetings performed in physical rooms. Virtual Workspace Definition from (Christiansson, 2001a); "The Virtual Workspace, VW, is actually the new design room designed to fit new and existing design routines. VW may well be a mixed reality environment. The VW will host all design partners from project start with different access and visibility (for persons and groups) in space and time to the project, and will promote building up shared values in projects. The VW thus acts as a communication space with project information support in adapted appearances. VW gives access to general and specific ICT-tools". A Virtual Space (VS) may also be characterized as a mixed reality environment optionally involving many physical spaces and many virtual spaces. A VS may be set-up within one building or many buildings placed in the local community or on the other side of the world. A VS does not have to be stationary but can e.g. follow a person defined as the immediate surrounding of that person.

Today we can decide on how close we want the connection between the physical and virtual world to be. Real and virtual worlds can be merged to a Mixed Reality. We can augment the reality (Augmented Reality) or augment the Virtual Reality (Augmented Virtuality) (Milgram et al., 1994) depending on service relevance and surrounding constraints. See also Figure 2.

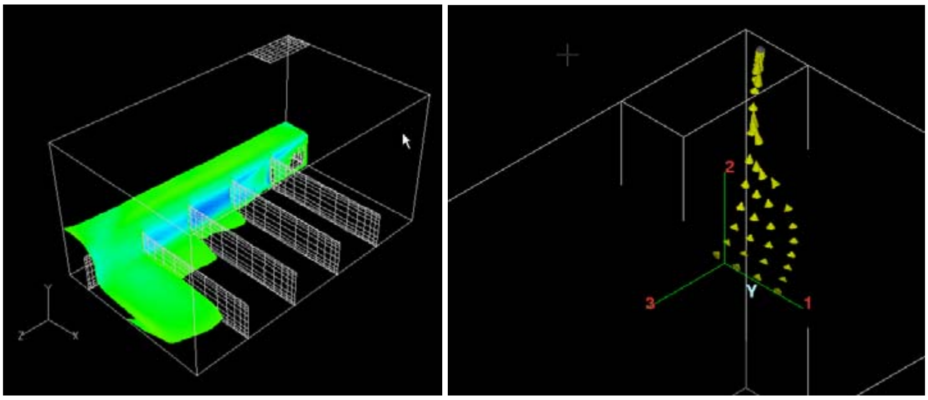

Figure 2: Dynamic interactive 3D visualization of airflow in a livestock building. The CFD (Computational Fluid Dynamics) simulation results were displayed and analysed with the visualisation software VU (Pic and Ozell) in a panorama and a six sided CAVE environment at VR Media Lab, Aalborg University. (The VU system was launched in 1993 and adapted for VR environments 1998.) From (Svidt et al., 2001)

The building process models have during decades gone through de-formalization and subsequent formalization to more completely cover a wider building process domain. The building industry has now for more than 40 years been engaged in building formalized digital descriptions (models) of the building process and particularly of the building itself. An important driving force has been development of advanced Information and Communication Technology (ICT) tools from relational databases in the late 1970s to the Semantic Web in 2001. The Resource Description Framework (RDF) from 1997 paved the way for handling metadata on the WWW and The Semantic Web, see (Christiansson, 2003).

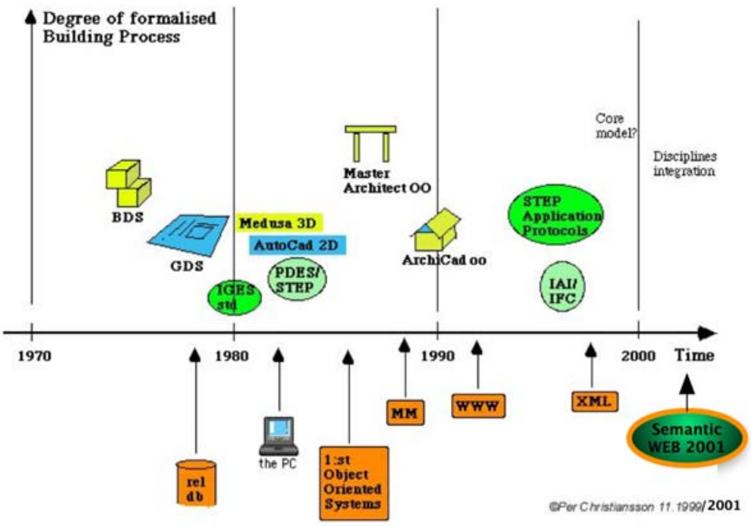

Figure 3: Building Product models development have during the latest decades had periodic focus on achieving a highly formalized non-redundant building product model, Virtual Building, VB. From (Christiansson & Carlsen, 2005).

Comments to Figure 4. A) Today's storage in CAD systems, where building models are developed and stored in CAD systems and transferred between CAD systems typically used by different disciplines. B) The ideal case, where discipline models can be merged into the shared IFC Building Model, http://www.iai-international.org/, either direct (simultaneous work on the building model) or via model file transfer. C) A possible situation of today, where building sub-models are extracted from he model server, checked and stored locally by e.g. Solibri modelchecker, http://www.solibri.com/. D) A rare situation today, where even changes on simplified VR-models (often surface models) can be transferred back to discipline models in CAD systems and further to the IFC Model server for merging. VR models are made due to lack of computer resources and low network bandwidth to allow direct interactive work on large building models. These VR-models may typically be used for design brief and design review. E) Is the same as D) but updates on the VR-model has to be manually transferred from VR-model to discipline models.

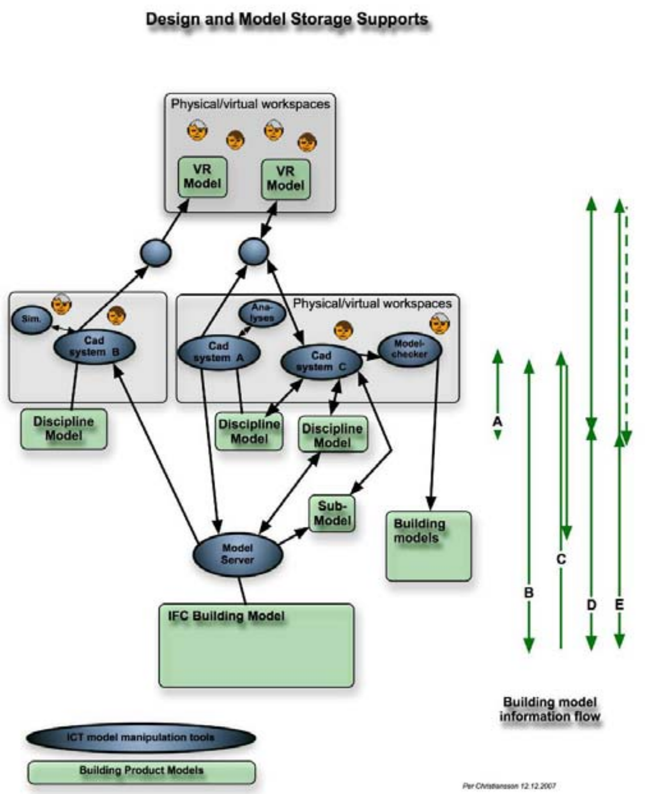

Figure 4: Building product model can be stored shared and distributed.

3. SCENARIO AND VISION

In the following a short scenario is sketched describing a future Integrated Building Design Environment (IBDE) from the user perspective: A client contacts a client advisory system on the WWW to learn more about the prospects on a new office building he is going to build. He contacts an architectural-engineering company and starts the project. The client involves a group of building end-user representatives in an early user-driven creative design process. He also includes the contractor in the early decision process to secure constructability.

After that alternative building solutions, expressed as Component Building Systems (CBS) and Functional Building Models (FBS), are evaluated by end users against needs and external requirements. A FBS may for example be a comfort system to provide personal living and working quality, a personal transport system, a load carrying building system, an escape system, or a communication system (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, see also (Christiansson, 2007). Before a client end-up with a requirements specification on a building and its services, the design team has to recurrently traverse the end user needs capture and consolidation process. The end-users of a building are typically building inhabitants, external service providers, operations & maintenance (O&M) personnel, and building administration. They may in 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, see (Prahalad &Ramaswamy, 2001) and (Christiansson et al., 2008).

The design process is then partly carried through in virtual spaces with access to the building product model on different detailing levels (volume, space, building element etc.) and can be browsed in geometric and time coordinates (4D).

The client early specifies representation, content and functionality of the building model to be delivered after construction is completed. He also demands to get a model where he can acquire design rationale on different alternative solutions and rich multimedia access to as-built documentation on component building systems.

4. NEEDS ANALYSES

We are now prepared to start formulating needs on the future Integrated Building Design Environments (IBDE). The IBDE should be able to provide new functionalities, new services, new ontologies, new human computer interaction environments, and be useful in different business environments supporting new business models, collaboration forms and less dependence on today's often phase locked process.

Practical experiences on how to organize and carry through collaboration on digital building models (Virtual Building, VB) should be (publicly) accumulated and contribute to the future implementation of tools for collaborative design using digital models of buildings and associated processes (BIM, Building information modelling).

What important trends can we observe today?

- Local business is becoming global local-like business.
- Business models are changing. We have today business models very much based on locally optimizing value chains, see also Figure 5.
- Innovation in building is a challenge (fax and mobile phones were real hitters).
- Virtual Organization is more often brought into play.
- Moore's law will be valid for at least another 20 years (memory, speed, ubiquitous computing).
- Extended development and use of meta-data marked www-accessible information (e.g. semantic web based solutions). See also (Lai, 2006).
- Clients get instruments to formulate better requirements on buildings, see also Figure 6.
- We are introducing, also in practice, the time dimension (4D) in Virtual Building models, see e.g. (Fischer & Kam, 2002).
- Virtual building (VB) models access is getting more standardized through use of the IFC standard, http://www.iai-international.org/.
- Efforts under way to create International Framework for Dictionaries (and Ontologies) (IFD), http://dev.ifd-library.org/
- Intelligent products and buildings with embedded sensors and actuators are again in focus.
- Energy optimization and ecological building is gaining importance.
- We should be in a continuing reflective development process aiming at moving goals.

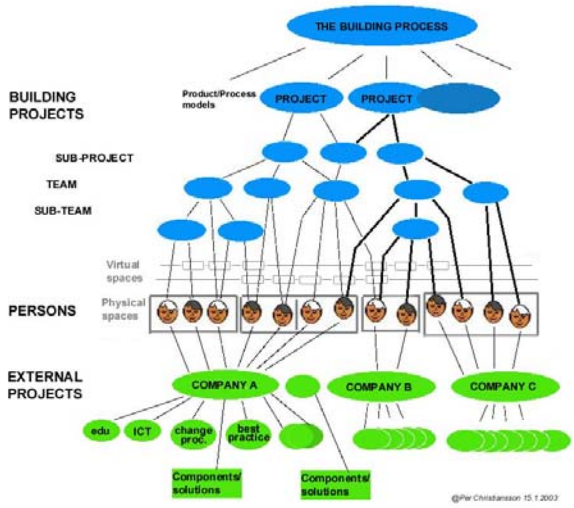

Figure 5: Organizational view on internal and external building project actors, activities and attached information containers. (Christiansson, 2003).

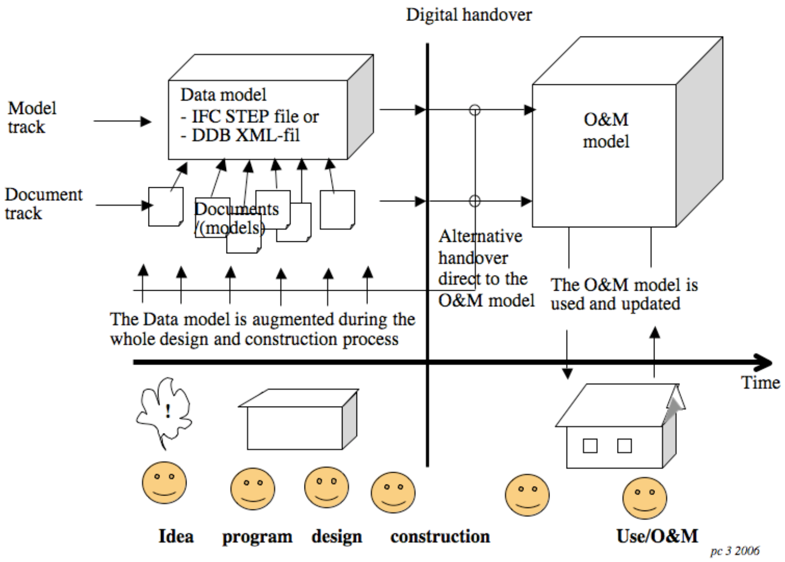

Figure 6: The newly released, January 2007, Danish digital construction requirements let public clients put requirements on the content of the digital models of the building handed over to the client after finalised construction. (DDB, 2006). From (Christiansson, 2007)

Needs list (that could and should be revised and extended)

- Quality Assurance (QA) on building process to minimize errors in the final product.
- Important decisions to be taken early in the process.
- Better interactive process models for simulations with automatic update possibilities of VB.
- More user-friendly design tools supporting use of thin flexible screens, haptic feed-back, ubiquitous access).
- Efficient distributed collaboration on Virtual Building models in virtual spaces.
- Common ontologies at least on business meta level, see also Figure 7.

- Ontologies for functional building systems (FBS) such as comfort and personal security systems, see also Figure 8.
- Landmarks (on high business and ICT levels) to aim at during long-term research, development, and organizational and work method change.
- Increase in general competence level and preparedness for organizational and work change due to global paradigm shift, going from the art of writing via art of printing to the art of communication.
- Increased possibilities for user driven innovation and co-creation in the design process.
- Motivations and tools for open ontologies and open business models development.
- More building informatics related education on university level and ICT supported learning, see (Christiansson, 2004)

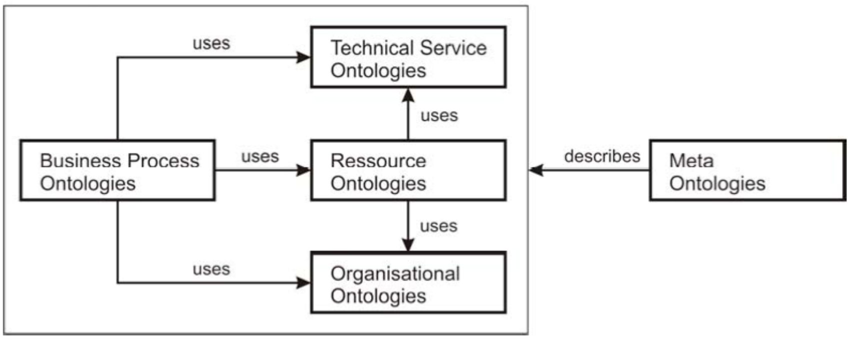

Figure 7: Overview of meta building ontology domains and their relations. From (Sørensen et al., 2008)

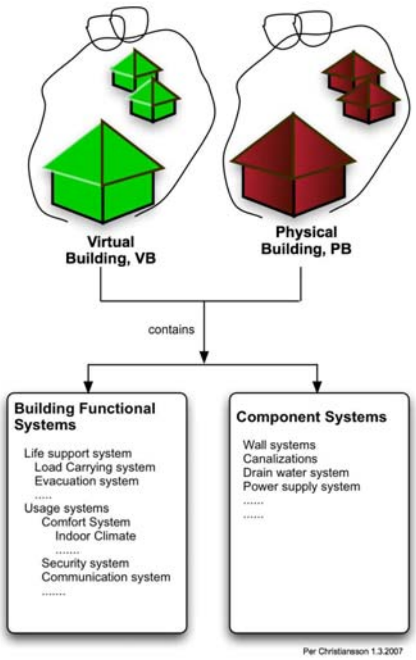

Figure 8: The Virtual Building (VB) model should be a digital copy of the real building, the physical building (PB), even before it is built. (Christiansson, 2007). In (Christiansson & Svidt, 2006) it is further described the relation between functional building systems (FBS), and Component Building Systems (CBS) and detail levels of VB descriptions.

5. SYSTEM DEVELOPMENT

5.1 INTEGRATED DESIGN SYSTEM

In the real world, see Figure 9, we identify activities, things, processes, context, and persons. The real world building can be described as (interrelated) building systems (FBS) (no de-facto structure is available today) to accomplish different functions e.g. a comfort system to provide personal living and working quality, personal transport system, load carrying building system, escape system, and communication systems (collaboration, knowledge transfer, mediation, virtual meeting). The systems are modeled in context and more or less formal conceptual models, and later data models in formal representations, are designed. The data models are implemented in computerized information handling systems, and the ICT systems performance is (continuously) evaluated and usability tested, (Christiansson, 2007).

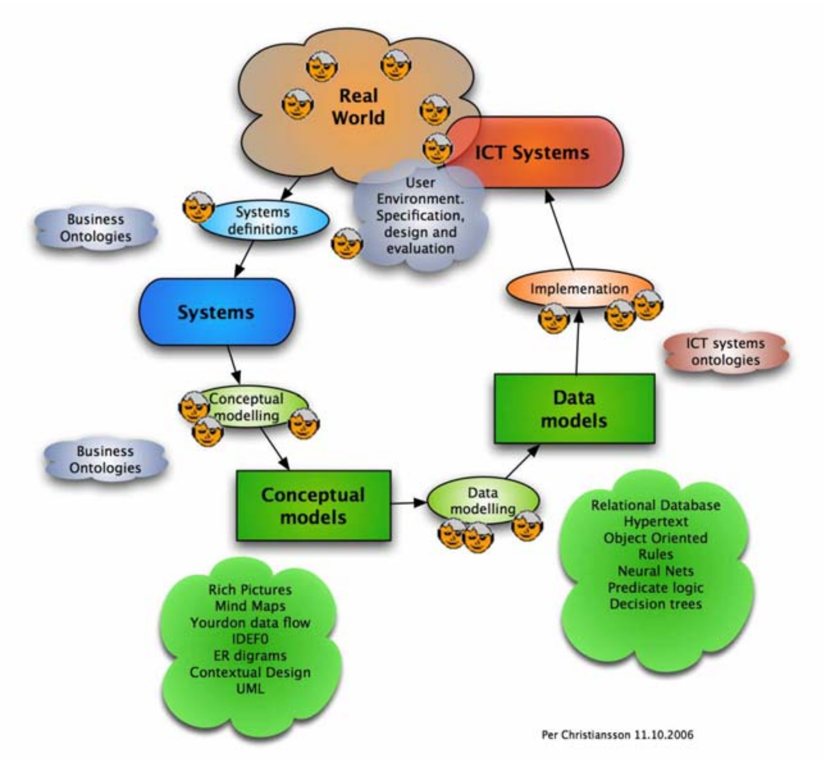

Figure 9: Real world systems supported by ICT systems. The Systems may in connection with Integrated Building Design Environments (IBDE) characterize a building or the design process.

Needs and requirements formulation from end users leads to specific requirements on the building functional systems and their implementation as a physical building. The traditional functional building systems may be improved to help in making the building more intelligent and responsive to end user needs, usage context and surrounding constraints. From (Christiansson, 2007)

5.2 AMBITION, RESOURCES AND TIME

During the last century the so-called 'industrialism' has been the ruling paradigm. We are now in the phase of changing to something new, which we could call 'globalism' ('the global village') or 'organizm' (from organization and organic). During the industrialism there was a need for man skill in the realm of logics to make known processes more effective. Today we need more non-parametric studies and creative thinking to formulate and try out sometimes totally new processes on all level in our society, (Christiansson, 1993).

The higher the degree of formalization the more effective and efficient the computerized models of building product and processes will be and less flexible to changes, see Figure 10. It is of course a question about optimizing in a set of constraints, (Christiansson, 1993). These constraints may be dictated from external needs and access to resources (such as workforce, material, money resources) and available time as well as type of building product. During the 1960s there was probably another set of constraints than today.

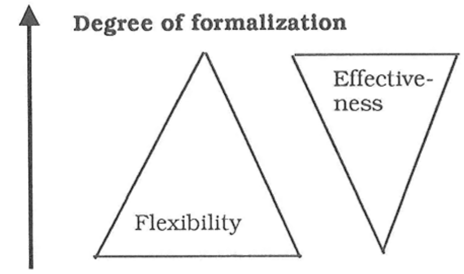

Figure 10: There might be a negative correlation between effectiveness and flexibility for different representations. From (Christiansson, 1993)

5.3 USER DRIVEN INNOVATION

Figure 11 shows the basic layout for a user driven innovation and design system developed by two main engineering and architecture companies in Denmark , Rambøll A/S and Arkitema A/S, and Aalborg University, Civil Engineering department. See also (Christiansson et al., 2008).

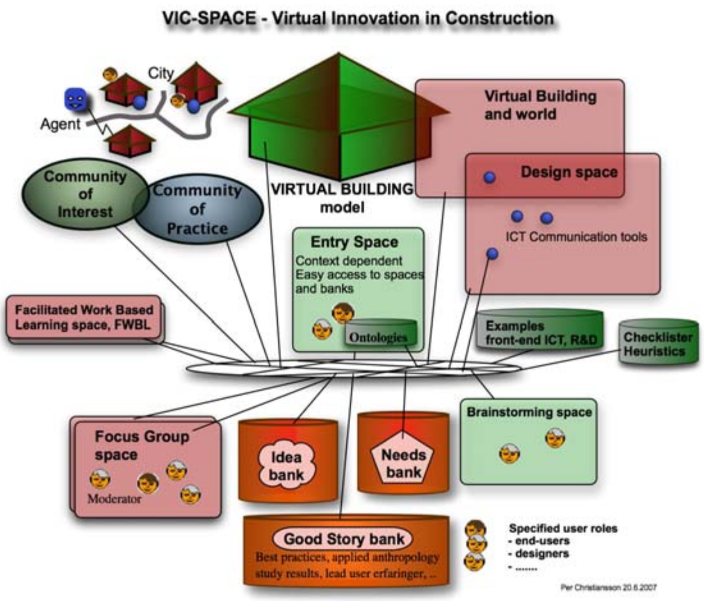

Figure 11: The Virtual Innovation in Construction methodology, VICMET, will house a number of spaces suited for different activities. From (Christiansson et al., 2008).

6. CONCLUSIONS

We are in the middle of a great change process concerning development of Integrated Building Design Environments. Design activities and design competences collaboration are increasingly carried through in a global context in more or less virtual spaces using rich multimedia interfaces, and digital virtual building and process models. We are in fact accomplishing an innovative creative design of future design tools and buildings, requiring significant end-user involvement usability engineering. Ontologies and dictionaries have to be further developed especially on business and meta levels to secure effective systems interoperability, and information handling. Functional Building Systems have to be categorized and the client needs capture and requirements formulation and modeling be further advanced. There is a great need for increased efforts within building informatics education to secure needed competences for leading and carrying through the future research, development and innovation activities.

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