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KNOWLEDGE REPRESENTATIONS AND INFORMATION FLOW IN THE INTELLIGENT BUILDING

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ABSTRACT

The concept of Intelligent Building was established 1982 by AT&T. The Informart building was erected in Dallas to demonstrate how advanced IT from different suppliers could be used in the intelligent building. Now almost 20 years later industry and researchers again starts to talk about new services in the intelligent and responsive buildings and digital cities. The paper gives an overview of existing and potential new services of the intelligent buildings and how these services may be designed and implemented using advanced IT. Special emphasis is on the relation between new services, user interfaces, the cooperative building and underlying knowledge representations as well as services integration on physical networks, communication protocols, systems and applications levels in the intelligent and responsive buildings.

INTRODUCTION

For almost 20 years we have talked bout Smart Houses, Intelligent buildings, and Responsive Buildings. After years of trials, demonstrations, creative design and standardization efforts we can now experience an accelerated pace in implementing some kind of intelligence in buildings.

At the same time there is a lot of talk about the digital city. A city that provides new and in may cases not yet defined IT based services to its inhabitants and visitors. Of course there is a global social and cultural scale also in the process namely the forming of global villages/regions with other than geographic borders. This latter evolution can be expressed in terms of cultural, social and economic parameters (Christiansson 1992).

The future; Intelligent Buildings, IBI, will be different compared to today's IBIs. The IBI will

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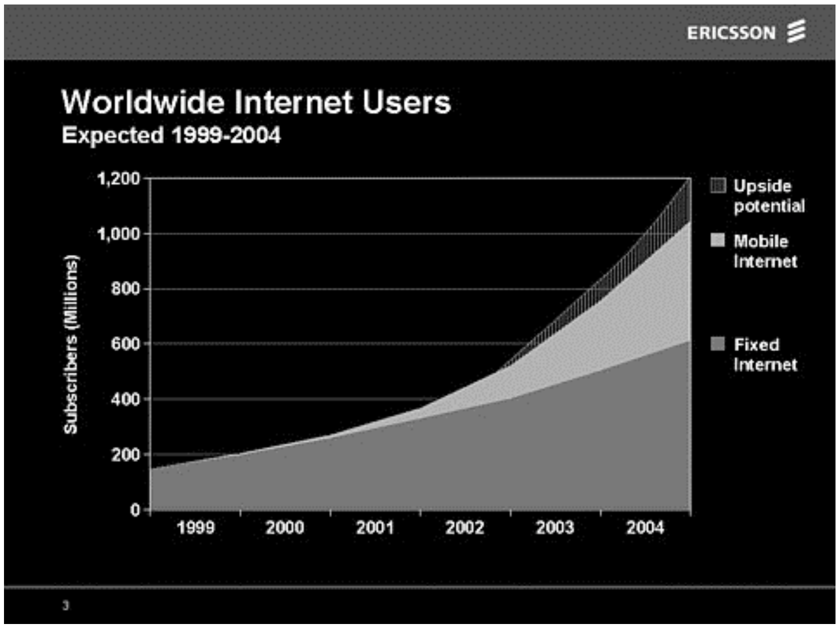
- be more *organic* and *cooperative* and active in it's support of different user needs.
- to a high extent support user information *communication* both through it's physical design and it's IBI-systems.

The paper focuses on some important questions as
- what type of enabling IT can we expect in the future?
- how can we efficiently design the intelligent and responsive building involving new competencies?



- what IBI properties and functionality will be feasible?

Figure 1: Expected devlopment of Mobile Interne. Ericsson Inc., Sweden, at CeBIT 24 Feb 2000. http://www.ericsson.com/cebit/webcast/sld003.htm

PERSPECTIVE

In (Masuda 1982) we could read about changes in society, information and knowledge industries, participatory democracy with examples from Japan. In 1982 AT&T establishes the concept "INTELLIGENT BUILDINGS" due to marketing reasons. The INFORMART building is erected in Dallas containing latest IBI systems on display. In 1984-85 The Smart House Development USA (National Association of Home Builders, NAHB) starts and we talk about 'Automated Buildings', 'High Tech. Buildings', and 'Smart Houses'. STS, Shared Tenants Services, companies are started with minor success. There are today many Smart House systems available for the family villa.

In 1986 we arranged a Intelligent Office workshop at Lund University where some still valid conclusions were drawn - man/machine environment important, lack of knowledge, information vulnerability, flexibility requirements, too little holistic problem views, new building construction coordination and procurement forms needed, and lack of standards. N.Y. Times writes 1987 "I.B. is a dumb idea". 1990 LonWorks technology work starts (LON, Local Operating Network for IBI systems, developed by Ecehelon Inc. http://www.echelon.com/).

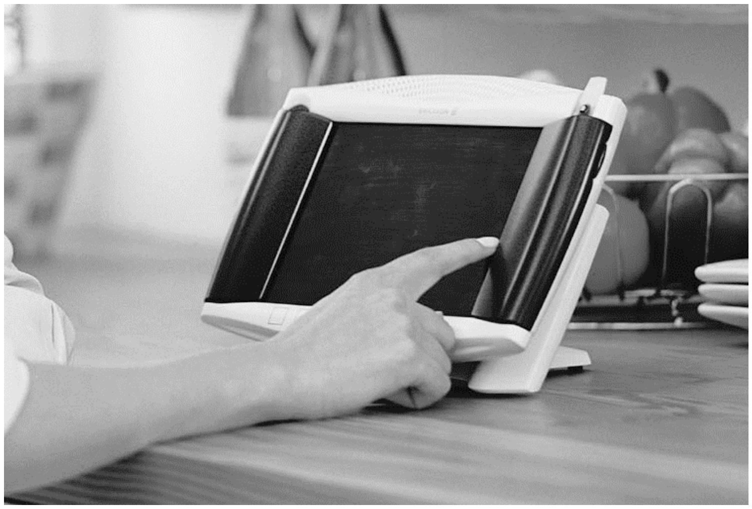


Figure 2: Ericsson Cordless Screen Phone HS210 with Internet Access, e-mail, and telephony using Bluetooth wireless communication (from http://www.ericsson.com/cebit/webcast/sld005.htm)

During the years a lot of efforts have been spent in the area and today we have building automation standards, large scale Internet and networks implementations and powerful human computer interfaces. We though lack wide spread creative design and large scale testing of new services using IBI.

We can expect personal http-servers in great amount in the coming years. These will be used internally within and between families and friends, provide public information (which will be scanned by robots and indexed), and be part of different project-intranets. We will expect to have personal access (with personal views) to our home servers from optional location in the world.

Figure 1 shows predictions from Ericsson Inc. on expected development of mobile Internet and figure 2 from the same company the new durable cordless multipurpose screen phone with touch display.

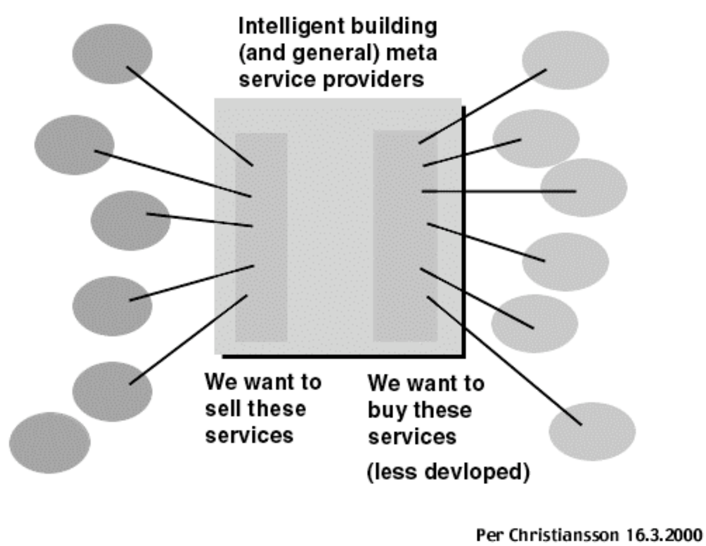
There will be a great need for new services and meta-services for creating and easen design, testing, and implementation of new services, se figure 3.

IBI DESCRIPTION

There have been many definitions of IBI made during the last 20 years. The IBI will possess some important characteristics

- be *flexible* and *responsive* to different usage and environmental contexts such as office, home, hotel, and industry invoking different kinds of loads from nature, people, and building systems,

- be able to *change states* (clearly defined) with respect to functions and user demands over time and building spaces (easy to program and re-program during use)
- support *human communication* (between individuals and groups)
- provide *transparent* intelligence, simple and understandable to the users (support ubiquitous computers and networks)
- have a distributed long term and short term memory
- contain tenant, O&M, and administration *service systems*
- support *introduction* of new (sometimes not yet defined) services
- be equipped with *sensors* for direct or indirect input and manipulation of signals from users, systems and the building structure
- be equipped with *actuators* for direct or indirect manipulation installatations and the building structure
- accomplish *'intelligent' behaviour* (self diagnosis, trigger actions on certain events and even learn from use)
- *integrate* different IBI systems to form complex systems
- contain IBI *life time standardized solutions* as far as possible
- be well *document* (in 3D with functional descriptions) available in Virtual Reality with physical structure overlay
- provide *canalization* (information roads) that shall house 'wires' carrying new services
- be able to handle *high band width* information transfer.
- provide dynamic *secure information domains* (i.e not based on a non-routed Ethernet in a residential block)
- be open to efficient communication between applications based on for example XML implementations (Christiansson 1998), and platform independent solutions as Jini on Java Virtual Machines, (see



http://www.sun.com/jini)

Figure 3: New services and meta-services will be offered in the society and in the IBI.

Services announced today by IBI-system companies are typically - fire alarm, energy control, heating control, telephony/computer net, ventilation control, climate, surveillance, lightning, power, security, passage control, and automatic door functions.

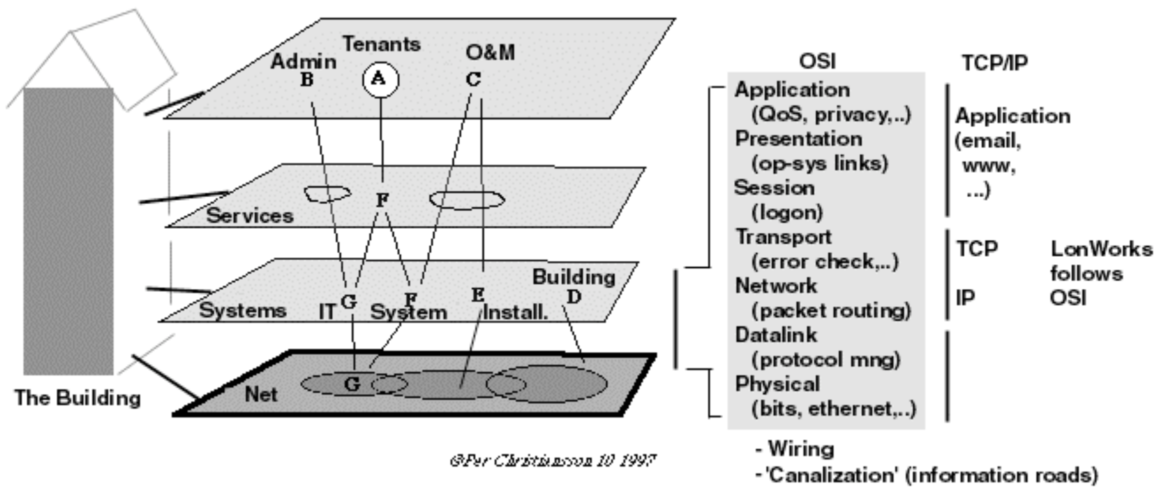


Figure 4: The IBI integrates Internet, intranets, IBI systems, and the physical building. Canalization may be canals, carrier frequencies, existing wires, overhead lines or other reserved space.

The IBI is part of a world wide communication network and must not be viewed in isolation. Three views are presented below

The Global view

- with Cutural, Social, and Econmic parameters

The Digital City User View

- *Acquire information* about - commune service, planning data, city resources (companies, services, associations etc.), shops and their products, museums , libraries, (virtual) universities, maps, news etc.
- *Request services* - social commune service (schools, nursery, hospital etc.), learning material, property data, energy flow control/data , goods flow control/data, traffic flow control/data, water supply control/data , educational on line support, infrastructure service/capacity/security, leisure (order theatre ticket,..), status information (buses,...), etc.
- *Input* information for decision support (the democracy process) - feedback on decisions, voting, decision support, local planning (views on plans, discussions), 'Speakers corner', etc.

The Intelligent Building view (Christiansson 1993), see also figure 4 and 5

- *User* service - voice/video/mail communication, group communication, fault reports, building descriptions, transport support, resource booking, (complex) alarm functions, locking/passage control, security, service documentation, access to external nets, home care, etc.
- *Operation and Maintenance* - building operation systems control/documentation/maintenance (energy, water, climate, ventilation, power, transport,..), building and property documentation, building self diagnosis, etc.
- *Administration* - facility and property management systems, economy and planning systems.

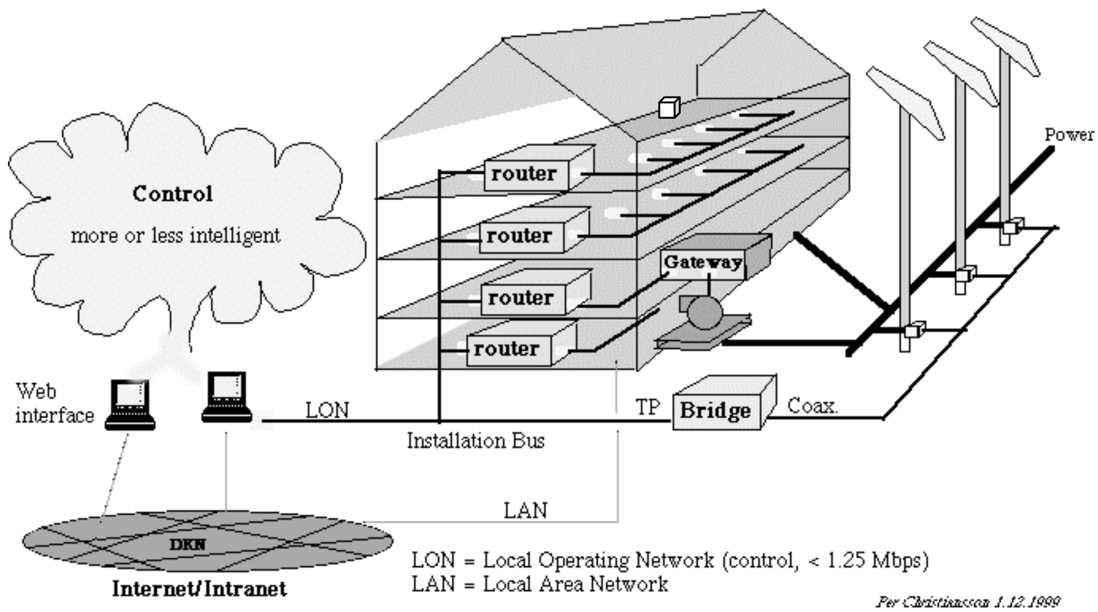


Figure 5: The Intelligent Building wired with LonWorks and Internet/Intranets. The light circles in the house are LonWorks nodes.

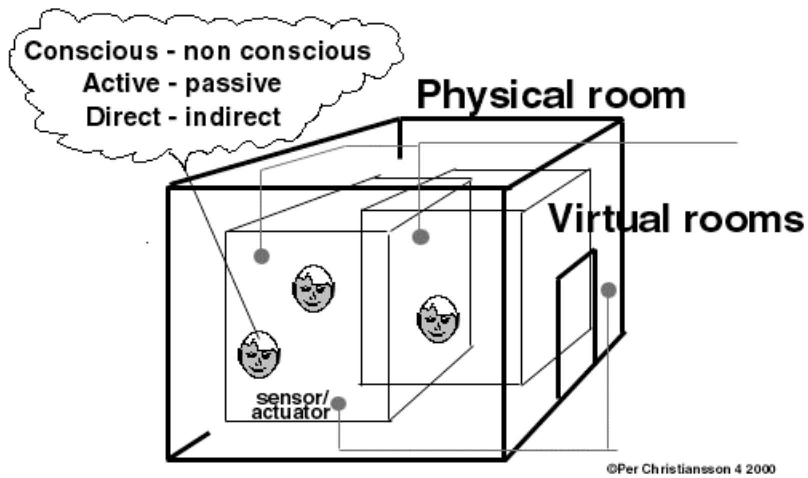
COMMUNICATION AND INTELLIGENCE

Figure 6 shows one user view to the intelligent building. The IBI should be responsive to the user needs and easily be re-programmable. We may have to define virtual rooms to house different activities at different times and even occupying different spaces (for learning, creativity, virtual meetings, thinking, relaxation, sleeping, etc.) in the buildings. The building shall support communication in all respects also the communication directly involving it's users. The physical form and functionality of the rooms will be more tightly related to the underlying IBI systems.

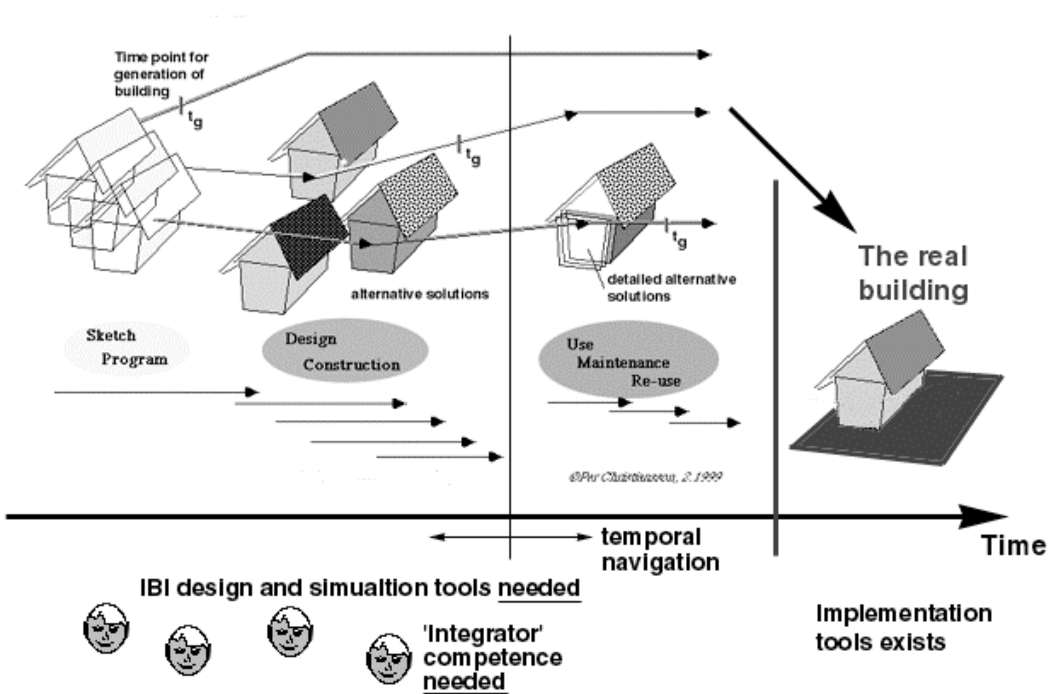
We may again after some years of not widespread interest look at AI, Artificial Intelligence, based computer stored knowledge representations. For example induced decision trees with partly manual interaction for IBI decision support and Neural Networks to learn control procedures and user behavior.

DESIGN OF IBI

In the future we will to a higher extent design and try out the building during it's whole life cycle before it is even built. We will first build a Virtual Building, VB, in the same way as cars, ships, and airplanes are built (Christianson 1999). Simulation of building (VB) behavior will be even more important to perform in the complex IBI. Unfortunately there is a lack of both powerful VB models and IBI simulation tools which emphasis intensified R&D within area, see figure 7.



F igure 6: The building users populate physical and virtual rrooms. The virtual rooms may be easily changed.



Figur 7: The complex IBI will require advanced functional design tools to be

used on the Virtual Building model during it's simulated life time.

IBI design (as well as other designs) should put user requirements and functional specification in focus.

With temporal data introduced into the VB new opportunities arises. From (Christiansson 1999), we can store snapshots of different building processes and *backtrack* to make a re-design and re-simulation with changed requirements (regeneration of the VB), document and retrieve *causal connections* over *time* and *space* in the VB, store *lines of reasoning* and possibilities for analyses of their relations, and effectively use time parameters in the *life time documentation* of building behavior.

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