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Appropriating Intelligent Buildings

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Abstract
"Intelligent Buildings" is a new term for an ancient concept. Nevertheless the rapid advances of IT and automation since the beginning of the 1980th have allowed application of many concepts. Modern IB defines a building using a controller integrating; management, security, appliances and multimedia communication systems. Few IB projects have achieved comfort, time, energy and administrative cost savings and increasing worker productivity, however, many other have met difficulties, resulting of numerous application drawbacks. Literature review shows that there is no consistent method of developing an IB that meets the true needs of the end user. Moreover, IB projects are costly, concentrating on management, security and physical needs. The research investigates implementation shortcomings and challenges, while trying to propose future development. IB should: be appropriate to all involved parties, coexist in a favorable context of intelligent users and cities, and need widespread changes to the way buildings are made. The study concludes that even though fast evolution of technology would resolve many problems in the near future, IB requires appropriating mechanisms to achieve its objectives along with the known architectural requirements, while ensuring that we could easily control the building intelligence not the other way around.

1 Introduction: Overview of IB

“Intelligent Buildings” is a new term for an ancient concept, where the Great Pyramid of Khufu at Giza, Egypt (2480-2600 B.C.), with its sophisticated design, constructions and functions not all revealed yet, is probably, the first application of IB. Nevertheless the rapid advances of IT and automation has allowed application of many concepts, man has dreamed of for long.
In 1982, the modern IB concept has appeared in AT&T telecommunication building built in New York, USA, which implemented IT through systems on display [1]. Since the mid 80th, many applications, workshops and literature has dealt with IB, resulting to worldwide spread; from advanced countries to developing countries, e.g. Egypt and Dubai with the establishment of smart villages.

1.1 Definitions of IB

Intelligent building are perceived differently around the world; the Japanese's call it the most technologically efficient, Europeans think it should meet the needs of everybody living or working, while Americans think that a building completely sold or let is intelligent! [2].
The Intelligent Building Institute in USA has proposed: "an intelligent building is one that provides a productive and cost-effective environment through optimization of its four basic elements - structure, systems, services and management - and the interrelationships between them. This concept is best expressed in the mission statement of uniformat.com, by applying ASTM E1557-96, where the UNIFORMAT approach to building intelligence encompasses previous definitions [3]. On the other hand, a recent international conference in Finland considers that IB can be described as: *one that will provide for innovative and adaptable assemblies of technologies in appropriate physical, environmental and organizational settings, to enhance worker productivity, communication and overall satisfaction [4]*.

1.2 Elements of IB

Intelligent buildings use electronics extensively in four areas [3]:

- energy efficiency
- life safety systems
- telecommunications systems
- workplace automation

There is another area; building structural systems, which includes building method and materials, however, it rarely uses electronics. Over time, the four categories have merged into two broader ones: facilities management (energy and life safety) and information systems (telecommunications and workplace automation.) In general, facilities management deals with the physical structure itself and how it is operated. The term information systems refer to the way information is handled within the building.

1.2.1 Facilities Management implies a computerized system that controls building operations, generally energy and life safety (Fig.1). The goal is to reduce energy use without sacrificing occupant comfort. For this, many systems are used, e.g.: Building Automation System (BAS) (see Fig. 2), Energy Management System (EMS), Energy Management and Control System (EMCS), and Facilities Management System [3]:

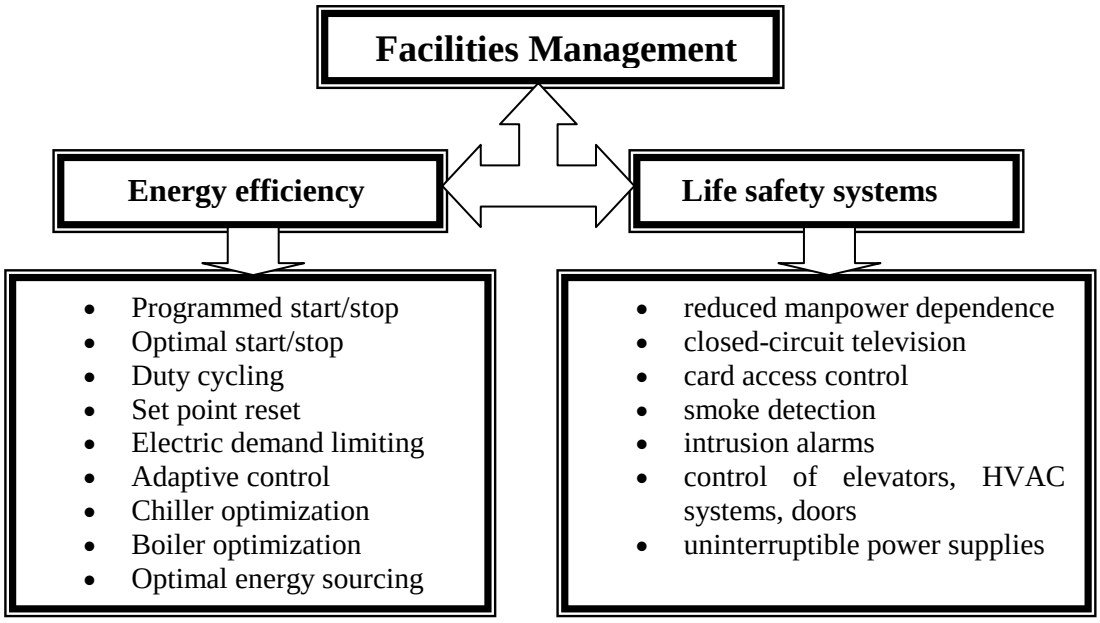

Figure 1: Facilities Management

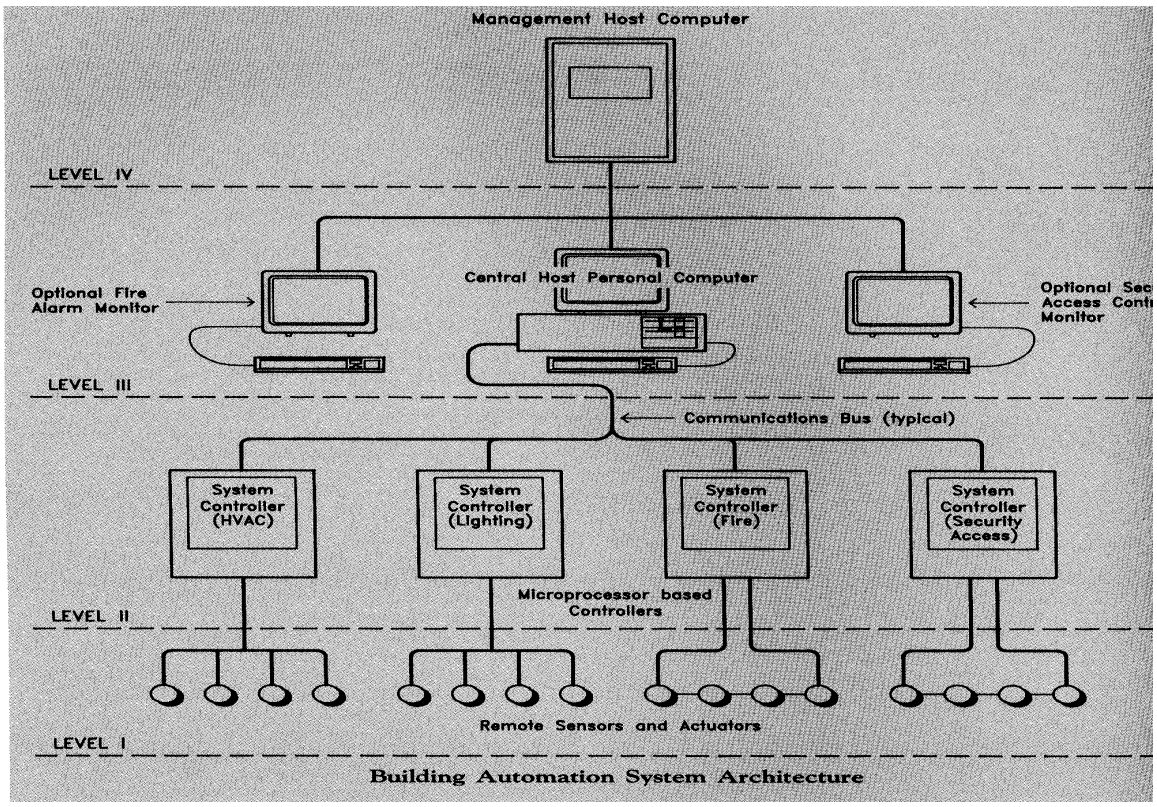

Figure 2: Building Automation system [5].

1.2.2 Information System includes telecommunications and workplace automation [3] (Fig.3):

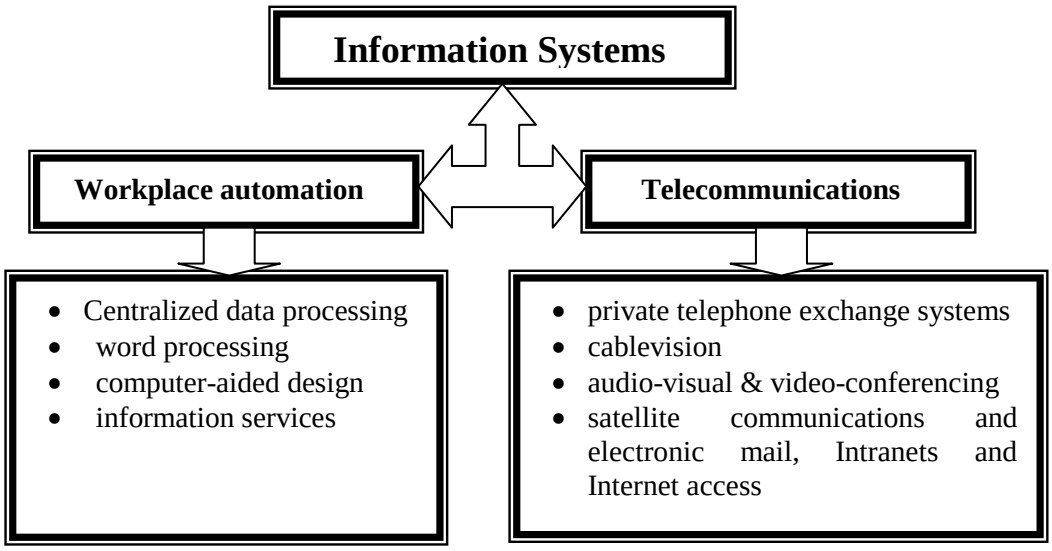

Figure 3: Information Systems

1.3 Benefits of intelligent buildings [6]:

- Standardized building systems wiring enables simple upgrade of control systems.
- Higher value building and leasing via increased individual environmental control.
- Consumption costs are managed through zone control on a time of day schedule.
- Occupants/tenants control building systems after-hours via computer or telephone.
- The service/replacement history of individual relay and zone use is tracked.
- A single “human resources” (hire/fire) interface modifies telephone, security, parking, LAN, wireless devices and building directory, etc.
- Benefits turns into cost savings primarily to the developer/owner/operator, while functional enhancements are mainly enjoyed by the occupants/tenants.
- Achieve comfort and security make life easier.
- Increased productivity of workers, thus increasing return on investment.

2 Research problem and previous studies

Literature review of IB applications and experience reveals that despite benefits, it has faced numerous problems, and challenges, besides many shortcomings. Kilsh and Nouby think that high cost and problems makes IB available only for very limited number of users [7]. Dewsbury argues that there is no consistent method of developing an intelligent building that meets the true needs of the end user [8] which ends up with inappropriateness and unjustified cost. On the other hand, many IB are complicated to users , which drives Lweis to say that the most difficult task in creating IB is ensuring that the building in not too smart for the users, who want their building to be user-friendly, economical and appropriate to their style [9]. This represents a dilemma, as users are different in back ground, culture and education. The research hypnosis is that the term IB has been misused for business, promotion and propaganda reasons. The research supposes that majority of IB projects are showcases of automation and IT innovation rather than architecture, thus it could hardly called as intelligent.

3 Research objectives, methodology and limitation

The research questions the validity of the term "intelligent buildings". The paper objective is to set up a development frame work for appropriating intelligent buildings, which does not neglect the known architectural requirements of function, stability, flexibility, ethics, psychological and physical comfort in a reasonable cost. It is needless to say any innovative technology implies many risks, and cannot be assessed quantitively until settled and widespread. Thus, the study investigates IB problem from the appropriate technology point of view, analyzing IB shortcomings and challenges into the different phases of the application process, in addition to the economical aspect. The outcome would suggest some actions regarding the different phases and the required future development. Because of the conference's restriction of 8 pages only, the study would be limited to published IB drawbacks, not accompanied with an application review, which could be easily found in many Web Sites.

4 IB implementation drawbacks

There is a scarcity of reference IB projects that are fully instrumented and documented. Many intelligent buildings projects have been showcase projects, demonstrating specific attractive examples but not seriously quantifying the costs and values nevertheless risks. Without careful quantification, IB economics cannot be made, since initial costs are often high, and money recovery would be over the building age. For example, energy cost saving or rising can change the conclusion. Few IB assessment studies have been conducted, which would be reviewed to reveal the challenges and drawbacks.

4.1 Evaluation study of 12 office buildings in Helsinki, Finland

The study was focusing on energy management and indoor air, from the user point of view [10]. Although Finland is an information intensive country, nearly all workers (90 %) prefer human to computer aided means in assisting with building management. The total energy consumption of IB is the same as the average energy use of non-IB offices in Southern Finland (!), because illumination and office equipment consume most of the electricity. The energy consumption figures of the intelligent office buildings differ from each other in the use of electricity and heating energy. The questionnaire of office workers response of IB, have shown similarities to the latest results of social science, learning, nutrition and ergonomics. It is good to stand and walk in office instead of sitting by desk all the time and reaching everything while sitting. Moving is good for muscles and digestion, but it is essential for thinking and creating new ideas [11]. The study argues that designers and contractors are not yet mastering IB features well enough according to users' requirements, of some basic technology such as heating and ventilation.

4.2 Technology Roadmap for Intelligent Buildings

This study explores and explains the current status of intelligent building technologies in Canada [5]. It indicates that the most successful IB comes from integrating communications and ensuring that the traditional systems have the ability to intercommunicate and interoperate. IT thinks that current trends to work from home encourage remote interaction with building communications and services, which depend on resilient communication infrastructures. The study concludes:

- Although Intelligent building technologies are available form 20 years, they are not yet widely adopted in the western rich world, nevertheless, other countries.
- There is reluctance by much of the development and construction industry to embrace them because of initial cost and many shortcomings.
- Developments and initiatives must occur for these technologies to become widespread.

4.3 Healthy Buildings Workshop 30:

The aims of the workshop was to identify user needs in depth, explore and recommend new ways of working for the design, construction and facilities management processes, in addition to examine ways of feedback from buildings in use. It was found that IB demands intelligence continually applied at the concept, construction and operation stages of project by all involved actors. All participants felt that the basis for IB should be open integrated design of the building using a system approach (i.e. architecture, construction and technical systems). They thought that IB should provide a responsive, effective environment where an organization can meet its performance objectives, and although the technology still generally basic, it should be seen as the enabler rather than as an end in itself [4].

4.4 A study of "How can buildings be intelligent"

After Coggan has reviewed 200 intelligent buildings in USA, he offered a simplified explanation of IB, claiming that it could result from the straightforward application of the ASTM Standard E1557-96 - UNIFORMAT II [12]. However, strangely enough, he concludes that he has found that intelligent buildings do not differ greatly from conventional ones (!), and marketing IB seems more important than actual building intelligence [3].

4.5 Author paper of home improvement to be IB

When the author has conducted a research on improving home design to accommodate the new trends of distance working and learning, he came across some drawbacks of "smart homes" [13]:

. High cost of construction.
. Laziness because of staying home and watching monitors most of the time.
. Individualism -self-unity- due to less talking.
. Low interaction because of indirect contacts with teachers and employers.
. Disruption of the socio-economic descplin due to unlimited working and learning hours
. Invasion of privacy, where IT could be used to monitor residents, degrade their civil wrights.

5 IB problems and development

The previous studies indicate many problems and challenges facing IB. As appropriate technology deals with the process in all phases, not the product which in our case is BAS, appropriating IB should be the same. Problems are categorized in the four phases of the process; concept, design, technical installation, usage context, in addition to the economical aspect. Naturally, future development would be in the same areas, which all are summarized in Table1, due to the paper limitations.

6 Criteria of appropriate IB

Appropriate IB depends on a detailed review by a team comprised of: owner, architect, financial advisor, BAS engineer and a member of the building operating staff. The team should establish the goals and objectives of installed BAS, following logical approach in evaluating systems, with emphasis on economy, compatibility with building systems, user friendliness and vendor support quality [5]. The general criteria of IB should be:

- Achieve known architectural requirements for each type of building.
- Easy to use and maintain, to be as intelligent as users, whom have different cultures.
- Reliable and safe.
- Flexible and up gradable in layout, structure, technology and connection to infrastructure.
- Accepted psychologically, where users should feel good in and with the building.

- Give user individual environment control e.g. heating and ventilation.
- Uses space and energy in an optimal way.
- Built with materials which could be reused –recycled- and have low embodied energy.
- It has to coexist in a favorable context, presented in intelligent cities.
- To be affordable at reasonable cost.

Table 1: IB problem area and required development

---------- Area	Problem ---------- Drawbacks & challenges	Development
Concept	- Different definitions worldwide, because of different perceptions - IB reflects building automation systems -BAS- - No consistent method to develop IB - IB concept sometimes seen as an end in itself - Many IB are more intelligent than users. The most difficult task in creating IB is ensuring that the building in not too smart for the users	- Difficult to achieve - IB concept needs shaping - Development would emerge method - Should be seen as enabler - User-friendly, appropriate to their style and use while ensuring critical balance between user and building intelligence.
Design & Architecture	-Developers are generally IT experts, not architects, thus focusing on IT innovation rather than architectural requirements. -Many IB projects doesn't meets the true needs of the end user -IB could not, so far, respond to new user activities and life functions -Design concentrates on security, management, productivity and physical comfort while ignoring psychological and self-harmony. -Insufficient awareness of designers of tele-mated systems leads to design mistakes and higher cost.	- Architects should lead the process by defining the needs, which IT applies. - Distinct BAS objectives. - Flexible deign and function analysis - Building should comfort body and soul of users. - Widespread of info, development of training and education of designers.
Technology & installation	-Building tele-mation advances are faster than application. -Impractical to integrate several systems of many suppliers, while costly to deal with one provider. -Changes in approach is needed throughout the supplier community -Bidding of fast evolving technology is difficult. -There is a scarcity of reference projects that are fully documented -Automation requires widespread changes to the building process. -IB is built with conventional building materials and techniques, which are static by its nature. -Contractors are not yet mastering IB features according to users' needs. - Installation of some basic systems in IB , such as heating and ventilation of open spaces, cannot provide the personal control.	- Flexible and up gradable systems - Wait until technology widespread. - Needs awareness and widespread. -Online data availability may help - Needs post-occupancy evaluation - Restructure of the building industry. - Application of smart materials and advanced flexible building techniques. - Awareness and training of contractors. -Not resolved yet.
General context (urban, social, health and management)	-IB requires cooperation among architects, systems' designers, manufacturers, contractors, utility suppliers, and regulatory agencies of the building industry and the cities authorities. -IB needs intelligent city & infrastructure. -Invasion of privacy, IB could be used to monitor and control people -Disruption of the general socio-economic descplin due to unlimited working and learning. -Mental and physical health problems, e.g. individualism, self-unity, laziness. -Family relations are minimizing due to less talking and watching monitors most of time.	- IB should be appropriate to all involved parties. -Needs info media, e.g. optical fibers and wireless network. - Law and order should be enforced. -There must be certain times to sign in, even online. -Moving is good for muscles, and essential for thinking. - Needs awareness of consequences.
Economy	-Initial high cost. -Initial cost and drawbacks cause reluctance by developers and contractors to embrace IB. -Ongoing operational cost isn't truly assessed. -IB projects are showcases, demonstrating specific attractive examples not costs and risks. -Energy consumption is the same as non-IB --- -Ignorance and technology-rejection, cause IB marketing and promotional difficulty. -Over-expectation of building intelligence.	-Technology advancement would decrease cost, e.g. pc. - Same as above. - Long term assessment. - Same as above. -Environmental design. -Awareness and natural development of society - Real evaluation and awareness.

7 Conclusion

The term IB has been used extensively for more than two decades worldwide for promotional reasons regardless how smart is the building. Most of IB doesn't differ much from non-IB, which proves what someone has said "it isn't enough to provide the building with wires to call it intelligent".
IB has achieved some success, but literature review and experience reveals that it has faced numerous problems, and challenges, besides many application drawbacks. So far, there is no consistent method of developing an intelligent building that meets the true needs of the end user, thus most ends up with inappropriateness and unjustified cost. Moreover, there is an IB dilemma of how to ensure that the building in not too smart for the users, who want their building to be user-friendly. The research finds out that majority of IB projects are showcases of specific attractive automation and IT innovation, without clarifying real consequences and risks.
The study has investigated IB problem from the appropriate technology point of view, analyzing IB shortcomings and challenges into the different phases of the application process. It sets up a development frame work for intelligent buildings, in addition to the criteria of appropriate IB.
It could be concluded that hence IB is still experimental, some challenges would be alleviated by technology advancement, e.g. cost, easy usage and maintainability. However IB require appropriating mechanisms to achieve its objectives, while ensuring that we could eventually control the artificial intelligence of the building, not the other way around.

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