Intelligent Buildings as Distributed Information Systems

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Abstract
Intelligent building it is intelligence subsystems connected by information interfaces. In paper is introduction of a concept and structure of distributed "intelligence" in buildings. The structure of the intelligent building is presented as partly integrated and the full integrated. Integrated Functional Systems were showed. Models of this system are key factor for design and optimization new information structure in intelligence buildings.
Keywords: intelligent building, information systems, distributed computing, modelling, building automation.

1 Introduction

First attempts at the integration of electric energy management systems in bulky buildings were made in the seventies (of the previous century). The term "intelligent building" was formed in the USA at the beginning of the eighties. Only by rapid development of computer networks in the nineties was the current structure of the intelligent building generated.

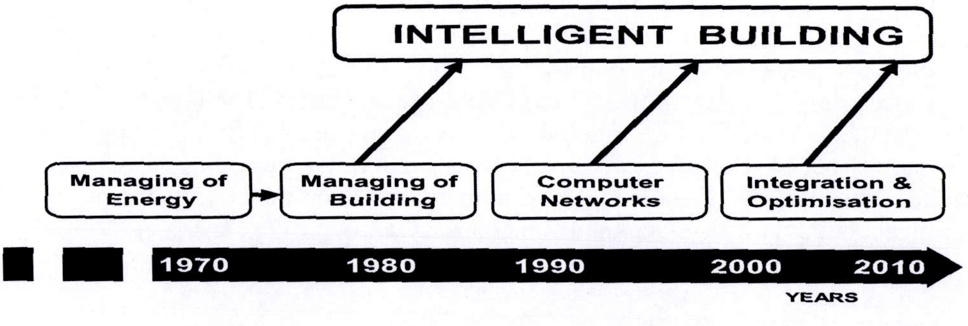

Figure 1: The history of intelligent building.

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There are very many definitions of the intelligent building in literature. Among them there are the following:

- **Intelligent Building** is an object which maximises users' efficiency in managing resources effectively at a minimum cost.
- **Intelligent Building** is an object which can be adapted to a new technology and varying needs of an user organisation.
- **Intelligent Building** is an object where all contributing subsystems create a friendly environment and automatically react to threads and a change in working conditions.

Most of the definitions focus on efficient information management aiming at using the object's functionality to ensure the best building operation conditions. This implies the need for information acquisition, processing and control in order to achieve the assumed effects. The satisfaction of these assumptions involves a specific structure of the intelligent building in terms of technology and information. Contemporary intelligent buildings are based on data transmission via structured computer networks in parallel with distributed data processing.

2 Structure of Intelligent Building

2.1 Traditional Structure of Intelligent Building

The classic structure of the intelligent building involves many independent (autonomous) functional systems. They fall into two non-integrated groups: security systems (systems of the safety) and technical systems and include Anti-fire System, Fire-Sprinkly Systems, Anti-Burglary System, Close Circuit Television (CCTV), Access Control System, Phone and IT Systems, HVAC System (Heating, Ventilation and Air Condition System) , Electrical Systems, Lighting Systems, Sanitary Systems, Radio & Television Systems, Audiovisual Systems, Home Cinema Systems and others. Local systems, also called subsystems, have their own central units (processors) to process information and control. The connections between the systems and building are of specific nature. Measurement, logic and control signals are closely related to a specific application of each of the systems. No building systems are integrated. That means that there is no central recording or visualisation of parameters. No impact on the building resources can be coordinated or optimised. It may happen that signals are transferred directly between two systems for a specific effect. The links between a fire alarm system and lift control or public address systems are a classic example here. If a fire hazard occurs, the lifts can move in a desired way or warning messages can be issued automatically. Figure 1 shows a traditional, non-integrated structure of the intelligent building with autonomous functional systems.

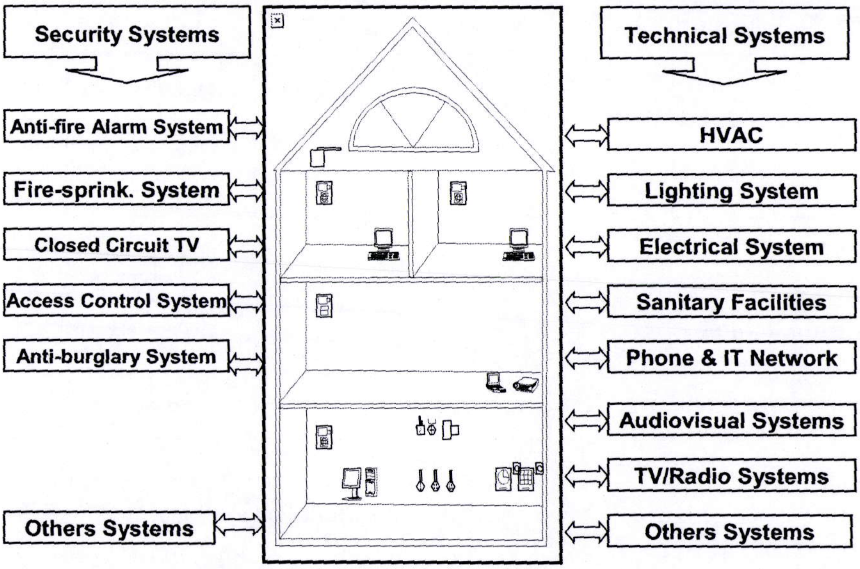

Figure 2: Non-integrated systems in building – traditional structure.

2.2 Intelligent Building Structure with Partly Integrated Systems

The traditional, non-integrated structure of systems in the intelligent building has many functional limitations. The unfeasibility to visualise, communicate, archive and manage events centrally is a basic disadvantage. Individual subsystems form closed circuits, which communicate one with another exceptionally via non-standard connections. The partly integrated structure is frequently taken for adapted buildings with medium-size dimensions. Therefore the subsystems are concentrated by specific functionalities [3]. Each of the systems integrated in that way has its own process station and a bus-based structure. Information is managed at an intermediate level, for selected functional subsystems. The archiving, processing, visualisation and diagnostic processes are also conducted at that level. Thereby the above operations are independent of other integrated systems. Links among process stations occur occasionally and not systemically. On the scale of a building such solutions form a partly integrated structure. In practice, the handling of such a partly integrated structure requires independent monitoring stations, with no mutual redundancy of functions. Three main integrated multifunction systems are sources of information. There are (fig.3): Integrated Security System, Integrated Systems for Managing Energy and Comfort, Integrated Multimedia and Telecommunication Systems. Another configuration of such a partly integrated structure is also possible.

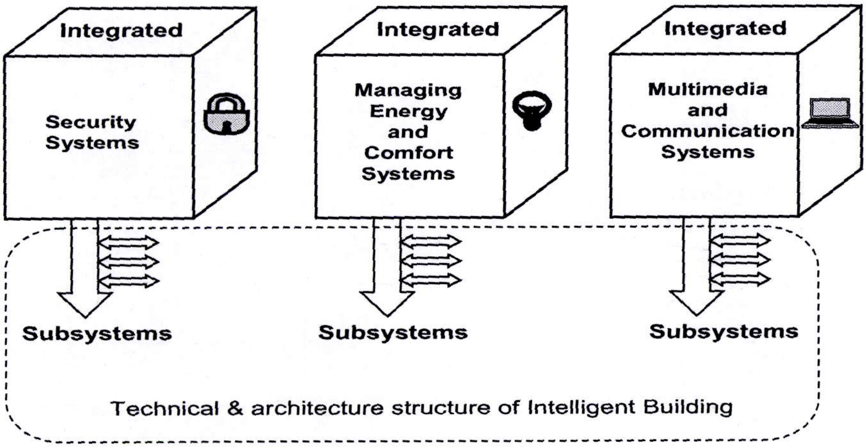

Figure 3: Main integrated multifunction systems.

The Integrated Security Systems (Fig.4) in the intelligent building include: close circuit television systems (CCTV), anti-fire alarm system, extinguishing systems (for example sprinkle system), anti-burglary system, access control system (and sometimes with work time recording systems) and other systems performing similar functions. The integration of safety systems offers more efficient risk management and hazard prevention.

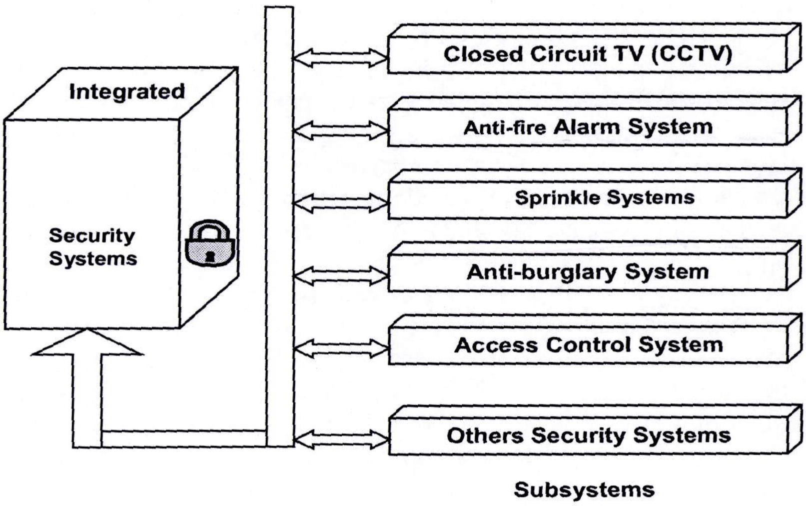

Figure 4: Integrated Functional System - Security Systems.

The Integrated Systems for Managing Energy and Comfort (Fig.5) include: heating systems, air condition and ventilation systems, electrical power systems (distribution and measurement subsystems), lighting systems (for example intelligent control of lighting), meteorological systems and other functional systems of similar nature. The concentration of all information in such a system contributes to effective management of the building's power safety and resources, individualised comfort in every room or building sector, lighting adjusted to the building residents needs and tastes, with energy consumption being dependant on weather conditions, time of the day, week and year.

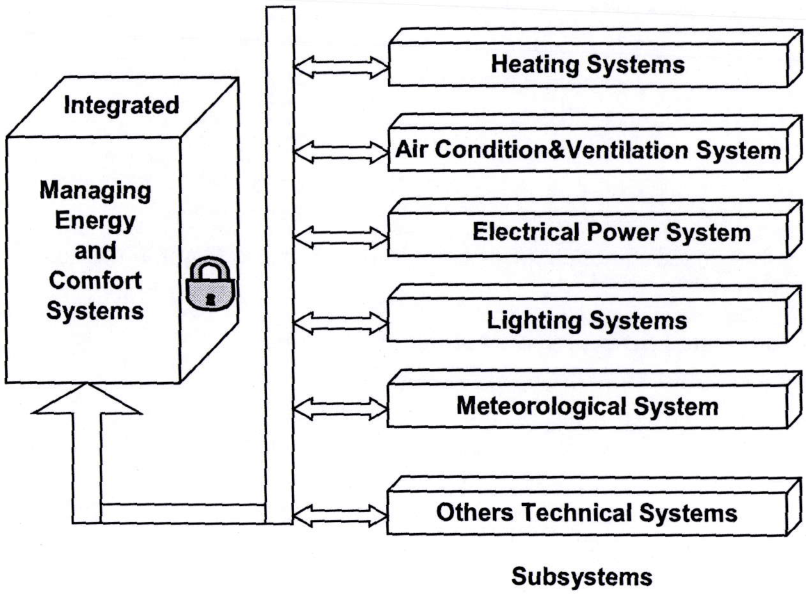

Figure 5: Integrated Functional System – Managing Energy and Comfort Systems.

Figure 6 shows an example of the structure in Integrated Multimedia and Communication Systems of the intelligent building. The Integrated Multimedia and Communication Systems include: computer networks (IT systems), VoIP (Voice over Internet Protocol) and Phone System, audiovisual systems, broadcasting audio system, distribution and interactive television systems, Internet TV, videoconference systems, in-house communication systems (for example intercom systems) and other functionally similar systems. This integrated functional system will develop most dynamically in the future. New technologies for generating, processing and transferring audiovisual information will shape the structure and functionality of the Multimedia and Communication Systems.

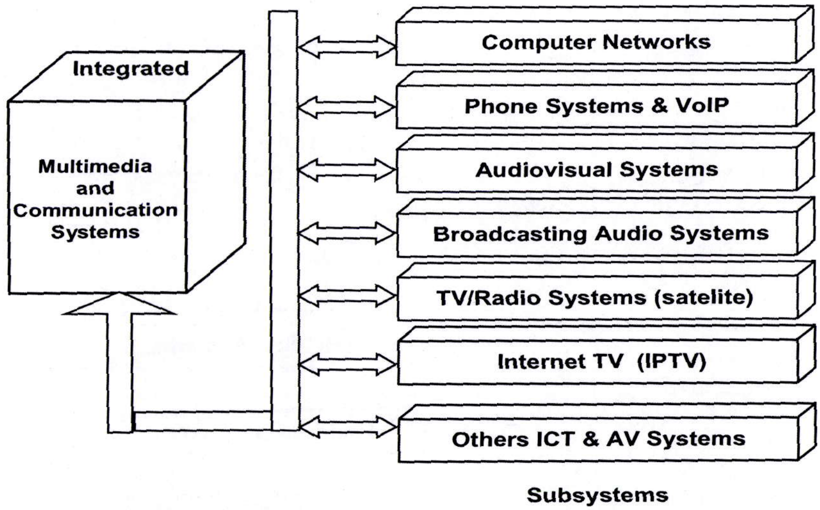

Figure 6: Integrated Functional System – Multimedia and Communication Systems.

2.3 Fully Integrated Structure of Intelligent Building

The above structure of a partly integrated intelligent building features a number of limitations. The limitations are particularly significant in bulky buildings (hotels, office blocks, apartment houses, multifunctional structures, etc.). The most essential limitations include: no information exchange among locally integrated systems, no potential for the implementation of optimisation algorithms, no central visualisation or archiving of data and an impediment to effective redundancy of management systems. In order to use a huge amount of information contained in Integrated Functional Systems, the systems need to be integrated globally. Total integration in the intelligent building is ensured by Integrated Building Management System, IBMS (Fig.8). IBMS is connected by system buses used in building automation and systems integration in the intelligent building [4]. Generally, it is a multilevel information system with distributed intelligence. The structure of processing and transfer of information in intelligent buildings is analogous to that in distributed control systems (Fig.7). Process stations are the equivalents of integrated functional systems in the intelligent building. However the supervisory system of control is the equivalent of the IBMS system. The nature of information transfer and processing in intelligent buildings is manifold. It includes measurements, generation and analysis of digital, analogue, sound and pictorial data (AV). Such a diversity of signals let us define the intelligent building systems as information and communication systems.

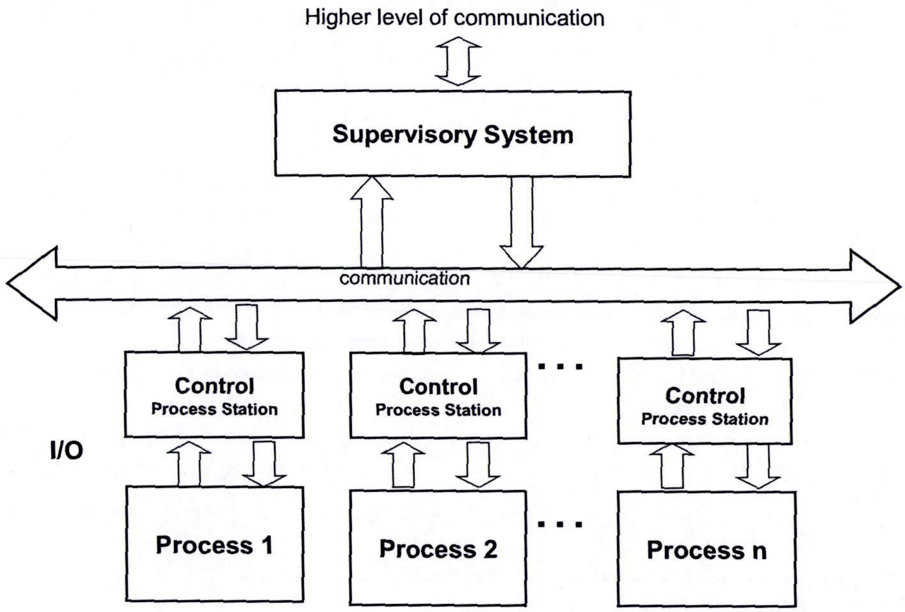

Figure 7: General structure of distributed systems for control and data processing.

Such a distributed and integrated structure of the information management system in instrumentation systems (DCS, Distributed Control System), in particular in intelligent buildings (IBMS), creates a new quality. The merits of a solution of this kind include:

- Central access to all information contained in Integrated Functional Systems or Process Stations and thereby to all data on automated processes,
- A potential for the implementation of optimisation algorithms requiring data from various processes (e.g. energy, risk or cost management),
- Central visualisation, archiving and processing of information of various type,
- Parallel data processing in lower level intelligent systems,
- Increased systems safety due to a distributed structure of the system and independent operation of intelligent subsystems,
- Significant flexibility and scalability of an integrated system,
- Shortened time for, and cost of, system implementation for a given technology or intelligent building due to the possibility of writing software and debugging in parallel.

The global (management) level includes operator stations, both supervisory and process ones [4]. The operator stations are equipped with special HMI graphics interfaces (HMI –Human Machine Interface). The interfaces are used by technical services for exercising overall control over IBMS. This layer's equipment is most frequently integrated via a local computer network and network mechanisms for making the contents of data bases available (e.g. DDE, ODBC, OLE).

Supervisory stations are at the top of the hierarchy and manage all controlled subsystems. An operator of that layer has access to any information on every element of the system and can control it. In case of an alarm or emergency situations, the management level equipment can take control of the entire system through taking over the authorisations of a lower level. The management layer equipment mostly collects, stores and processes data and generates reports which are used afterwards to conduct a long-term analysis to support intelligent building management.

The intelligent building consists of intelligent subsystems connected by information interfaces. The intelligent building is a complex object with distributed intelligence. Functionality and structure of the intelligent building are very important for information analyses purposes. The composition of the systems making the intelligent building is as follows.

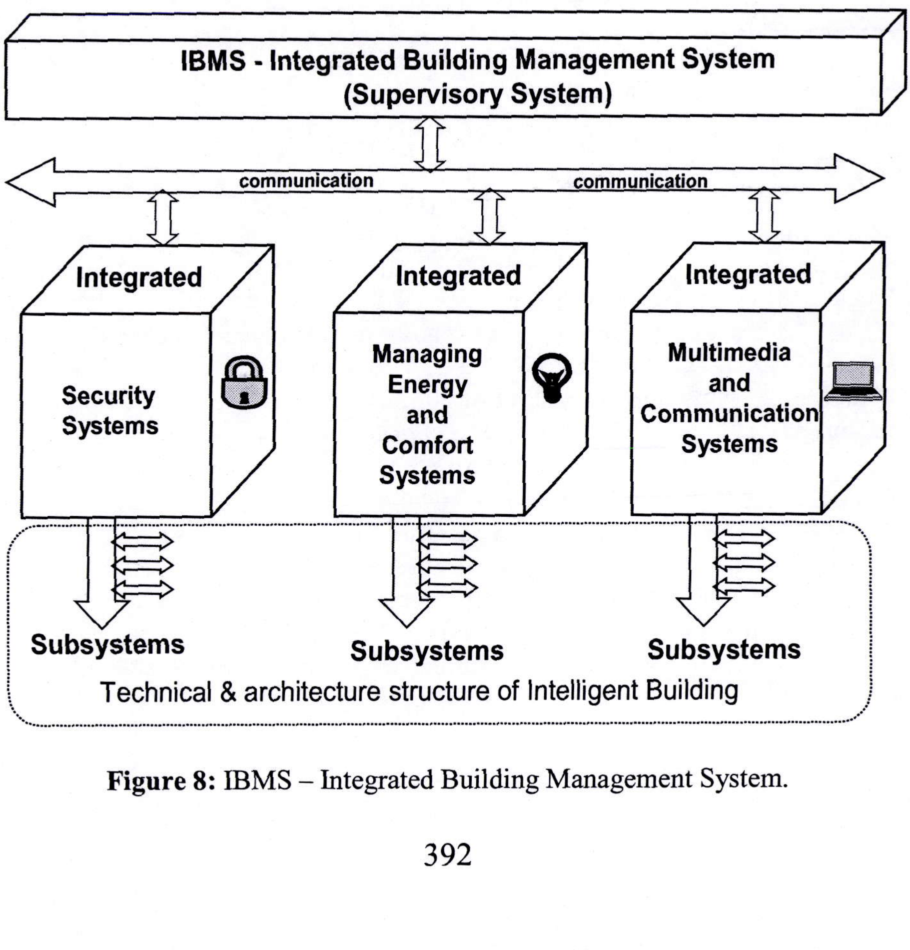

Figure 8: IBMS – Integrated Building Management System.

3 Major Objectives of Distributed Information System

The intelligent building as Distributed Information Systems requires diversified computation algorithms to be followed in parallel [1]. Every subsystem receives different input data and generates output signals for different purposes. This implies a diversity of information processing algorithms and a diversity of technical solutions. It also implies a natural need for information processing locally in local processors. Several information processing algorithms should be implemented in order to benefit globally from the integration of subsystems and from an integrated building management system. They are as follows:

- **Safety algorithm** – basing on data from access control, break-in and burglary, CCTV, fire detection, lighting control and energy management subsystems,
- **Risk management algorithm** for extreme situations – using data from all integrated functional systems and the documents concerning the building architecture,
- **Comfort algorithm** – using data from air conditioning and ventilation, heating, weather, water and sewage, lighting and access control subsystems,
- **IT resource management algorithm** – basing on data from IT, telecommunications and multimedia systems;
- **Energy optimisation algorithm** – using data from all subsystems, including that from weather stations,
- **Adaptations algorithm** for adjusting the building structure and resources to users changing needs – together with on-line analysis of building operation costs,
- **System diagnostics algorithm** – analysing information from all subsystems and taking into account the state of communication lines and supply systems.

The algorithms use data from those systems and data sources that impact directly or indirectly on the ultimate comfort, data transmission and energy cost minimisation. The above list includes only a few out of all algorithms. In practice every building needs to be analysed individually and requires specific data processing algorithms to be developed.

Concentration of all information about an object helps to take the right decisions and analyse complicated and complex situations. With IBMS systems, alphanumerical information can be generated together with visual and acoustic one. This is of particular significance when a hazard occurs in the building. The IBMS system features another very significant quality, namely the potential for resource reconfiguration in such a way that building functions management is adjusted to users' changing needs and requirements. IT system applications are naturally linked with the building's architectural documentation. The history of all archived events helps to analyse the events and use the experts methodology. An analysis of the IBMS structure needs to be conducted in the system design phase for comprehensive and quick data processing. The best results are achieved in distributed computation systems.

4 Conclusion

Models of this system are the key factor for design and optimisation a new information structure in intelligence buildings. A distributed information system in the intelligent building is an effective distributed real-time computing system. It is important to define synergies among architecture, technology and electronics in the intelligent building in the future as a result of the interdisciplinary process of modelling and design.

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