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INTELLIGENT BUILDINGS: buildings as robots

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ABSTRACT: *Those outside the construction industry often wonder how an assembly of inanimate building materials can be intelligent. The rapid evolution of information technology has led to the development of systems that can measure, evaluate and respond to change. An enhanced ability to control change has sparked developments in the way the physical environments are (particularly the buildings) are designed, resulting in significant growth in the area of intelligent buildings. Intelligent buildings can be likened to machines as they bear strong similarities to machines, in that they contain a myriad of mechanical, electrical, electronic, computing and communication devices. This paper examines the development of intelligent buildings as buildings controlled by machines or robots using high technology to optimise user comfort, energy consumption, safety and work efficiency; it discusses the benefits and the future of intelligent buildings with the purpose of advocating their rapid development in Nigeria.*

Keywords: Building, development, Intelligent, Robot, Technology

INTRODUCTION

In the last few years there has been an avid study of artificial intelligence and as suggested by Derek (2004), it is difficult to think of any human intelligence in which a machine will not be able to outperform. Others suggested that machines could one day develop higher intelligent levels and take over the world and hence human beings should be genetically engineered to improve human intelligence greatly to prevent this happening.

So what does intelligence mean? One view, according to Derek (2004), is that intelligence is an innate, general cognitive ability underlying all processes of conventional reasoning. Intelligence is therefore defined not as an attribute but as a complete hierarchy of information processing skills, underlying an adaptive equilibrium between individuals and their environment. This definition can be extended to how people work or live in buildings and interact with their micro-climate, building fabric and the external environment.

It is true that a building in itself cannot be intelligent. In order for a building to be intelligent, it relies on some human involvement to give artificial intelligence. Vic et al (2000) describe intelligent building from the computer science viewpoint as one that utilises computer technology to autonomously govern a building environment so as to control, monitor and optimise user comfort. In intelligent buildings, computers together with artificial intelligence (AI) techniques are used to orchestrate the operation of the building services (e.g. lighting; heating; security (close circuit cameras, CCTV and alarm systems); access control; audio-visual and entertainment systems, Ventilation (filtration and climate control); time and attendance control and reporting) to provide a level of control that is normally associated with human intelligence, such as reasoning, learning or adaptation. Machines such as robots are able to do this through the inclusion of behaviour-based artificial intelligence. There are enough similarities between machines (particularly mobile robots) and buildings to justify such techniques being applied to building control systems to make them behave more intelligently. Both deal with a highly dynamic and unpredictable world. This paper examines the development of intelligent buildings and discusses their benefits and future with the purpose of advocating their rapid development in Nigeria as buildings of the 21st century.

BUILDINGS AS ROBOTS

The word robot according to CBC news (2007) made its debut in 1921 in the play "R.U.R" (Rossum's Universal Robots) by Karel Capek. It comes from the word "robota", a Czech term for forced labour. Since then, fictional robots have been portrayed as machines (www.cbc.ca/news/robotics).

The definitions are many in literature, some are as follows. The Oxford dictionary (2001) defines a robot as

(i). One of the mechanical men and women in Capek's play; hence a machine (sometimes resembling a human being in appearance) designed to function in place of a living agent, especially one which carries out a variety of tasks automatically or with a minimum of external impulse.

(ii). A person whose work or activities are entirely mechanical; automation.

Robot is also defined by international organisation for standardisation (ISO) under ISO 83 73 as an automatically controlled, reprogrammable multipurpose manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation application" (www.cbc.ca/news/robotics, 2007).

Robots have had applications in many fields including Agriculture, Medicine, Engineering and Architecture. The application of robot techniques to control environmental variables such as heat, light and other services has given rise to what is known today as intelligent buildings. Intelligent buildings rely on the installation of electrical-mechanical devices together with artificial intelligence to perform complete automation functions. Le Corbusier's famous remark that "a building is machine for living" can be likened to intelligent buildings today. Building automation systems have been developed in all the building types (Residential, Public/Commercial and industrial buildings).

HISTORICAL BACKGROUND

The origin of intelligent buildings has root in the industrial sector in the 1970s, from the systems and controls used to automate production processes and to optimise plant performance. The concepts and applications were then adapted, developed and modularised during the 1980s, enabling transferability of the technology and systems to the residential and commercial sectors (Albert & Wai 1990).

Intelligent buildings were first advocated by UTBS (United technology Building System) Corporation in United States of America (U.S.A.) in 1981 and became a reality in 1983 with the inauguration of the city place building in Hartford, Connecticut, USA. The UTBS Corporation was responsible for controlling and originating such shared equipment as air-conditioning equipment, elevators, and disaster prevention devices. The company further provided each tenant with communication and shared tenant services such as office automation services, using local area networks (LAN), digital private automatic branch exchange (PABX) and computer. The Hartford building was advertised as the world's first intelligent building (Albert & Wai 1990).

DEFINITIONS IN SELECTED COUNTRIES OF THE WORLD

The expression "Intelligent building" has not been given a universally accepted definition for the past 25 years. However most designers appear to agree with the statement "Intelligent buildings" are not intelligent but they can make the occupants more intelligent. Various definitions are given by many countries. Here, this paper has considered some of them.

(a) Definition in USA

In accordance with the intelligent building institute (IBI) U.S.A., Intelligent building is defined as one which provides a productive and cost-effective environment through optimisation of its four basic elements i.e. building structure, building systems, building services

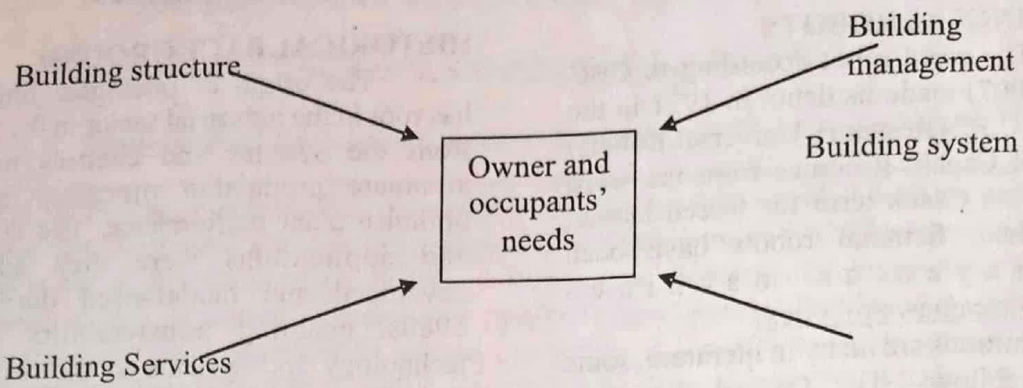

Fig. 1 Basic elements of intelligent buildings

- Building structures include:- space, slab to slab, ceiling, heights, raised floor and drop ceiling, windows, roof and floor loading, access to utilities (electrical and telephone fixtures), finishes and furnishes, fire proofing materials, curtain-wall, conduits etc.
- Building system includes:- Heating, ventilation and air conditioning, lighting, electrical power, Telecommunication, information management, wiring, controls, elevators, domestic hot water, access control, life safety etc.
- Building services includes:- Office automation, voice, data and video communication, shared office meeting and computer room facilities, fax and photocopying, telephone and computer equipment, electronic mail and voicemail, security management, parking and other transportation, cleaning and maintenance, building directory, training.

(b) *Definition in Europe*

The UK based European intelligent building group (IBG) defined an intelligent building as one that creates an environment which maximizes the effectiveness of building's occupants while at the same time enabling efficient management of resources with minimum life-time costs of hardware and facilities.

Based on this definition, building providers and developers need to understand precisely what sort of buildings they should develop that will be both profitable and able to meet users increasing complex requirements.

(c) *Definition in China*

In Shanghai, the developers will rate an intelligent building as "3A" or "5A". 3A means building contains three automatic functions, namely, communication automation (CA), office automation (OA) and building management automation (BA). Some intelligent buildings will divide the fire alarm function from BA, such that it becomes an independent fire automation system (FA), while some intelligent buildings will have a comprehensive maintenance automation system (MA) to integrate the various automation systems within the building. Such buildings are rated 5A (Andrew et al, 1998).

BUILDING DESIGN

The ultimate dream in the design of an intelligent building has always been to integrate the four main operating areas namely; building structure, building services, building systems and building management to the satisfaction of the occupants and building owners in terms of cost, comfort, convenience, safety, long-

term flexibility and marketability (Albert & Wai 1990).

(a) Buildings Structure:

Intelligent building infrastructure can be installed in existing buildings thereby transforming them to intelligent buildings through the installation of single structured cabling network. A fresh design of intelligent building, however, demands intelligence applied at the conception, construction, and operation stages of project by clients design consultants, contractors and manufacturers for optimum results (Derek, 2004)

(b) Building Systems

The building systems in intelligent buildings include; heating, ventilation, lighting, electrical power, telecommunication, information management, elevators, access control, life safety. They are designed to function through automated control system. For example, in the case of a fire, the fire alarm communicates with the security system to unlock the doors. The security system communicates with the HVAC (Heating, Ventilation and air conditioning) system to regulate the flow of air to prevent the fire from spreading (Albert & Wai 1990).

(c) Building Services

Intelligent buildings are designed to offer services which include; Office automation, voice, data and video communication, telephone and computer equipment, parking and other transportation spaces, cleaning and maintenance. Which are designed and controlled by two main methods:-

- Time based:- providing heating or lighting services etc. only when required and
- Optimiser parameter based: - often utilising a representative aspect of the service, such as temperature for space heating or illuminance for lighting.

BENEFITS TO OWNERS AND OCCUPANTS

Greater Control over Work Environment:

The major benefit of rapid evolution of information technology has been the development of systems that can measure, evaluate and respond to change. This in turn has influenced development in the way our physical environment is designed, in particularly the buildings. Workplace automation is achieved at a reduced cost for tenants by virtue of shared equipment. Some factors involved in workplace automation includes:-

- Centralized data processing
- Word processing
- Computer aided design and
- Information services.

Cost Savings:

The intelligent building recognises that the true cost of building is not simply its cost of construction, it must include operating and maintenance costs over the structure's life span. Intelligent buildings yield cost reductions (through sharing of equipments by many users) in all of these areas by optimising automated control, communication and management systems. They also guard against repair costs, employee time/productivity loss, and revenue loss.

Energy Savings:

With the dramatic increase and awareness of energy use concerns, and the advances in cost-effective technologies, energy efficiency is fast becoming part of real estate management, facilities management and operations strategy. For lighting, energy savings can be up to 75% of the original circuit load, which represents 5% of the total energy consumption of the residential and commercial sectors. Energy savings potential from water heating, cooling or hot water production can be up to 10%, which represents up to 7% of the total energy consumption of residential and commercial sectors (Derek, 2004).

Environmental and Green House Gas Benefits:

Green house gas emission reductions depend on and correlate to reductions in energy use. Intelligent buildings contribute to a reduction in energy use, in commercial, industrial, institutional and residential sectors.

FUTURE OF INTELLIGENT BUILDINGS

Changes in the society and technology are shaping our future. Demographic changes, changes in population, size and life expectancy, globalisation and communication are some of the major changes and opportunities facing the world thereby making the future of intelligent buildings an exciting one. As suggested by Derek (2004), it is important in designing new intelligent buildings or refurbishing old ones which will be functioning in the 21st century to appreciate or accommodate all the issues below:-

- Artificial intelligence and virtual reality technologies will allow problems to be solved well in advance of today's capacity,
- By 2015 the world will be predominantly urban with over half of the world's population living in cities. The number of the people living in cities of over 10 million will increase to over twice this number.
- The application of developing technologies in order to deal with existing problems can help to improve the quality of life and productivity of a country.
- Wire-free networks are increasingly common.
- Source consumption has grown and this is indicated by growths in energy consumption in the transport and building sectors, increased emission of carbon dioxide and increases in solid waste.
- There is a growing demand for more sophisticated products with emphasis on the user.
- Storage capacity and network connectivity are expected to grow at even faster rates and this will be evident by the increasing number of domestic users on the internet.

All the above issues of population growth which affect urban centers; energy consumption in buildings which calls for greater energy saving; wireless and network connectivity are ever increasing and the demand for the application of new technologies will serve as potentials drivers for the rapid development of intelligent buildings all over the world.

ADVOCATING INTELLIGENT BUILDINGS DEVELOPMENT IN NIGERIA

This paper has particularly advocated bringing about profound changes to the country's urban landscape. There are several factors that will shape these changes such as:-

1. **Rapid Urbanisation:** The population of cities in Nigeria is growing rapidly, partly due to rural-urban migration. There are many cities in Nigeria with population over 5 million (e.g. Lagos, Kano, Onitsha) and space is becoming a major constraint. Consequently, there is ever-increasing demand for effective urban planning and better ways of managing the limited resources. This calls for the adoption of intelligent buildings.
2. **Deregulation:** Deregulation is sweeping across the country especially under the Obasanjo's administration. It is seen as a means of bringing about greater efficiencies and competitiveness within the economy. Among the areas that have been or are still been transformed are telecommunications and energy services. The transformation of energy services is particularly

important and the government should also explore the areas of solar energy services. This will encourage developers both within and outside the country to develop and operate intelligent buildings at low cost.

3. **Catching up with the Rest of the World: -** The world technology is ever dynamic and for Nigeria of the 21st century not to be left behind, must seek to become increasingly technology driven. This means leap-frogging of technologies to the next generation technologies. The public/private sector co-operation will serve as a impetus to this drive.

CONCLUSION

The idea of shaping the Nigerian cities with intelligent buildings is linked to a broader dream of intelligent cities. In this regard, intelligent buildings are not just stand-alone entities, but interconnected hubs within the citywide infrastructure. The natural consequence of this is the development of cities within cities with smaller ecosystems comprising a tightly integrated network of buildings that better enable the management and optimisation of systems and resources. This will give rise to an entirely different set of drivers that make intelligent buildings an economic and business necessity. Perhaps the most important business driver is the ability to reduce cost, optimise manpower utilization and improve service level through aggregation, service integration and process automation.

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