Evolution of Digital Edifices: from Shanks and Adobe to Smart and Intelligent Edifice; a Trail to the Future

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***Abstract*– Edifice today is characterized by a lot of physical and digital development ranging from simple door bell to access code, burglar alarm, robotic assistance etc. Burdening on these; this paper examined the evolution of digital edifices (herein used synonymously as houses) starting from its very origins- shanks and adobe-, why they are called smart, the architecture built into them to make them intelligent and smart and the effect of being smart with an attempt to predict what the future holds for smart and intelligent edifices. Along the line of research and analysis, it was discovered that the body scanning machine could do more in keeping the body log of subject or visitors to an area which could subsequently help in weight monitoring. We also proposed and designed a hybrid or combination biometrics for a better access control, footwear (shoes), mattresses and subject body recognition, auto-swing walls and concluded on the future technological considerations in this paradigm.**

***Keywords*– Smart Homes, Edifices, Biometric, Footwear and Auto-Switch Wall**

I. INTRODUCTION

Right from time immemorial, house, abode, dwellings (generally referred to as edifices in this work) have been an integral part of human lives and existence; providing shelter against the scotching sun, most turbulent rain and other extreme weather conditions.

Down millions of years, humans have developed in their natural instinct to always return to a certain abode after the day's work. These abode could either be a cave, a real house, tree tabernacle, tree holes or branches etc. For those who believe in the existence of the supreme being – God or in the metaphysical, the housing concept is so important to the extent that He (the supreme one) deemed it fit to create one (inform of a Garden) for the first person (Adam who is believed to be the first man in the universe) even before he – the would be occupant (or resident) himself was created [24].

Whether he was created by the supreme and sovereign being, or evolved from other lives according to theory of evolution detailed in [14], man has in his intellectual capacity and as a dynamic mind try to redesign and modify the initial home he was given; moving from the initial trees and shanks to develop the tree tabernacle, and then to building blocks using Mud and modern cement and later aluminum and glasses, to intelligent edifices. All these he did in order to make his abode more accessible to him, make his live more secured and comfortable. In what follows, the trends leading to the present digital and smart edifice of man is analyzed.

A) Trends in Human Abode

The first age as stated earlier, biblically, the initial man created lived amongst other creature in the woods (in the garden provided by the supreme and holy one) until they sinned and were ejected from the garden [24]**.**

Scientifically, [11] illustrated same year by Chris Buzelli, emphasized that the early man, believed to have evolved as hominids did not actually live in a cave. Although the cave idea which was cultivated by the 18th-century scientist Carolus Linnaeus may fits well with some historical perspective of human evolution, particularly, the ones which describes a stable development of the primitive human to the now complex ones [21].

If we reason along this line, these theories follow a particular pattern like: Humans first descended from the woods or trees, then stumbled about and found the land, made their homes in holes of rock or caves, and later found beauty and solace in mighty edifices.

The mid-age events as chronicle in [21**]** on: "In Search of the First Human Home" believed that early hominids must have sought for cover under densely packed leaves same way as apes do today when it rains. According to the interview granted by Professor Emeriti Margaret Conkey same year, archeological evidences shows that the early human did not stay at a location, they were moving from one place to another leaving evidences such as stone slabs, colored pigments, flint etc.

About 400,000 years ago, a *Homo heidelbergensis* species also called hunter-gatherers, constructed a camp on a beach at Terra Amata, a suburb of the present day French city of Nice. The camp was oval in shape, about 30 feet long and made of stones and hearth to provide camp fire [21]. Then, there was the ice age; the years that followed see man moving from the trees, shanks and oval shelters to adobe (mud) made houses. According to [15], Indigenous forms of earthen shelter and materials have developed on every continent. These events are what constitute the mid- age.

The present days of edifices is characterized with many features. These features include amongst others biometrics,

access codes, CCTV cameras, auto switch power systems and so on. Some of these modern technologies are looked into under existing work segment of this paper.

B) Main Objectives of this Work

The main objectives of this work are:

i). To identify the existing intelligence built in present edifices which made them smart.

ii). To come up with alternative designs such as hybrid or combination biometric access control; footwear and mattress – body recognition for future edifice.

iii). To predict the future and level of smartness in tomorrow's edifices.

II. REVIEW OF EXISTING WORKS

The area of smart home or edifice construction has attracted great interest in recent times. To an extent, we believe it is because of man's technological inquisitiveness or largely because edifices or houses has a direct impact on us and our overall output at the end of the day [7]. In this section, we try to analyse some earlier works done in this area vis-à-vis security, the robotic angle and access control of modern digital edifices. However before proceeding, it is considered very imperative to formally define an intelligent or smart edifice.

An intelligent edifice or smart home is that with incorporated communication network connecting all major services, including the electrical and also allows remote accessibility and monitoring [12]. In a similar view by [23], an intelligent home is seen as an automated home with enhanced security services, which gives end-users total control and administration of all the smart devices (such as lighting, entertainment, power) installed in and around the home, and provides means of monitoring them. Till date several designs and technologies have evolved for making houses smart and intelligent.

[18] on "Applications, Systems and Methods in Smart Home Technology: A Review" provided an outline of some smart edifices products and their basic functionalities. These products include: CCTV cameras, motion sensor, finger prints scanner for door handles, audio for entertainment, remote access controls, and channel modulators which distributes received video signals all around the house and aided the security features. Their work was able to propose a positioning method for applications in smart homes by pre-installing some devices called beacons in choice areas of the house. Christensen's work on "intelligent home appliances" also indentified three categories of task domain for domestic application of smart home appliances. The task domains are in home entertainment, daily tasks and serving as assistant to the less privilege and the elderly. The work stressed that recently quite a number of robot systems have been designed and currently being purchased and used domestically. Examples are: Sony AIBO with security embedded security camera in the nostril, the Dyson – DC06 vacuum cleaner, Sony SDR-3X, NEC M100. These robots have been used autonomously mostly in the area of entertainments and cleaning of the house; thereby making the house intelligent and smarter.

Again in [2], an intelligent home design based on mobile phone vis-à-vis "password protected SMS services" was implemented. This work depicts how a typical user can make use of SMS in monitoring and controlling some basic utilities such as light, home equipment; security gadgets etc and subsequently, user receive report as regards the status of the different gadgets via the same mobile phone. They carried out two major experiments to activate and deactivate installed smart applications; one with users using same telephone network and the other using different telephone networks. The result showed that responses were received between 20-22 seconds after. What we discovered here is that the initial consideration of a design like this may seem to solve some basic administration and security issues. However, the work seems not have considered a situation where there is an unplanned circumstance. For example network congestion; such that the feedback SMS is delayed at critical times when it is needed urgently or a case when the phone is out of service area.

In their work, [17] came up with a body scanning machine aimed at making edifices – homes, hospitals, airport safe. However, this machine is primarily for the security of an environment in which it is installed. It scans to check if any object is concealed in the body of the subject or in any object being carried into the vicinity. Research of [3] on "smart home intelligence – The eHome that Learns" try to depict four modules architecture for a smart home.

These modules as explain by the author are:

1. The Central Management Unit (CMU)
2. User Interface (UI)
3. Home Equipment and Appliances Interface (HEAI)
4. External Communication Interface (ECI)

Diagrammatically, these four modules can be represented as shown in Fig. 2:

Based on this analysis and other works that exist in theory, attempts have been made by some authors to shed light on what is to be expected in the future. In [13], several gadgets such as the Roomba 980 with connected Wi-Fi which helps in house cleaning, Sense aids better sleep and so on can be designed in the home to create a home of the future. However, we observed that most of these automations are limited in operation and may be constraint by some other circumstances like power and level of intelligence. For example, the Roomba 980, may not be able to clean in a disorganized room except programmed to arrange before cleaning and this may seems a little complex in terms of decision making. From [6] prediction, future homes will be able to recognize us by our mere heart beat. While describing this technology under wearable technology devices, foreman states that the home will be able to identify owners (or authorized persons) and gadgets come alive as owner walk through the house by simply authenticating owner's identity by pairing a customized device designed as wrist bands to the heart beat. A limitation of this is that there are no apps yet which provide real time feedbacks to end users so end users are yet to see the need to adopt its usage.

If [13] on five home gadgets needed to create a future home and that of [6] predicting that future edifices and homes would be able to identify us by our mere heart beats and other

works in this area of study are anything to go by, then one may be tempted to believe that all the future holds for smart edifies have been explored; but we say there are more to it. In the next section we try to come up with propositions of some of the future expectations of smart edifices in two major categories –the security and Services /Learning.

III. METHODOLOGY

To accomplish the set objectives (stated above) and the various contribution, first an analysis of existing major works and designs in this paradigm was conducted resulting into identification of some gaps which then serves as a base for the biometric alternative design presented as a contribution to an existing architecture in the later part of the work.

Again, notable propositions were made in the area of security by designing footwear (enhanced with GPS devices plus an IC and sensor panel) which also synchronizes with an equally smart door area (foot mat).

Sources of materials used in establishing points include Journals, proceedings of conferences, magazines, newspaper and books (including e-books).

IV. FUTURE EDIFICE

The thought of what comes next for edifices is quite an intriguing one. Actually, we believe the future is now. However, just before showcasing what more to expect for "e-edifices", it is paramount to state (based on deductions from the existing literatures and design analyzed earlier) what really should be the essential constituents of an Intelligent or smart edifice.

To be smart or intelligent, an edifice needs to be designed in such a way to have (but may not be limited to) the following basic components.

1. A device or component that helps in managing other components and gadgets in the edifice /house inclusive of the auto synchronized autonomous robotic systems.
2. Connectivity or links between the house and different components embedded in the house, also amongst the component. Such links could be physical links e.g., cables or wireless device (routers, switch etc).
3. An Intelligent system or software which enables easy and quick accessibility, automate the different gadget at home and through which the user could manage and perform administrative function remotely.

Hence, having this at the back of our minds, one can then begin to figure out based on today's technology, what the future holds for human edifices. As states earlier, it is safe to begin by stating that the future is already here; for whatever we can create now is simply what we will build on. Probably a major development in the future edifice are a combination of robotic guards and help, voice activated security, finger print, retina scan and a host of other biometric functions. Deductions from both [18] *and* [2] revealed that till date, each of the technology mentioned have been used in different capacity to either ensure the security of a device, an area or as a guide and help in a smart home. However, as would be seen later, a combination or an enhancement of two or more would suite well as a single technology for a future edifice.

Propositions for the Future Edifice

The future of edifices is proposed to have amongst others the following:

A) Hybrid or Combination Checks

As an alternative method to the work of [2] where SMS was the basic technology for controlling and monitoring of smart home gadgets, we propose a hybrid technology where a combination of two or more biometric authentication methods is used. This is because the house owner, janitor of an edifice or any authorized user could lose the attached telephone line through theft or misplacement, even the network may not be available at the critical point when access needs to be granted, and then the alternate methods would come handy.

Irish Council for Bioethics – [2] defined "biometric as any physical or physiological feature or behavioral attributes that can be measured and (or) used to identify an individual or to validate the identity being claimed by an individual". As established by [2] and [19], biometric encompass many parts. We have the Iris and retina, fingerprints, voice, the facial and vein pattern recognition. Each of these biometric entities has been discovered to have unique identifiers that can be used for authentication. Although based on the argument of [1] while doing this, it must be taken into cognizant that the data is being kept in a database, hence ethical issues must be complied with in order to draw line between security and invasions of privacy.

As represented in Fig. 3 below, both finger print and the retina scans are acquired at the same time. Initial check is performed to establish if or not the subject whose biometrics has just been received is human or animal, or possibly it is a print from a dead owner or scan from a paper. After this, the acquired retina scan and print are checked against the ones already stored in the database before both biometrics are matched together. However, some conditions may arise where the system will not accept subject's input. For example, if subject is affected by an eye infection or the finger are covered in layers of dirty substances such that the full retina configuration or finger prints could not be obtained as stored in the database. In such cases, the administrator may have to be consulted for a security override.

B) Footwear and Capet Synchronization

Recent development in the footwear industry has shown that footwear are "promising tools" and an integral consideration in making edifices very smart in the nearest future. Shoes or footwear have been very useful in helping the blind perceive nearby objects [22]**.** Also in [1] Alzheimer's patients have been tracked using their specially designed shoes enhanced with GPS. Based on these, future footwear could be designed with integrated circuit (IC) and sensors that are recognized by an equally "intelligent door mart" and the sensitive floor of edifices such that: an alarm sounds when an unknown or guest steps on the mart. Basically, as depicted in Fig. 4 below, it involves:

i). Equipping shoes of regular occupants of the house with GPS device and sensor plus IC panel as shown in the diagram.

ii). Footwear details (size, pattern etc), IC and sensor configuration is logged in database of the system.

iii). ICs in conjunction with the sensors are programmed to detect and synchronized with the sensor of the door mat and door area. When a subject approach the door, if it is a regular occupant, the shoe then try to establish a match as they step on the outer floor or the entrance foot mat. If match cannot be established, the alarm sounds, alerting the arrival of an unknown subject. However, if there is a match, no sound is generated and access is granted.

Like every system, a limitation to this is that the door area has to be made of material which can accommodate and allow the functionality of IC and sensors. Also a major disadvantage is that a legal occupant's shoe may be forcefully obtained and used to gain entry (since there are no ways of testing for living cells like that of biometric explained earlier). A major advantage here is that it helps to keep track of visitors.

C) Full Image and Body Log

Up until now, we have the normal body scan machine such as the one presented in Rapiscan Secure 1000 [17]. Common application areas of these machines are in the airport, hotels and the hospitals security points. The future edifice may likely have image log; capturing not just things concealed in and around the body, but also detailing other things like: frequency of visit to the house, a log of body weight and other statistics. Data from this machine could also help in weight management as previous statistics or reports on the last visit of guest are chronicled and can be compared to a most recent visit if requested or desired.

D) Mattress and subject's Body Recognition

The skin is the largest organ of the body which represents 8% of the total adult's body weight and covering almost the entire body (approximately 16,000cm^2) from head to toe [10]**.** Hence, no matter how little, the bare skin (such as face, hand etc) still touches the mattress when subjects lie on it. Therefore, the mattress's role in the future home can be elevated from just a sleeping platform to a major tool.

Just as mattresses are layered with electric materials to make warm during winter [20]**;** mattresses can be layered with sensors, which enables it to accept input inform of electrons (or heat) and using the advantage offered by machine learning's ability to classify data through nearest neighbors, decision tree or perceptions [5]**,** the mattress can immediately recognize whoever lay on it as soon as possible and can learn certain behavioral activities of the subject. These in turn helps in registering the sleeping habits of occupants such as snoring, number of hours spent in bed, number of actual sleep period and sex life during bed / sleep section and even prescribe when next sleep is due.

E) IC Enabled, Auto-switch Wall

Irrespective of how smart the present house or edifice is, they are still characterized majorly by rigid walls. Here we propose a 3D auto switch and IC enabled walls. For instance, as shown in Fig. 6 below, in a typical manufacturing area, during inspection the utility manager may want to physically visit or see the energy section and hence has to walk through the work area before getting there. But supposing the work area could be collapsed (when there are no operation going on) or rotated and switched at an angle (say 45^0 degree) by a click or switch; such that only the needed section is made closer to the administrative/executive area without any noticeable impact on the operation being carried out; thereby making the whole structure a robot itself. Although this area to be visited could still be viewed with camera, as different types exist today through which a user could viewed both locally and remotely any activity going on in the areas in which they are installed [8]. Yet once in a while or at intervals (during periodic visits) physical supervision may be needed and so the auto –switch and IC enabled facility comes handy.

F) Further Discussion and Implementation of Ideas

Aside the ideas and designs presented above, a lot could still be considered as the future of edifices or houses as we try to make them intelligent and smarter. For instance, one of our most abstract and thought provoking imagination for future edifices is: if or not edifice (or house) can be designed to operate like submarines with very rugged architecture; having a combination of panels, sensor and IC which behaves like fins and enables it to float or go under water should there be flood? Again, can they move on wheels or fly like aircraft? We believe once it is imaginable, then it can be created!

A salient point to note is that most of the ideas and designed in this work are not fully implemented yet. Hence, it is believed that during implementation, the various designs may be limited in certain areas such as sustainability vis-à-vis frequent changes of end users requirement. Also, full implementation of designs and ideas raised here requires moderate cost, as well as regular supply of power or electric which could pose a major challenge in developing countries (such as African nations including part of Asia). However, where it is possible and affordable, options of inverter, solar source/energy, generating set (or plant) could be used as alternate power sources to ensure proper implementation.

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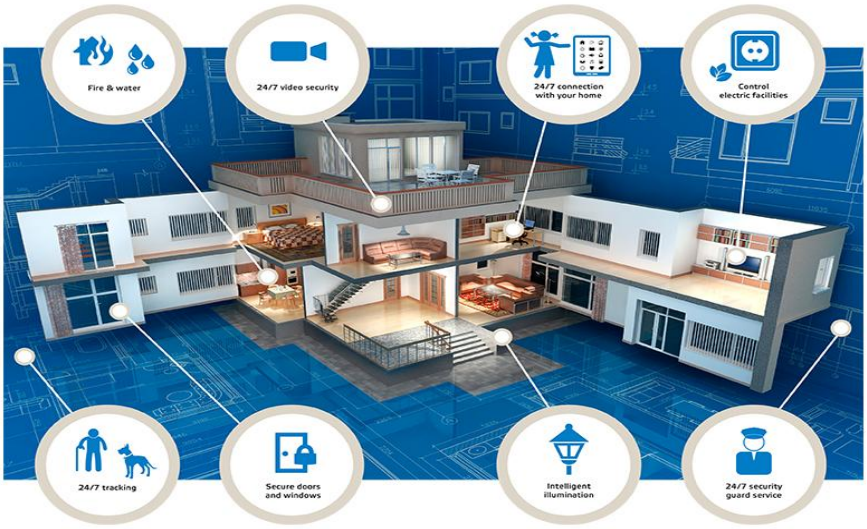

Fig. 1. An example of an intelligent/smart home (source: /picture credit Teleste.com [23])

Fig. 2. The smart home model architecture (source: [3])

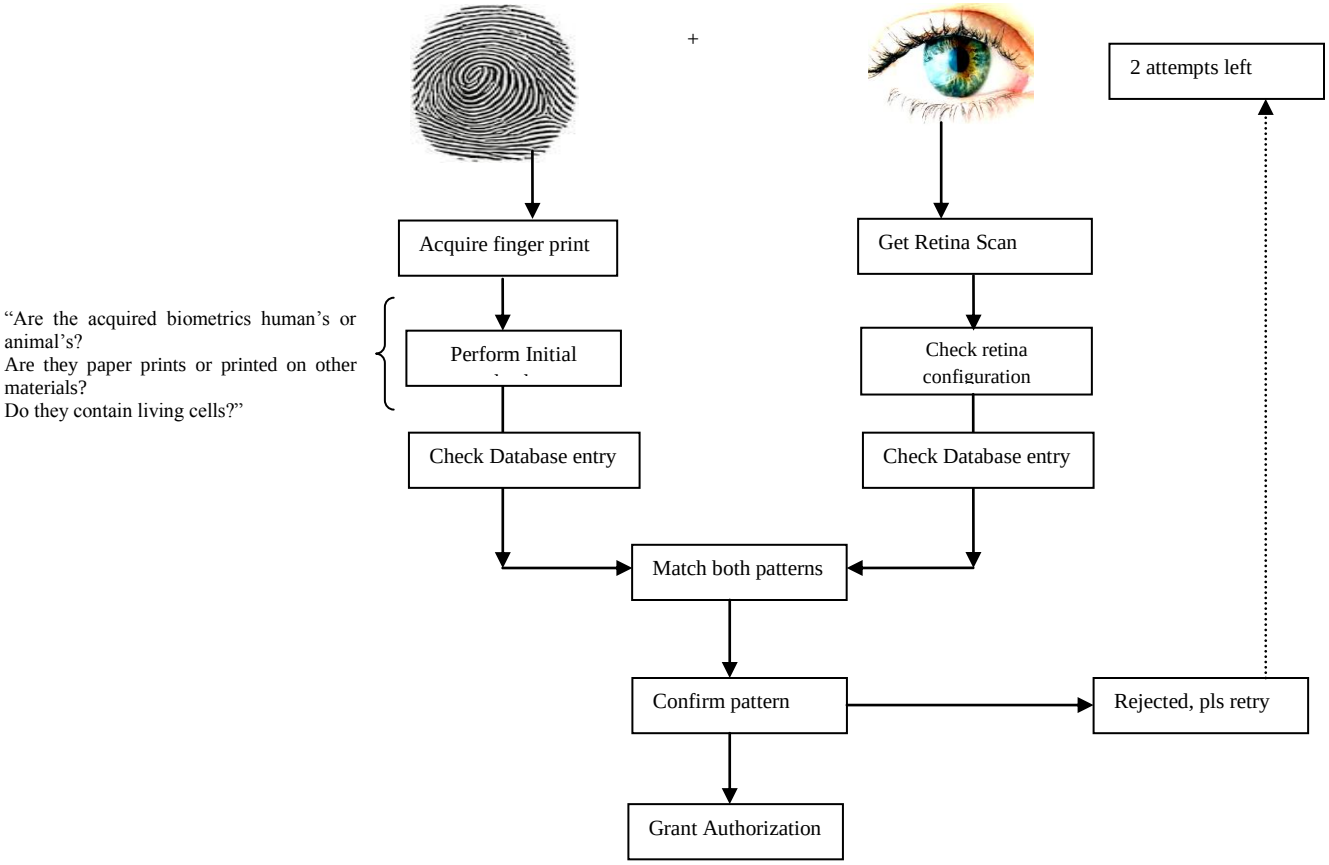

Fig. 3. Showing the process involved in a simple hybrid biometric

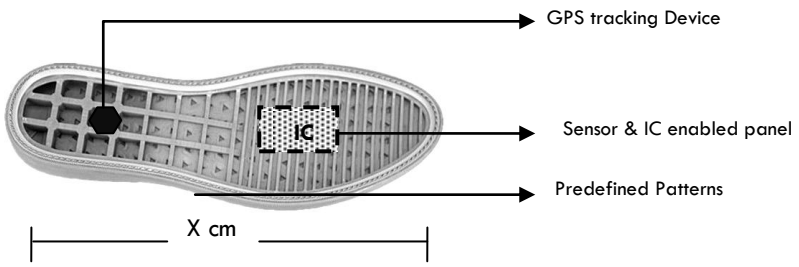

Fig. 4. Showing footwear with embedded GPS tracking device, sensor and IC panel

Fig. 5. Showing mattress layered with sensors and possible interaction with subject's skin

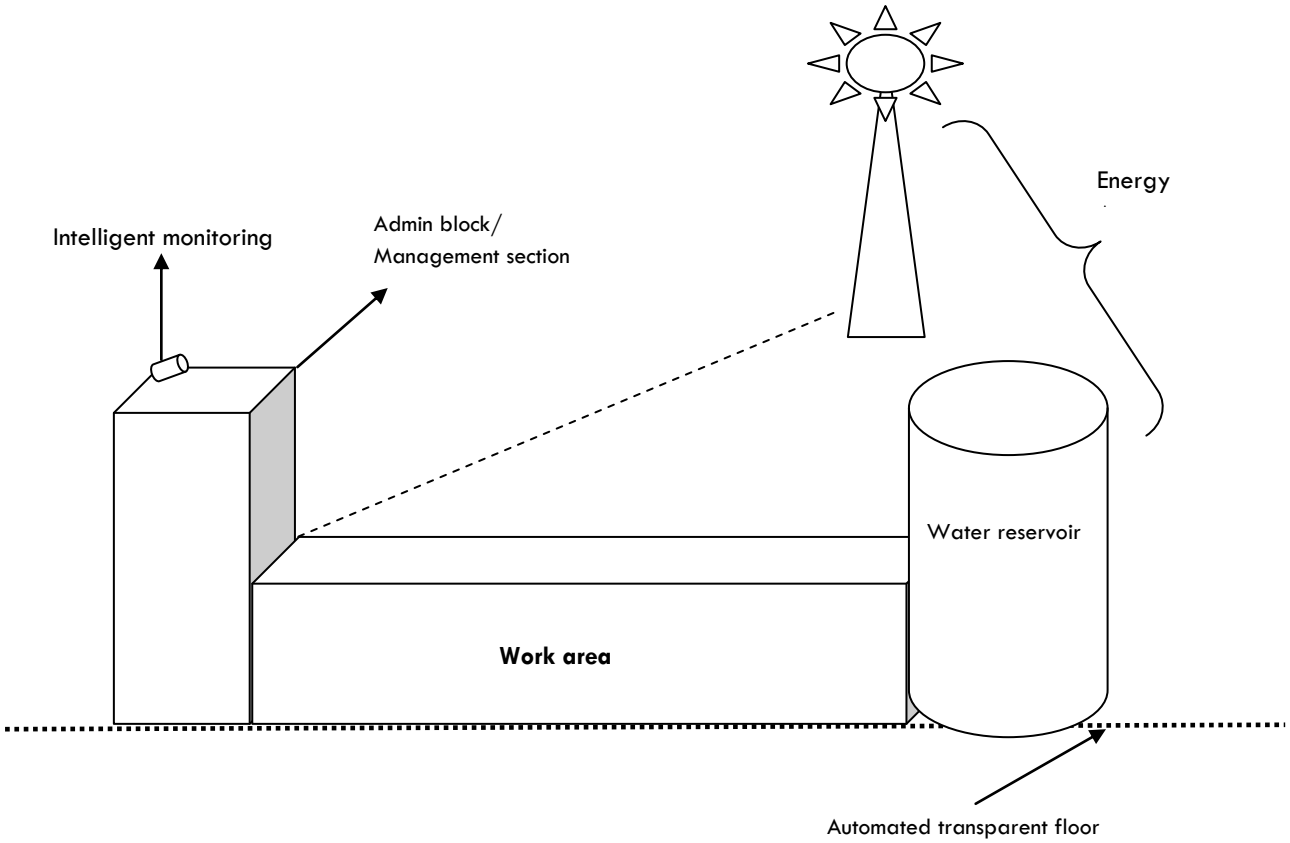

Fig. 6. Depicting a block diagram of a typical factory management