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Smart construction companies using internet of things technologies

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ABSTRACT

The digital world is enriched due to the increase in the number of things which are rapidly connecting to the Internet. The Internet of Things (IoT) facilitates and improves the work efficiency and human life in various fields. IoT was adopted extensively to male buildings more effective and extra smart. For example, buildings are consuming a considerable energy amount. In buildings, there is a critical requirement for energy efficiency, whereas one of the smart building's aims is monitoring, reducing and managing the energy consumption of buildings without compromising the operational efficiency and the comfort of occupants. The systems of Heating, Ventilation and Air Conditioning (HVAC) are contributing to considerable consumption of energy in buildings. Also, plug loads and lighting are consuming a lot energy. Thus, smart buildings have the ability of using many IoT sensor types in HVAC along with other mechanical systems making such more adaptive and intelligent. The embedded sensors as well as their related controllers which are mounted in smart buildings are generating a huge amount of data (big data), such data might be subjected to extraction, filtration ana analyzation and utilized for the analytics of smart buildings. For example, the big data analytics might be utilized for analyzing and improving the energy efficiency in addition to the residents' overall user experience in building. It has been verified that there is an increased focus on smart buildings and big data analytics and management. Yet, there is a requirement for identifying the problems and solutions for overcoming them in such field. With the use of a design research method and model driven architecture, this study aims to develop such system. The major aim of this work is introducing a technique with increased possibility for moving Intelligent Buildings (IBs) towards next-generation model. It depends on IoT adapted to IB for integrating smart re-configurable subsystems and components of IB into Enterprise Network Integrated Building Systems (ENIBSs), also, if possible, into ENIBS' global networks. The study is presented in the following way. Section 2 is providing an overview of IoT, it is indicating that IoT is relatively new and no associated contribution on using the IoT on IBs or, on the ENIBSs, were indicated in such regard. Section3 is presenting the methodological model that has been used to design a generic model for the IoT with the applicability in the IBs as well as generic architectures for re-configurable smart plug-and-play control systems for quick configuration and integration regarding smart components of the IB. Section 4 provides the theory' experimental test. The study ends up with the conclusions and some suggestions for the future work.

Keywords: IoT, Smart home, IB cloud, Android, ENIBS

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1. Introduction

Internet of Things Throughout the last decade, a lot of research attempts and technological developments were made in IoT to target the concepts of smart buildings [10], the most significant and primary one is the significant increase of smart devices and smart objects taking part in the IoT ecosystems. By 2020, the number of interconnected objects is going to grow to more than 50 billion as stated by Ericsson. Also, it is anticipated that the number of various smart device types and many connected wearable devices with data processing and inherent sensing abilities is going to be reaching trillions in total. IoT is significantly enabling human work

and life in various fields, such as disaster management, transportation, healthcare and automation. It is enabling the listening, hearing, seeing and communication of objects at the same time.
IoT is expected to be one of the solutions for growing connectivity demands between devices, companies, individuals, gadgets and organizations, while it was aimed for the start foe achieving real time control as well as access to the information for the intelligent and optimal managements of the integrated resources. According to the concept of M2M (i.e. machine-to-machine) connectivity, fueled by actuators and smart sensors' development, along with certain technologies for communication (RFID, Bluetooth and Wi-Fi), also supported via the technologies of cloud computing, IoT is becoming a certainty with the aim of making "things" more interactive, effective and aware for safer and better world. All smart devices which might be addressed through using a communication protocol might be considered as one of IoT parts. EU research cluster upon[1] IoT, defining "things" as being active participants any type of "social, business and information processes, in which they have been enabled for interacting and communicating with environment and with themselves, through exchanging information and data 'sensed' regarding the environment, whereas autonomously reacting to the events of 'physical/real world' and impacting it via running processes which are triggering actions and creating services without or with direct human interventions.
The internet won' be just a computer's network in future. However, it is going to comprise billions of embedded devices and smart objects. Thus, the IoT applications are going to raise exponentially in size and scope,[2] offering new challenges and opportunities. A lot of nations created long term national plans to implement IoT. The already-indicated initiatives of development created the IoT foundations. In the Internet, it is expected that IoT is going to be the next big challenge and opportunity [3]. Figure 1.

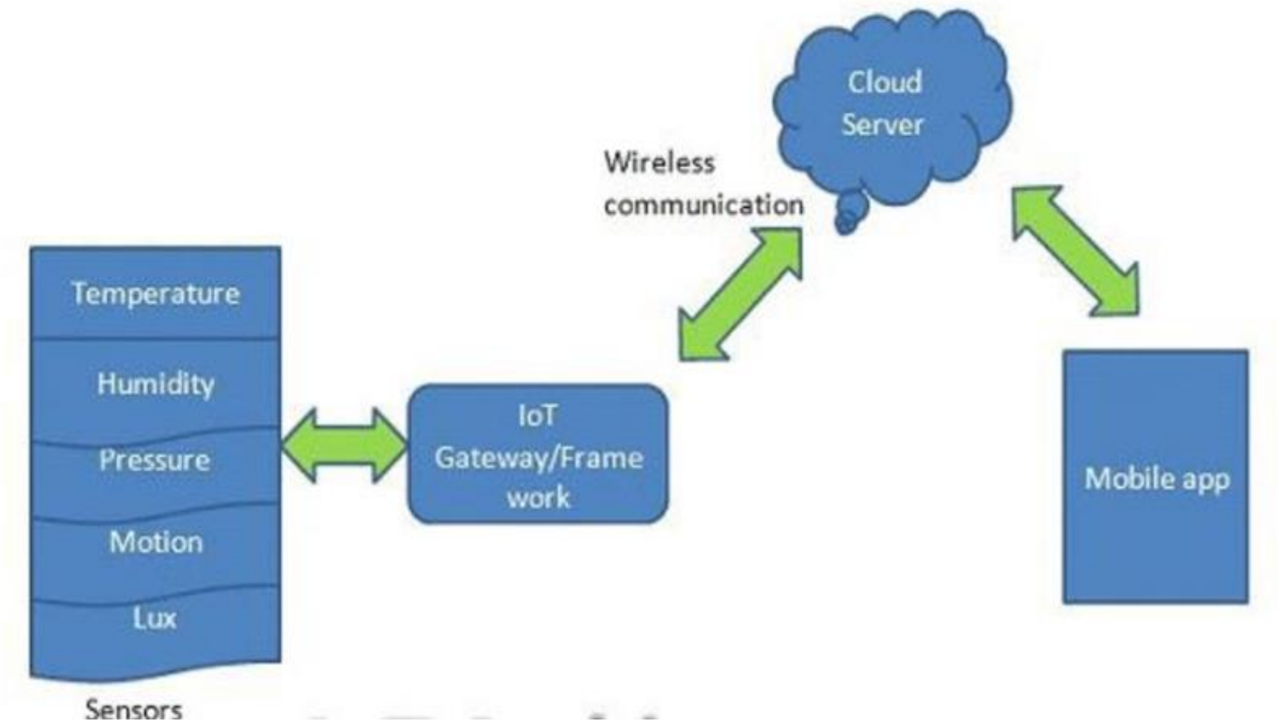

Figure 1. IoT design

2. Material and methods

Smart home option A main part of such IoT devices which is installed in the building thus, resulting in the smart buildings' concept. With regard to smart buildings, many appliances and electronic devices were interconnected and have been communicating together. Big data is generated in these systems, in which there is a communication between large number of devices [4]. It has been expected that big data analytics and management are of high importance in enhancing the IoT enabled smart buildings. Also, in smart buildings, the capabilities and basic features are indicated in the next sections.

Figure 2. Smart building

Nowadays, there is smart home option in the majority of appliances related to domestic life, some of them are[6]:

- Smart TVs connecting to internet for the purpose of accessing content via applications, like on-demand music and videos. Gesture and voice recognition are included in certain smart TVs.
- Utilizing garage door openers and smart locks, users might be denying or granting access to visitors. Also, the smart locks are detecting when the residents were near and thus unlocking the doors for them.
- Pet-care might be automated with connected feeders. Lawns and house-plants might be watered via using connected timers.

2.1. Concept of re-configuration

The re-configuration paradigm utilized on IB indicates the IB's capability for rapidly reconfiguring its resources for obtaining an adequate system with the required functionality as responses to the environment changes and/or users or other requirement types. The concept of re-configuration is on the basis of 6 core functions [8].

-Modularity can be defined as one of the key enablers related to re-configurable systems of IBs and re-configurable units/module (RU), it indicates a system characteristic enable creating complex systems from basic software and hardware modules.

-Integrability is representing the capability of RU and RS for adequately cooperating with future and actual developed technologies irrespective of the producer.

-Convertibility represents the capability of RU or RS for managing its resources for rapidly changing over between current tasks or shortly adapting to the upcoming tasks.

-Diagnosability can be defined as one of the core functions allow to track and troubleshoot issues of functionality. Self-diagnosis has been defined as a significant extension regarding such fundamental functions.

-Customizations are representing the capability of the RU or RS for rapidly responding to new requirements and continuously adapting to various technologies and tasks

-Scalability represents the propriety which allow removing or adding functionalities or components dependably.

Using the core functions mentioned above provides the possibility for obtaining developed control architectures which contain intelligent, simple units, with significant properties [9]. Building RU (re-configurable units) isn't an easy task. Also, RU (re-configurable units) shouldn't be mistaken for the modular units. Far beyond fast connecting joints and modularity, RU (i.e. re-configurable units) should have the capability for quasi instantaneously transferring the information between modules and from each one of the modules to master controller periodically or continuously, in the case where it is needed. The information has been considered to be complicated, also it refers to many issues such as: each module's position relative to the ones interfacing with, present state with regard to failure monitoring and control, each model's history

regarding previous use, dynamic data, calibration requirements and accuracy data, etc. The master controller should be able to do convertibility and scalability, such factors are requiring local embedded smartness, via utilizing software and hardware means, also suitable communication protocols and algorithms for efficiently building intelligence into the system. Some results were indicated in such reconfiguration topic.
Being such problems, in ENIBS, long-distance services and maintenance are other challenges. In addition, efficient links existing between the producers and the users of the re-configurable units will be achieved through tele engineering techniques (such as remote service, remote maintenance also remote monitoring and control) [8]. Which has resulted in the necessitation of the implementation of the adaptive sensory systems to RU level, optimum sensor's placement plans, effective data compression as well as preprocessing phase for supporting the agents of monitoring (i.e. the watch dogs) conducting real-time, online and simple process change detection, important methods for managing the information, using information for self-learning purpose, on-line alterations for maintaining accuracy rather than monitoring degradation, simplified diagnosis algorithms, and so on.

3. Theory

The EU IoT research cluster gathering within strategic researches road-map the enablers of the technology which must be tackled to achieve to the actual goals of IoT. In the presented study, the major goal is delivering connectivity to the re-configurable smart IB devices/components like being monitored and controlled via software applications that run on the mobile devices (Android compatible in this case) for increasing the mobility for facility management, ensuring effective remote data management as well as fast decision-making in case of crises [7]. Identifying issues and enablers which must be tackled, the ones considered important in this study are indicated below:

- Smart IB networks equipment/components improved with embedded distributed intelligence for dealing with the challenges of scalability.
- Interoperability regarding effective communications of the IB components
- Extended communication abilities for the intermittent connectivity of the network and distinctive IB components and modules
- Micro electromechanical systems as well as sensors in terms of augmented implementations in the IBs and building automations or awareness and foreknowledge of the things that will happen
- Remote human machine interfaces and interaction; maintenance service and support for the IB
- Reconfigurable and energy-efficient modules of the IB
- Plug and produce IB components and modules, High information processing and computational power, data availability and data storage.

3.1. Tackling the above-mentioned challenges

For tackling the above-mentioned challenges, one must consider the general design conflicts: Conflict-1: increase in re-configuration, whereas maintaining low-costs integrations; Conflict-2: Increase in adaptability, whereas maintaining low-costs integrations.

With regard to conflict 1, the innovation suggested via TRIZ (Theory of Inventive Problem Solving) technique changes the concentration and modularity of functions [10]. Whereas in conflict 2, there are 3 interventions' areas suggested via TRIZ for changing the functions' concentrations, developing non uniform structures and making a few properties of the components changing space and/or time. Thus, the concept has been upon developing motors, sensors, and other units have self-intelligence, have the ability for carrying information regarding their past events, also information related to their kinematic, dynamic and geometric properties (involving offsets), [11] such intelligent units must be changing a few of their functions (using software algorithms and data). Also, they must be incorporating an interface to communicate quasi-instantaneously with the other intelligent units with regard to self-reconfigurations in the new RU configuration types. The major concept is about using buffers to avoid loss of information is bringing many advantages with regard to system re-configuration throughout its running, such ideas will be reflected in the presented solutions.

4. Results

Our vision and the proposed architecture for a higher level of clarity, some proposed architecture layer has not been presented, amongst them is: middleware, security and overall information management [12].
As shown in figure3, ENIBS was made from smart re-configurable resources connected via using wireless or wired communications between them and to the information management layer and the system control.

Actuators and sensors have been considered to be part of the re-configurable resources, that, when joined, have the ability for creating further complicated resources acquiring extended functionalities.

In addition, the IB reconfigurable resources might be specified as things since they have been addressable via utilizing communication networks (wired or not) and they have the capability for processing, storing, sending and receiving data, also monitoring or controlling devices (sensors, actuators). Also, they have the capability for communicating with the other re-configurable reacts and resources to changes for maintaining certain process parameter set-point through many ways. Smart re-configurable resources were improved by the distributed intelligence, offering local control in terms of physical resources, capabilities of plug&play as well as high computational power [13]. The software and hardware building blocks related to the re-configurable resources might be rearranged for obtaining different than before functionalities with least delay and effort. Figure (3)

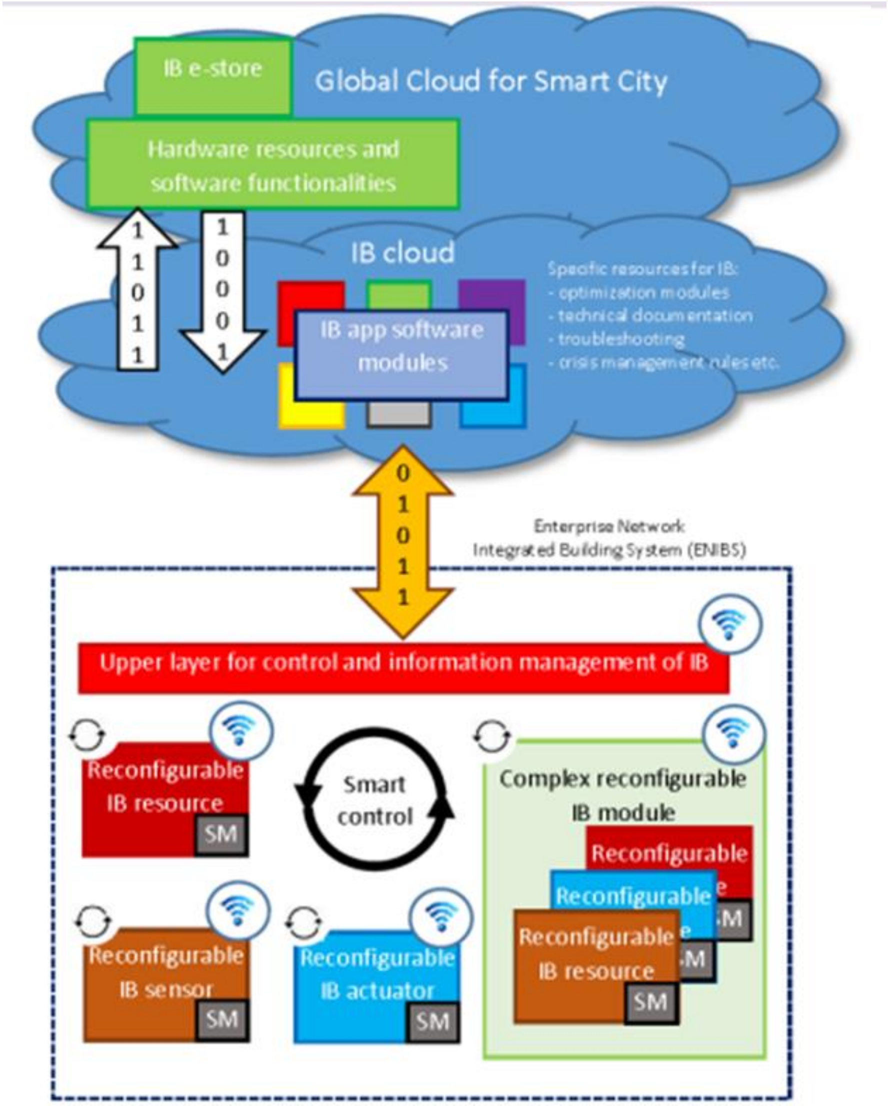

Figure 3. IoT for smart building via utilizing Rus in ENIBS

Smart building cloud was developed for being a service which is connecting the enterprise network integrated building systems) or smart building resources to layer larger unit. It has been envisaged for providing accesses into the process information, computing services, applications of IB software in addition to supporting the data share with the served processes, yet no limited to that. Enterprise (for instance, smart cities) cloud will provide the ability for the remote connections to certain IB resource, monitoring the status, enhancing software algorithms or downloading new algorithms [8].
Figure 4 shows the conceptual architectures related to smart resources. A lot of experimental developments to use smart re-configurable equipment as well as control architectures were done via the authors of this study published in.Figure (4).

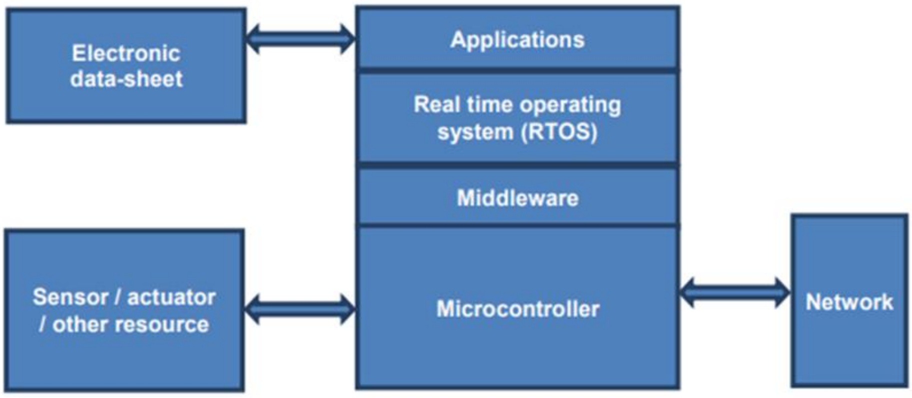

Figure 4. Intelligent resource IoT

Clouds are representing the global networks regarding smart buildings and systems, while an enterprise has the ability for buying or selling hardware and software IB technical support, data, support and resources [14]. There have been 3 main anticipated outputs from suggested model. Initially, the developments of smart re-configurable resources, allow the re-arrangement of their constitutive blocks for fitting the process requirements via choosing the most suitable software application group from global or smart building clouds in constraints of provided hardware modules. From such resources, further complicated re-configurable smart building resources might be done, resulting in re-configurable smart building systems. Furthermore, their development is going to be supported through highly-interoperable modular software and hardware blocks, real-time embedded operating systems, generic embedded systems, informational-electrical-mechanical interfaces and intelligent information management algorithms.

The graphical human-process interface its mean the second output that will result in providing a more preferable user experience to IB processes through the PC devices, tablets and smartphones [15]. This interface is utilized the algorithms of design control for the re-configurable sources or to the modules, through the use of software functions and technical resources that IB e-store or ENIBS cloud provide. The algorithm of the control is transferred to a resource that has been designed for via computational resources of the layer of information management and upper control of IB systems, which holds the responsibility for a number of activities: auto-integrating newly connected re-configurable resources of IB, for supporting operator in the process of configuring newly attached resource of IB, for the provision of a framework to design the control algorithms, for transferring the control algorithms into IB resource, for monitoring data that has been received from resources of IB and for taking over the IB resource control if required.

IB cloud its mean Third to be the IB industry virtual space, which provides ENIBS that has the access to the e-store of IB, which allows acquiring, selling, testing and developing resources of software and hardware.[22] Global cloud is a certain ENIBS virtual model which links IB cloud with facilities of the ENIBS. It hosts the information which is associated with ENIBS as well as its processes, a data-base with the available functionalities of software which may be downloaded to resources of hardware and a base of knowledge with the troubleshooting actions, technical resources, and so on. Amongst first steps toward the implementation of suggested model is testing and implementing the selected solution of connectivity [24]. That part will be focused upon the monitoring and control of IB resources with the use of a device that is compatible with Android. Which is why, it is expected successfully delivering a minimum of the following properties of the IoT as can be seen from figure1: anyplace, anytime, anybody and partly any network. Which is why, for this process, an embedded system has been designed around ATmega32-U4 micro-controller that runs at 8MHz where numerous sensors may be connected. Through the deployment of the algorithms of software and the intelligent management of information, those sensors are considered as smart ones [16].

The micro-controller's communication protocol of the UART has been configured for the purpose of working at an 115,200 bps 8bit data baud rate, with no control of flow and parity and 1 stop bit [16]. On interface of UART communications a wireless shield from the Roving Networks (RN171ek) has been connected as gate-way of data from embedded designs to wireless networks, as has been represented in Figure 5, which represents the wireless network.

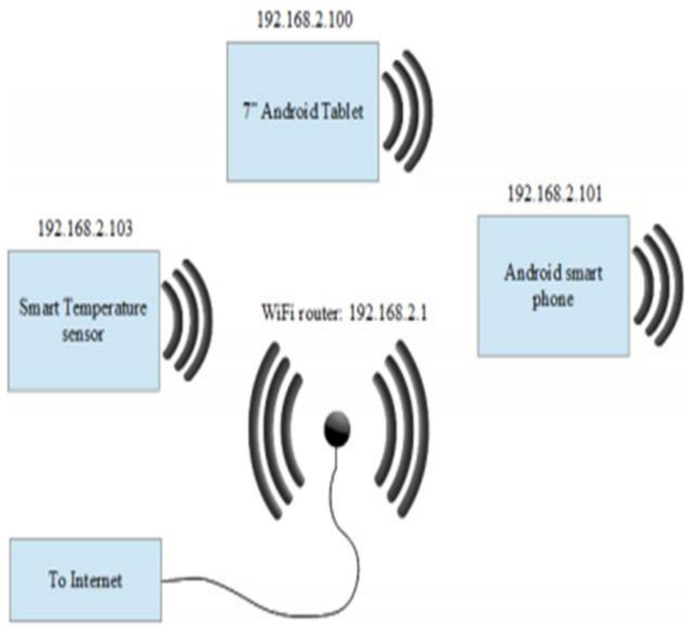

Figure 5. Wireless network

A temperature sensor of LM35 is connected to embedded design and the readings of this sensor are transmitted to a device that is compatible with Android, then, this Android device should be a 7inch tablet [17]. One of the software applications from the roving networks has been utilized as a terminal for the purpose of checking whether or not the data that has been sent from embedded design through Wi-Fly shield has reached device. The abovementioned shield includes a radio processor of 2.4GHz, real-time clock, full TCP/IP stack, and supports the FTP client, DNS, DHCP, and HTML client protocols. The secure authentications of WiFi by the WPA-PSK, WEP, and WPA-2-PSK and the configuration over the ASCII codes through the use of the UART interface [23]. Figure6 illustrates a photo from a 7” device that is compatible with Android with the information that has been sent from underlying design [17]. The listening port of the connection partner of TCP/IP is: 2000 and the IP is 192.168.2.103.Figure 6.

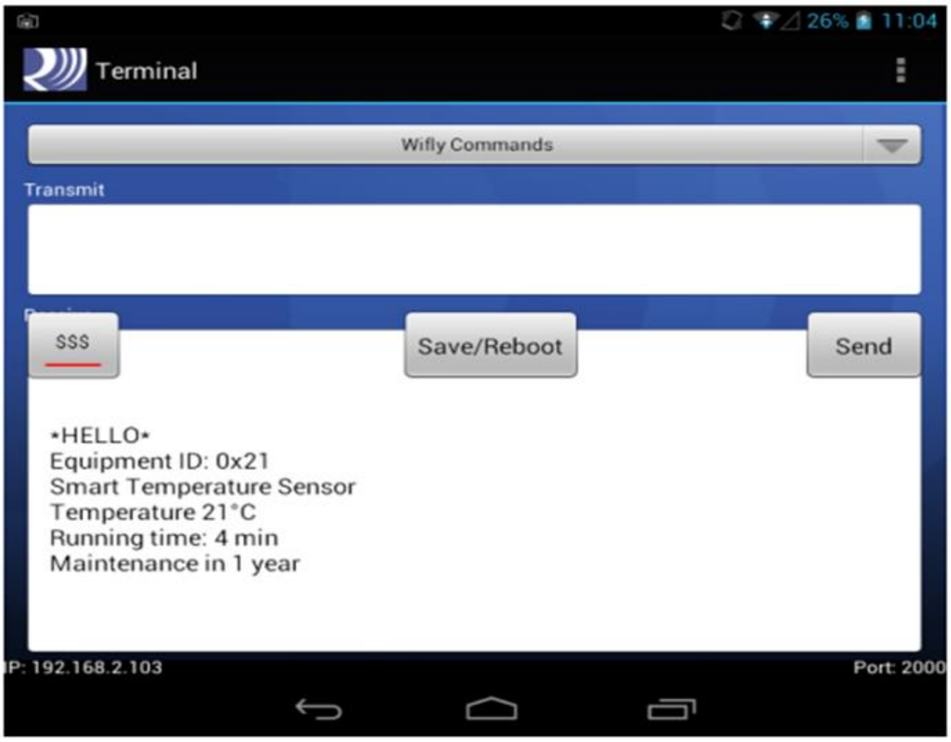

Figure 6. Android compatible device terminal

Figure 7. Experimental work-bench

Figure7 is a presentation of experimental workbench that includes embedded design that has a LCD for the local process information display, in combination with a smartphone that is compatible with Android. From figure7, it can be seen: a smartphone compatible with Android (1), embedded system (2), WiFly module (3), a local display (4), and an LM-35 sensor of temperature (5)[13]. The experiments show that the suggested solution of connectivity between a monitoring device and the IB resource meets the needs for now. Processing the data, i.e. the temperature, was transferred with success, with the use of the WiFi shield (from the Roving Networks) from 2 Android compatible devices and an embedded design, utilized for the surveillance [18]. As seen in figure6 and figure7, the operator or the user have an access to additional beneficial information such as: time since IB resources or embedded design are on, and knowledge of resource maintenance.

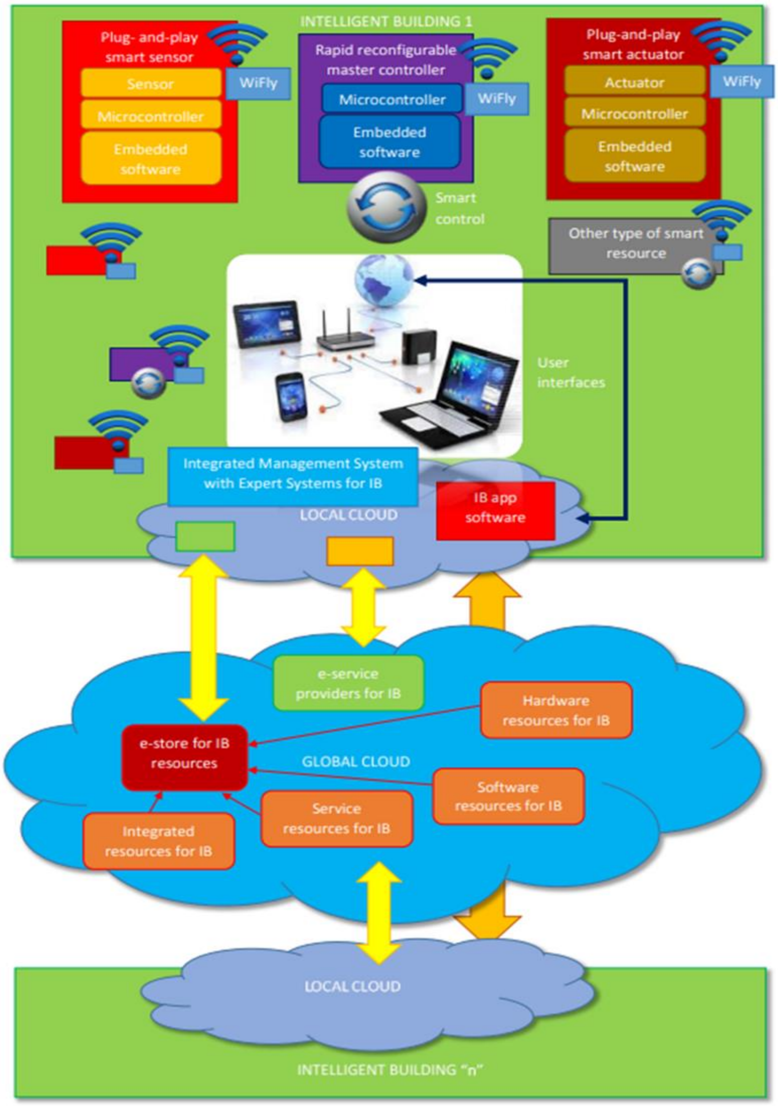

Figure 8. ENIBS enhancement

5. Discussion

The improved notion of Enterprise Network Intelligent Building System has been illustrated in Figure 8[19]. Every unit that is responsible for collecting data (i.e. the smart sensors for the servicing of a variety of the tasks, such as: heating, ventilation, water, access, equipment, security, power supply, smart units for the analysis and recording of the images, the units for the voice recording, and so on), execution of tasks (i.e. smart actuators to build automations, such as: windows, doors, roofs, walls, lifts, floors, stairs, and so on) or other tasks (such as the smart walls, smart facades, and so on) are wired or wireless connections to the smart master controllers, to the smart devices (such as smartphones, laptops, and tablets), or both.

The master controllers may communicate one another as well. The master controllers are fast re-configurable and any of the smart units may be disconnected or connected quasi instantaneously to/from associated master controller. Embedded software of every one of the smart units and master controllers comprises a logic for the management of the process and configuration in associated to the specified tasks. The master controllers have been connected with a variety of the fixed or mobile devices, providing an interface with a user, in addition to the access to resources of the local cloud, in which a variety of the applications are stored for the management of every function of a building. The expert systems have been included for ensuring the enhanced decisions as well as ensuring intelligent integrated managements of every building function. A variety of the resources and services, like a variety of the sophistication, customization, and integration levels may be accessed through the global cloud [20].
The intelligent buildings from a set of the buildings (such as the smart cities) have the ability of communicating one another in a direct manner or through global cloud, according to the management system's architecture that has been implemented. Which is why, the buildings have the ability of transferring resources and information (such as the energy) to one another.[21] A variety of the backup systems have to be taken under consideration too, in addition to the redundancy in critical function cases.

The IoT technology has a huge application area when it is used in other technologies such as sensing, identification and recognition, hardware, software and cloud platforms, communication and networks, software and algorithms, positioning, data processing solutions, power and energy storage, security mechanisms, etc. (Čolaković & Hadžialić, UEMK 2019 Proceedings Book 24/25 October 2019 Gaziantep University, TURKEY 508 2018). This technology utilizes advantages of intelligent devices, smart mobile devices, single board computers, and different types of sensors and actuators (Dehury & Sahoo, 2016). From this perspective, the awareness about benefits of IoT is rapidly increasing due to the current technology trend in the construction industry (Kanan et al., 2018). Therefore, the IoT technology has a great potential to become more popular in the future. Aforementioned past studies reveal that IoT has a potential to be utilized in order to solve decision-making and health and safety problems in the construction industry. For this purpose, especially sensors and monitoring systems can be used or developed by construction companies. Considering the poor health and safety performance of construction firms, minimizing or eliminating construction incidents may be possible by using such a new technology in construction sites. In this respect, the help of IoT applications may decrease the number of occupational accidents caused by construction machines.
Our work can be enhanced by computerized power transformer monitoring using IoT [25]. Cloud computing and e- government [26, 27], can be as well as future trends to advance more and more this study.

6. Conclusions

The present study introduced a control model for the IoT, enabling to build up the intelligent resources for the fast integration in the IB system. The intensive tests upon case study for the recognition of certain properties showed that the suggested control model is highly reconfigurable, functional, inexpensive, and IoT concept in the IB is practicable.
Some of the highly important characteristics to deal with the future issues that are related to the IB systems may be found as well in the experimental test bench of the present study: re-configurability, control unit is capable of configuring the on-the-go and at any time direction OUT or IN (in other words, the connections with outer world) concerning connected devices; the operator has the ability of asking a certain connected smart tool (such as a sensor that includes the micro-controller) to present its options of configurability and make a choice between those options a required manner of the way by which a device acts concerning the implemented configurations of hardware and software; plug-and-play, control unit has the ability of detecting

when a device has been connected or disconnected on the system of communication and insures the integration and configuration of connected part with no need to corrupt the transfer of the data on the system of communication; real-time assistances.

All the information concerning a device lies within the attached micro-controller's memory, thereby, connecting 2 incompatible devices or more will alert the operator and block any attempts to drive or control that device; independent decision making, such as the precautionary actions, in cases of the smart units has been based upon data statistics and process information of the process values. The de-centralization level is an additional significant feature that has been identified in the present design. It has been obtained from symbiosis between a certain resource of IB and a micro-controller that has been connected through by a network of communications to the other resources of IB and to higher levels of. A mean level of 5min is required for an operator in configuring connected resource of IB. according to results that have been concluded from the present study and the vision on the way through which the IoT may be applied on the field of the IB, the following suggestions of the future researches can be given: developing a use-centered and intuitive graphical human machine interface for the Android devices which have the ability of providing extended control and access to the information that has been stored in embedded design as well as its functionalities; for the purpose of developing software applications which may be downloaded from global cloud into a resource of IB and utilized by that resource for the monitoring and the control of the process; for the development of an IB resources' network for the implementation of the scalability.

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