INTERNET OF THINGS & SMART HOME MONITORING: AN IMPENDING PERSPECTIVE

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ABSTRACT: In this paper, the relevance of Internet of Things (IoT) with the smart home monitoring is elucidated. The IoT is all about the ability to sense things; understand and act according to the requirement of environmental conditions. The following information is about the potentials of IoT framework that everybody in business needs to realize, and its advantages over wide applications in daily activities. The intricacies in the design and development of smart home monitoring system in stirring to the IoT framework are revealed.

KEYWORDS: Internet of Things, Smart Home Monitoring, Wireless Sensor Networks, Pervasive Computing, Ambient Assisted Living.

INTRODUCTION

The developments of the Net Technology and Smart Sensor Systems have led to a new era of pervasive networks. Increase in users of internet and advancements in ubiquitous computing enable internetworking of everyday things widely. “Internet of Things (IoT)” is about “things” talking together, Machine-to-Machine (M2M) communications as well as person-to-computer communications by extending to “things” usages [1]. In the present technological scenario, the two terms “IoT” and “Smart things” occur together frequently. The IoT gives rise to the smartness of interconnected things. In general, the words “IoT” and “Smart Things” follow each other in their respective application scenarios. The main objective of IoT is to have the ability to uniquely recognize, signify and access things at anytime and anywhere in an internetwork and this can allow controlling of any “things” in an ideal situation.

The adaptability of IoT modeling in day-to-day life activities makes variety of applications. The design and development of these applications depend on many different technologies that correspond to its realization for daily use. Initially, the use of IoT was driven by the management of information through tags of Radio Frequency Identification (RFID) for tracking things, supervision and controlling of things and automation of electronic payments in trade markets. The advancement of hardware technologies has brought up the development of the IoT by means of miniaturizing wireless devices, smart sensors/actuators and micro-controllers. Those technological advancements have inspired many schemes for refining the software of embedded devices. These have led to efficient optimization of M2M communications, providing a greatly feasible and practical IoT related applications. In the present context, a paradigmatic approach for IoT applications has been presented to provide smart spaces consisting of numerous independent smart things. The future internet focuses on integrating real world services provided by the IoT framework into “mashup” of traditional services [1].

Applications of IoT

The following is an overview of the important IoT application domains presently recognized by the research and industry communities:

Monitoring of everything: "Every Thing in this world will be connected to each other via the Internet so that, we can know anything we want to know" [2].

Environmental Monitoring: The importance of environmental technology has become a vital field of research and development for ecological progression worldwide. The environmental/earth monitoring system receives information such as Air/Water pollution data, Lake/River pollution information, Land Monitoring statistics and Plant/Crop growth indicators. The applications such as traffic monitoring, lighting, pollution monitoring, chemical hazard detections, earthquake detection, flooding detection, volcano eruption forecasting and weather forecasting are becoming huge importance to society [3]. These applications can be realized using a low-cost, reliable and efficient system through an IoT framework.

Smart Cities: A wide set of IoT applications strive to create smart cities more sustainable, safe and enjoyable using IoT models. The cooperation among citizens, institutions and companies is very much required for the utilities and service providers to efficiently perform IoT operations. The applications of interest range from systems supporting urban mobility and its safety such as Smart Parking, Traffic Congestion, Intelligent Transportation Systems, monitoring or optimizing assets and critical infrastructures in cities for Structural Health, Smart Lightning, Smart Roads systems monitoring and protecting the citizens' quality of life using Noise Urban Maps and Waste Management [3]. Intelligent Buildings and Smart greenhouses can be controlled and optimized via wireless sensors and actuators in the framework of the IoT.

Smart Agriculture/Animal Farming: Smart Agriculture focuses on monitoring the soil used for growing agricultural products, plants, greenhouses, or the environmental conditions (e.g., weather) [3]. Closely related to Smart Agriculture is the Smart Animal Farming trying to enhance the productivity of animals for meat and related products (e.g., milk, eggs) by monitoring animal health conditions at different stages, animal tracking and identification (also used for product traceability), and living environment [3].

Smart Transport/Logistics: Smart transport supports good monitoring during transport, e.g., in trucks or cargo ships, support good detection and tracking in warehouses [3]. Mobile robotics applications in industry are very much supported by IoT in which mobile robots interact with fixed IoT infrastructures, e.g., to support internal logistics in manufacturing plants [3].

Industrial Control: Industrial control is one of the main application domains for IoT technologies (e.g., for remote monitoring of manufacturing lines through SCADA systems) [3]. These systems are typically deployed in manufacturing or process industries in order to remotely check machineries (e.g., M2M applications), diagnose the status and position of moving vehicles or robots or to monitor the conditions of the manufacturing environment (e.g., air quality monitoring in food processing industries) [3]. These systems help the transition of industrial automation from custom, closed developments to more flexible internet-oriented schemes integrated with enterprise systems. They simplify data-intensive applications like real-time tracking or predictive maintenance. Manufacturing applications leverage autonomous M2M interactions to monitor and optimize production lines [3]. Preventive action can be taken in advance and awareness level will increase.

Home Automation and Health Care Monitoring: A smart home monitoring system with distributed wireless smart sensing units and effective data processing system can be realized with the help of an IoT framework [4]. Additionally, the system can be used for monitoring the behaviour of inhabitant and evaluate the longitudinal elderly healthcare assessment. Thus, the IoT framework can fuse the smart sensor data of household appliances usages and execute multiple tasks of IoT for the smart home monitoring system. The Fig.1 shows the deployment of smart home monitoring system at an elderly home for remote monitoring of elderly behaviour recognition and usages of household appliances and electricity consumption through an IoT framework.

Figure.1: Smart sensing things and environmental monitoring units used for the Home Monitoring system and its web based application [4].

IOT FRAMEWORK

Wireless Sensor Networks (WSN) based data fusion interpretations were implemented from the start of the IoT framework modelling. The reasons for using WSN with IoT are i) low-cost, ii) long-term adaptable sensing and actuation abilities, and iii) dispersed resilient communications in the framework [25].

Key modules of the IoT framework implementation

Availability of Internet Everywhere: Providing internet facility is a financially costly resources and it may be extremely valuable proposition to think of the internet for other applications. The internet connection is the backbone for IoT framework and can be used to transmit the sensing data collected from widely distributed regions such as measurement of environmental parameters [1].

Design and Development of Smart Sensors and Measurements techniques for IoT: Smart sensing systems that interconnect everyday home systems and their environmental monitoring systems can be designed and developed for IoT framework. For effective transmission and high throughput of data across the WSN-IoT framework, the measurements of smart sensor data types, number of sensing channels, and the sensor data sample intervals are to be optimally configured. Most

applicable network protocols followed in WSN is the IEEE 802.15.4 (ZigBee) or 6LowPAN for effective and reliable communications. ZigBee was designed for use in local networks such as home automation environments. However, ZigBee/6LowPAN does not directly communicate with servers on the Internet without proper integrating mechanisms. Remote management and controlling of ZigBee/6LowPAN based devices over the IoT can be mechanized by following certain architectural design strategies of the IoT gateway [4].

Smart Sensor Data Fusion and data storage using cloud management for IoT framework: One of the key functions of IoT framework is providing internet services based on the data initiated from the smart things. In general, the IoT framework integrating the smart wireless sensing systems and their corresponding applications is depicted in Fig.2. The full potential and most viable application of the IoT can be realized by the combination of ubiquitous smart sensing systems with a cloud infrastructure. The advantage of the IoT framework with cloud computing is that it is highly scalable and offers flexibility in isolating the logical structures and its associated costs [5]. Sensing systems can link their communications network and transmit the sensing data using a storage cloud management mechanism. Efficient real-time data mining or artificial intelligence tools can be provided for extracting useful information and translating into corresponding knowledge base [4]. Also, computer graphics developers can provide a range of visualization software's for viewing the real-time IoT data through web applications. The integrated IoT and cloud computing infrastructures have the full potential of remote monitoring and controlling smart sensing systems as services.

The data generation processes, tools considered and the visualization procedures created during the application execution of IoT disappears into the background, tapping the full potential of the IoT in various application domains [5]. It can be observed from the Fig.2 that the cloud computing infrastructure integrates the distributed smart sensing systems by providing scalable storage, computation time and other tools to build new IoT businesses.

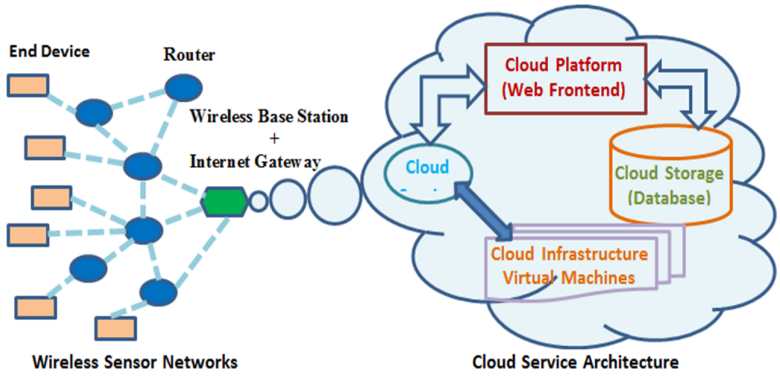

Figure.2: Wireless Sensor Network integrated with cloud services for Internet of Things [25]

DATA ANALYTICS RELATED TO IOT

The IoT framework should be capable of supporting i) real-time sensor data acquisition directly from sensing systems or be able to retrieve the data from the databases in near real-time, ii) easy

handling of real-time data analysis logic methods that process the streams of sensor data in the form of raw data processing or processed data using cloud computing facilities and iii) Recognize anomaly events on the sensor streams, and sent the outputs in a scalable manner to a visualization process [5]. The blend of IoT application and cloud computing facility will harness the power of distributed computing without knowing low-level details of creating reliable and scale application.

Challenges and Opportunities[25]

Some of the major IoT challenges are privacy, data storage, smart sensing instrumentation and measurements, data analytics, visualization of real-time data in the IoT enabled application. Apart from having robust cloud computing facilities, the challenges related to WSN such as the optimal number of sensing devices required for monitoring applications, energy harvesting techniques for long term active of sensor nodes, security of the sensor data, protocols to be considered for low power consumption, optimum data compression and Quality of Service (QoS) persists in the design and deployment of IoT framework in the present business situation. In the near future, the smart things should be easily deployed in the form of plug-n-play in any context using the IoT framework [5]. The internetworking mechanisms of smart things in the IoT framework are crucial with respect to standardization of communication protocols. It may be mentioned that to safeguard everything in the future, electrical power, computing systems and the internet should be ensured fail-safe operation that may be a huge challenge. Additionally, changing dynamics in the global economy can look into the issues related to security, misuse of data/information and formulate appropriate protocols.

SMART HOME SYSTEMS

A “Smart Home” is an expression utilized for dwellings outfitted with technologies that enable proper scrutiny of residents, promoting autonomy and upholding of better health [6]. Every individual has distinct requirements based on which custom support must be provided to each individual.There are several smart home test beds designed and developed in the recent past. Their main purpose is to monitor people with visual or cognitive disabilities. The focus is on the potential to efficiently monitor and prompt appropriate health care actions that lead to a better health outcome [7-10]. With the advancements in sensing technologies, embedded processors and communication systems, the deployments of smart home settings has been easy and manageable. This enabled the health care sector to provide appropriate services using smart home technologies for independent living people [7-10].

The improvements in Information Technology (IT) have resulted in the well-ordered and enhanced function of sensors, networking and computation technologies [7-10]. The developments of smart home technologies are towards risk-free sheltered as well as comfortable real life settings for the residential home environment. This supports the regular security and safety process by employing intelligent monitoring system as well as access commands. The smart home integration system is made of about three important entities: First, the physical components (electronic equipment – smart sensors and actuators); Second, the communication system (wired/wireless network) which usually joins the physical components; and Third, the information processing through artificial intelligence program to manage and control a smart home integrated system.

Components of the Smart Home Systems

A typical scenario in the smart home environment can be viewed as monitoring various household appliances for recognition the ADLs to know the well-being of the inhabitant. It consists of various electronic components in terms of instrumenting the objects to be monitored, and a

wired/wireless communication system to have interconnection among the instrumented components to derive proper information. The information gained will be able to determine the quantitative measurement of the well-being of a person. Fig.3 shows the basic elements of a Smart Home Monitoring System (SHMS).

Figure.3 Basic Components of the SHMS

In a smart home environment the physical constituents (smart sensors) sense the natural environment and pass to the home monitoring command system through networks and infer the sensor fusion stream to adapt the inhabitant behavioral pattern. Fig.4 depicts the interconnections among the basic elements of SHMS.

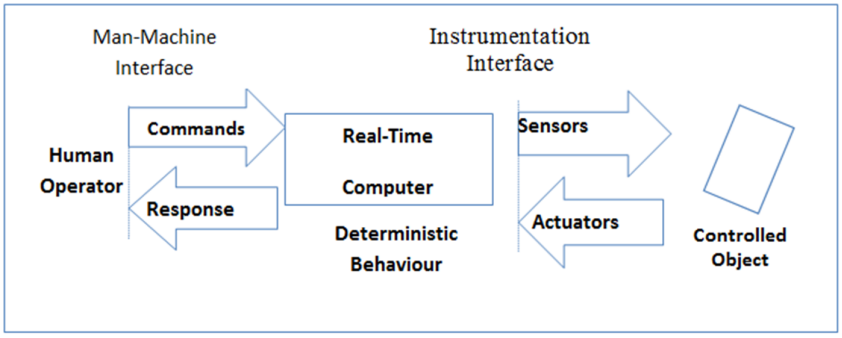

Figure.4 Interconnection among the components of the SHMS

Smart Homes Technologies Users

The following benefits are offered from the technology assisted smart homes: Anyone living independently, who is not able to look for aid in some emergency situations such as unconsciousness, falls etc. Disabled or older people who are suffering from cognitive like dementia and/or physical injury like visual, hearing or suffering from chronic diseases. Individuals who require aid in day-to-day life for personal care actions like eating, bathing, dressing and instrumental activities like cooking healthy meals [11]. There are SHMS technology users like formal health care provider or informal family health care providers for handicapped or older. People who are living in rural or urban communities with unsatisfactory health service provisions.

Advantages of a Smart Home Technology

Smart homes enabled with tele-care systems are providing specific assistances to support older or handicapped people who are suffering from prolonged illness and living independently. The health assessment of behavioural patterns and physiological signs will be interpreted into exact

forecasters as a proficient program to start proper activities. Smart home tele-care can provide facilities to overcome the transportation for organizing multidisciplinary care outside the hospital [12-13]. Home tele-monitoring of chronic illnesses provides information empowering patients with health related information and potentially developing their health check-ups[14]. The important benefits are ease of understanding of locations and services of quality health care. Some of the respondents highlighted the significance of selection in terms of actions and accessing services ways. As per the patients view, they are usually favourable in the direction of telemedicine such as eliminating consultation timings and reduced costs, etc. Most of the patients favor tele-consultations as it saves money as well as time [15]. Information technology like 'e-prescribing', 'electronic health files', and 'decision support systems' has decreased costs of tele-health care systems[16].

Current Limitations of Smart Home Technologies

Application of wellbeing care equipment's in smart homes is hindered by the need for research associated with user requirements. This is further aggravated by poor understanding of customer requirements and substandard requests for services to be utilized at smart homes. Also, the industry is controlled by providers offering "a technology-push, rather than a demand-pull system" [17][18], leading to customer dissatisfaction. Regarding health specialists, those external to networking systems are confronted with the need for skill to share medical information. The main reasons pointed by the medical doctors are the price and apprehensions on privacy as the key obstacles to execution of information technology [19]. Major difficulties in shared, moral and legal concerns hamper extensive use of these devices, notably Electronic Medical Records (EMR). Because of intricate automated devices plus inadequate access to funding costs by doctors and health care centres, and having substandard norms the sharing of medical information was not easy. A second obstacle arises with the amount of time need to understand the operation of these technologies. Distrust might result in suppression of data, revealing deceptive info to wellbeing care suppliers [20].

Smart home technology might unenthusiastically influence social communication associations. Individuals employing smart home type of technology could worry about equipment's substitute private communication with their doctors. Casual providers may apprehend that a better liability will be engaged on them. When a patient is not informed, the spouse or other legal heirs do not inevitably have permissible authority and the principles change for each country [21]. Establishing e-health arrangements evokes many concerns like unintentional revelation of people, communicating with incorrect people and inaccurate use of information [22]. A comprehensive regulatory structure for telemedicine is still missing.

The European and global telemedicine processes were unsuccessful in deploying smart home tele-care systems because they were too costly for patients [23][24]. A number of technologies are short of interaction between doctors and patients. The tele-medicine research is not strong enough, since it lacks in information evaluating of patients' insights. Practical faults such as trials, precise framework, and research design of the available study restrict the overview of the results. Tele-consultation is good enough for various situations, but concerns associated to a patient gratification have to be discovered in detail concerning patient–doctor communication. There are not many randomized restricted tests comparing tele-health interferences with traditional health care practices. Most of the works in tele-monitoring of chronic ailments were regular tests exclusive of monitoring systems. The researchers proposed that potential appraisal should focus on randomized tests with a greater number of patients over a longer time.

CONCLUSION AND FUTURE WORK

Several smart home technology and IoT research tasks were conducted in different parts of the worlds both in the recent past and under current conditions. But, still the answer for the smart home monitoring system with IoT functionalities in terms of cost, acceptability, technology friendly and service has not been uniquely obtained. Most of the systems developed are based on technology push rather than user specific requirements. Mostly, systems currently designed and developed for the smart home monitoring are wearable, and huge sets of sensing systems with IoT are required to realize several applications. The IoT methods developed are based on offline analysis and require set-ups to be changed for different requirements.

There is a need to get optimal solutions for the smart home technologies with IoT such as: Collection and fusion of on-line/real-time data from heterogeneous sensors on a 24/7 basis. Development of an real-time detection of irregular elderly behavior and better behavior prediction systems in a real home environment with IoT functionality including Cloud Computing. Predictive data mining for real-time sensor streams. The setups of an IoT environmental sensing systems with less cost that are reliable, flexible and easily managed for effective management is required. Development and finalization of WSN based systems with an optimum number of IoT sensors in smart homes very much required. Integration of IoT heterogeneous smart sensing, reasoning and predictions with cloud computing is very much required.

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