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Review

Review of Internet of Things in Different Sectors: Recent Advances, Technologies, and Challenges

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Abstract: Human beings and their activities are now connected through Internet of Things (IoT) with the evolution of wireless communication technologies. IoT is becoming popular and its usage is immensely increasing among various sectors. In this research paper, a comprehensive review has been conducted by considering recent and important literature review on IoT applications being operated in three major sectors. The three sectors studied are health, sports and transportation and logistics. Paper explored that with the help of IoT techniques, different miniature sized devices are invented which can record various parameters of human body, wearables devices have been invented which are playing important role in monitoring and recording daily fitness are working on CIoT technology and IoT emergence in the field of transportation and logistics helps in resolving several issues including conveniences, navigation issues, service cost and security issues. All the papers reviewed are journal published from 2010 to 2020. In latter part, this paper also highlighted security, privacy, reliability, consumption of various resources and policies as significant challenges for IoT.

Keywords: Internet of Things; healthcare; sports; transportation and logistics; wireless technology

1 Introduction

During the past few decades, wireless technologies are leading towards a new paradigm known as the Internet of Things (IoT). The concept of IoT was introduced by Kevin Ashton back in 1998. IoT has a vast range of advantages in different sectors including Industries, Health, Agriculture, Sports, Transportation and Logistics. IoT can be defined as integrating data providers to the end users which are working on internet and other communication networks [1]. IoT will connect world which will be rich in information [2]. Everything is connected through IoT with the evolution of wireless communication technologies [3]. Moreover, IoT usage and connectivity within a network and with other devices is increasing [4] and research studies proves that by 2030, approximately there will be 90 billion devices connected in a network and 20.5 billion per individual [5–6]. Therefore, studying IoT in different sector is one of the significant research areas in today's time. Additionally, IoT plays a significant role in different industries from small to giant ones. IoT serves as a source of improving system efficiency which ultimately enhances product quality in various industries including manufacturing, food, health and logistics.

Different IoT techniques include RFID, Bluetooth, WiFi and Cellular IoT (CIoT). One of the significant advantages of using cellular IoT is its wide coverage and reusability of existing cellular structure [7]. Usually, CIoT is characterized in two different terms which includes narrow-band IoT (NB-IoT) and LTEmachine (LTE-M) [8]. Also, Cellular IoT networks help in developing a continuous coverage for cell phone devices multicasting, and broadcasting services [9]. Cellular IoT tools are appropriate when real time data is being used to make a significant difference in the system efficiency

[10]. Several sensors connected with cellular networks to internet helps in the IoT communications [10]. Moreover, cellular networks are best for wide coverage of devices. Also, literature depicts that CIoT is suitable for activities in which real time data is valuable and important [11]. Research study shows that CIoT has not gain enough importance in the literature [12]. Furthermore, authors suggest that CIoT will substitute other IoT communication technologies in upcoming years and use of CIoT will immensely increase in coming years [12]. Besides these, 5G cellular networks is also a resource efficient technique which can accommodate many IoT tools [13].

This topic was chosen as literature states that IoT and 5G technologies are key factor in shaping future of internet in upcoming years [3]. Similarly, recent literature shows that IoT is an emerging research area [14] and because of it a smart environment is created in different business and non-business sectors. Moreover, research study depicts that advancements in wireless technologies are leading to a unique concept from the last few decades known as IoTs [15]. Furthermore, three different categories were chosen to be studied in which IoT is playing key roles. These categories include Health sector, Sports sector, and Transportation & Logistics sector. Health sector was chosen as recent literature states that research communities and public sectors are showing interest in studying IoT application domains in healthcare sector [16]. Also, sports and transportation and logistics was chosen for this study because research studies depict that advancements in IoT are getting more important day by day as they are driving the international competitiveness of the sport industry [17] and adoption of IoT technologies is being considered an essential step to make transportation and logistics business more effective and efficient [18], respectively.

2 IoT Category

To study the latest progressions and challenges being faced in IoT across various areas, different research papers, journal articles and authentic works were collected. For this study, papers and articles were used by exploring and searching different databases available. These databases include IEEE, Elsevier, ResearchGate, Electronics and other digital libraries. After collecting different literature works, each of the paper was placed in one of the areas and extensive literature was explored. The areas selected for studying IoT healthcare, sports, and transportation.

2.1 Role of IoT in Healthcare

There has been immense advancement in health sector after the emergence of IoT. IoT has been successful in altering hospital centric care to partially home-based care [19]. Moreover, it is helping people who are living far away from main cities in taking good care of themselves against chronic diseases like diabetes and high blood pressure [19]. Progression in IoT has helped these patients in collecting data without any hinderance in their daily routine as these devices can measure required factors anywhere that is in hospital, home, or workplace. IoT helps in detecting symptoms of these diseases at earlier stages [20]. In other words, IoT has made it easier for medical practitioners to monitor health conditions of people without physically going to hospitals.

With the help of IoT techniques, different miniature sized devices are invented which can record various parameters of human body. Study reveals that these devices can either be worn or implanted in human body and symptoms can be monitored through sensors in the form of subsequent physiological signals [21]. Literature shows that there are different devices which are using CIoT concept vastly in measuring symptoms related to different health problems. ECG electrodes is one such example which helps in detecting electrical impulses with the human heart beating [22]. Similarly, there is another device called blood pressure machine which calculates the blood pressure in human arteries when pumped. Also, a sensor named blood glucose is a small device which can determine the blood glucose level. Furthermore, there is a vital sign monitor which works on the Bluetooth technology connected with sensors to measure heartbeat rate and respiration rate for monitoring purposes after cardiac attacks [23]. Moreover, this monitor not only measures but also alert doctors if any abnormalities are observed as this system works on sensors and complex IoT algorithms [24]. Based on above discussion, it can be said here that from as

small as measuring heartbeat to as quick as monitoring blood flow inside human body, all can be recorded and assessed through devices operating on IoT based technologies.

For healthcare systems, activity recognition and context living, IOT has significantly become apparent in not only collecting information but also monitoring and sharing experiences [25]. A company named Augmedix has created a healthcare chart by using IoT algorithms which assist doctors and nurses to transit from traditional method to technology for assessing patients [26]. Moreover, CIoT has created secured ways to store patient databases in health departments. One of such examples is the usage of voice command system [19]. Similarly, there are many other systems using IoT for transmitting traditional health-based practice towards more technology-based systems. Health Smart Home is another example of it as it helps old patients to connect with their family and emergency staff members in case of fall or extreme irregularities. Moreover, ultrasound technology developed by Inter Company has also used this technology. Some other health sector developments based on usage of IoT are hearing aids created by Doppler laboratory, rural healthcare monitoring and control systems and ALERT system [19].

CIoT is an emerging area for e-health sector as different communication devices including smartphones, tabs etc have developed and numerous applications are created using these technologies to monitor human body. Furthermore, IoT including CIoT technologies are used to monitor wearable and sensor-based devices in health care [27].

Additionally, few studies depict that wireless sensor networks (WSN), wireless body area network (WBAN) and human bond communication (HBC) are significant areas for research in wearable sensor devices in healthcare [28]. HBC can help in determining and continuous monitoring of human body signs like fitness information, cardiac monitoring etc. Similarly, WBAN has the ability for checking blood pressure, oxygen level and other critical symptoms in a human body through different IoT applications [29]. Sensors for these devices can be hidden under clothes or inserted inside human bodies. Moreover, other significant works in health sector involves introduction of WSN based wearable devices including e-health application for monitoring human body while exercising [30], Ubiquitous Health- care applications uses WBAN for real time assessment [31], e-health tracking through various wired and wireless sensors [32] and biomedical information of patients through smart healthcare system which works on IoT aware architecture [33]. Broadly, IoT plays significant role in clinical care, remote checking, and context knowledge in health sector [34].

Overall, based upon the above discussion, it can be said here that IoT is becoming immensely important in health sector as several applications based on this technology are being used in monitoring glucose level, electrocardiogram observation, blood pressure, body temperature and oxygen saturation monitoring. Besides these, IoT applications are installed and helps in medication management, wheelchair management, secure records, and healthcare solutions by smart phones.

2.2 Role of IoT in Sports

In sports especially fitness related industry like gyms, consumer wearables working on IoT applications are immensely becoming popular [35]. Now a days, people are highly focused on being fit and monitor their daily health and fitness by doing different sports and exercises. Literature depicts two different types of devices which are using IoT technology that are body worn and sensor embedded in sports [36]. Wearables devices which are playing important role in monitoring and recording daily fitness are working on CIoT technology. The best example of these are the smart phone applications in which sensors record the human body levels and help people know how fit they are. Similarly, there are multiple wearable devices which are working on IoT principles like Fitbit helps in accessing human body while sleeping and exercising [35]. The key of using these wearable devices in sports in to measure exact performance of an athlete without any delay due to physical movements. On the other hand, body sensors are embedded on specific parts where they can work best. In other words, externally visible devices are the wearables whereas sensors are usually hidden inside clothes, but both are functioning on IoT domain applications.

Furthermore, importance of wearable technology using IoT as a base is becoming significant day by

day. Wearables are used to track spine movements which are of great importance when doing different sports [37]. Also, wearables are used in monitoring time health sports for players. A research study depicts that a single sensor using IoT technology is capable of performing multiple functions for example a sensor can measure both gestures and gait monitoring of player while doing sports [35]. Besides this, to measure head injuries, American football uses sensors embedded in their helmets [38].

One other research study shows that they have made an iBall through which they can track ball trajectory and spin in cricket [39]. This iBall was made based on the sports analytics using IoT technology. Besides this, IoT analytics shows significant role in analysing ball patterns, predictions and other insights through sensors-based cameras [39].

There are many other IoT based devices being used in sports. Some of them includes FitBit fitness bracelets, Hexoskin smart shirts and Apple wrist watches. They all help in monitoring different things while a person is doing some sports activity. Also, CIoT based several applications are being used in sports including miCoach app in which data can be transferred using miCoach small ball while using ball in the sports [40]. GolfTEC is a device used in golf play to measure angles and spin rates of ball. K-VEST is another IoT based technology which is used in golf to monitor hands, hips and shoulder movements [40]. It can be understood here that IoT is playing a significant role in several sports including cricket, football, golf, and others.

On the other hand, in sports, players reactions and performance are also considered important and sports analytics plays key role in this area as well. Player reactions in tense situations are gathered through different algorithms used in IoT to measure their physiological patterns [41]. Moreover, research studies are being conducted in many sports field which can replace the real trainer with a virtual trainer which will work on principles on IoT Technology and help in predicting training schedules [41].

Based on the above discussion, it can be argued here that in sports, IoT is considered relay important as IoT technology is being used in wide range of sport activities including exercise, running, playing cricket, golf, football and even measuring gestures and reactions of players while performing specific sports activities.

2.3 Role of IoT in Transportation and Logistics

Transportation plays an important role in the process of development. Supplying inventories, passenger mobility, logistics and moving inventories all these involves transportation. Transportation serves as a primary connection between supply chain and logistics. Logistics can be defined as “providing availability of the right product, in right conditions, in right amounts, in right place, in right time, with right cost and for a right customer” [42].

IoT emergence in the field of transportation and logistics helps in resolving several issues including conveniences, navigation issues, service cost and security issues [18]. Furthermore, IoT systems are being used in monitoring vehicle movement, tracking location and continuously monitoring vehicles in case any accident or risk occurs [18]. Moreover, few vehicles contain such products in which internal temperature and humidity is to be kept at a certain level. Through IoT technology, temperature, humidity, and light conditions can be monitored continuously in these vehicles [18]. Navigation systems are now installed in different devices using IoT and can provide guidance to all types of transport like water, air, and road transports.

Likewise, imports and exports are also managed using IoT in which a centrally controlled system is connected through an IoT network [18]. Also, IoT is being used in controlling traffic signals and managing traffic on roads. IoT applications have tremendously benefitted the transportation and logistics sector. An On-Board Diagnostic data system can monitor fuel range and locate nearest fuel station using android integration. This system help driver in locating nearest fuel station through map without wasting time [43]. Additionally, speed adjustment, weather warnings and metering routes to avoid congestion has been set in various vehicles using the CIoT applications [44]. Also, IoT help people in planning their journey as it gives them information about traffic conditions and incidents which happened on their planned routes [45]. Besides these, different blockchain and IoT technologies are proposed by authors

which are playing a significantly important role in transportation of dangerous products [46].

Literature shows that a web-based application was devised which offers a user interface for the traffic centers [47]. Moreover, through this user interface, traffic administrators can save the location, scan multiple Bluetooth devices and other similar characteristics of the transport. One other application is based on CIoT using android platform to help depict range of time between two points during transportation [47]. Besides these, various video cameras, ultrasonic sensors and other hardware devices are used to assess ongoing traffic.

IoT role in transportation and logistics is of immense importance as it is using IoT from small functions of planning route journey, navigation, weather warnings, controlling traffic conditions, tracking vehicles to giant functioning involving management of imports and exports from one country to another. In other words, it can be said here that IoT is one of the major elements in ensuring efficiency and effectiveness in transportation and logistics sector.

3 IoT Challenges

3.1 Security

IoT algorithms and wide connections of data collected through various devices is a big challenge to security of these systems. Specifically, in sports and health sector as discussed above, different wearables devices are used and one of the key challenges in these wearables detecting devices is maintaining security with keeping system complexity low and ensuring light weight for each of consumers.

3.2 Privacy

Privacy breach is a common issue in IoT as people are sharing their personal data and sometimes, unauthorized nodes in applications can compromise the data if proper privacy laws are not implemented. Especially, in healthcare, people share extremely sensitive data about their health conditions and disclosing it to someone they don't want can have a worst effect. There is a need of clear privacy policies to develop trust of people using applications working on IoT technology.

3.3 Reliability

IoT system runs offline if the power shuts or local internet service provider is experiencing an outage. Beside these, natural disaster, heavy rainfalls, and similar emergencies have a bad effect on IoT operated devices and systems. This can cause serious damage to the user in terms of data losses and disruptions.

3.4 Consumption of Various Resources

IoT applications need a continuous support from different technologies like gateways, hardware etc and usually these devices need some back up energy source to operate, which if lost, system becomes not useful. For example, in gyms, most exercise machines monitoring different human body things are working on electricity and without that, they are of no use. Researchers are working on devising methods by which devices can work more efficiently with little or no energy consumption.

3.5 Policies and Regulations

In some industries, still people are not adopting latest IoT technologies due to lack of proper policies and regulations available. For example, in sports sector, some sports clubs do not prefer using wearable IoT devices due to their leagues regulations although their usage there is feasible to implement.

4 Conclusion and Future Research Scope

IoT is offering numerous new opportunities in many real-life applications in various business and non-business sectors. This paper highlighted important research studies conducted in IoT in three major sectors that are healthcare, sports and transportation and logistics. Several research papers were deeply studied and different devices operating based on IoT technologies are revealed in the above mentioned

three sectors. Furthermore, paper highlighted few challenges related to IoT and its usage. However, IoT is playing significant role in other sectors including industries, education etc but usage of IoT in these sectors is beyond the scope of this research paper. Also, security and privacy issues are one of the greatest challenges in IoT applications and this study just highlighted few points about it, but a comprehensive research study is still needed to ensure a secured IoT network for clients.

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