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Challenges and Solutions for Applications and Technologies in the Internet of Things

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Abstract

It is undeniable that the Internet of Things is an emerging research area encouraging numerous exciting solutions to many problems encountered in numerous domains. The aim of this paper is to study the literature review of electronics applications in the context of the Internet of Things' challenges and solutions for emerging sensors and electronics applications. The analysis topics include: a review of electronics applications in the Internet of Things (IoT); what is the IoT; innovation directions of the IoT; IoT applications in the context of electronics; the IoT and future Internet technologies.

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Keywords: Internet of Things (IoT); IoT Innovation; Challenges; IoT direction

1. Introduction

The world has now entered into an extraordinary period in which company services or products and electrical devices (e.g., sensors) are connected devices. These devices communicate with each other without any interaction with a human. For example, smart sensors in traffic and road control structures assemble information about traffic status and roads, weather conditions, etc. In another word, the potential advantages of the IoT are virtually unlimited and today's IoT-based applications are changing the way we live and work by saving time and organisational resources and bringing new opportunities for development, innovation, and knowledge formation [1-2]. Successful

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IoT applications allow private and public business organisations to control their assets, optimise business performance, and design new business models. As the IoT often involves instruments for the interconnecting of devices and for operating as a general enabler of a hyper-connected society, the IoT has enormous potential to facilitate an aging society, to optimise all types of transportation and mobility, and improve energy effectiveness.

However, researchers are still facing many challenges in this area, such as (1) establishing safe and secure communication with different components at the network edge; (2) how to save energy using robust and reliable smart electronic sensors in infrastructure; (3) IoT technologies related to data secrecy and addressing confidentiality concerns; (4) identifying, assessing, and monitoring serious system components; and (5) ensuring an adequate level of secure exchange of information and trust between different vertical information technology infrastructures. Therefore, it is important to explore the topic in depth [3-4].

This paper aims and objectives are as follows: an in-depth literature review of electronics applications in the Internet of Things, factors affecting sensors and electronics applications in the Internet of Things, and challenges and solutions for emerging sensors and electronics applications in the Internet of Things.

2. Literature review and analysis

In this section, we present an analysis of the literature on this proposed topic in the context of: what is the IoT; innovation directions of IoT; IoT applications in the context of electronics; IoT and future Internet technologies; networks and communication; processes; data management and security; and trust and privacy.

2.1. What is the internet of things (IoT)

The term IoT was first used by Kevin Ashton from the United Kingdom in 1999. Ashton is considered a pioneer in the field of information technology [5-6]. Kevin Ashton defined the system as a state of combination of several objects and where objects are physically connected to the Internet by sensors. He invented the term to demonstrate the rule of joining Radio Frequency Identification (RFID) dockets, used in business for supply chain processes, to the Internet in the context of tracking and counting products without any intervention from humans [5-6]. Today, the term IoT has become very popular and widespread for describing situations in which computing ability and Internet connectivity spread to a variety of sensors, devices, objects, and day-to-day items [6].

Though the term IoT is comparatively new, the idea of combining networks to monitor, and computers and different devices to control, this overall process has been around for years [5-6]. In 1970s, for instance, information systems were used in the commercial sector in order to remotely access and monitor electrical meters on the grid through phone lines. Moreover, in the 1990s, developments in wireless technology permitted interaction between machines, known as “machine-to-machine” industrial and enterprise solutions for equipment operation and monitoring, which have now been widely accepted [7-8]. However, many of these early machine-to-machine solutions were only suitable for closed purposes, such as the specific standards of companies who built closed networks rather than building on Transmission Control Protocol (TCP), Internet standards or on Internet Protocol (IP) [7].

Connecting devices other than computers using TCP and IP is not a new idea. The very first Internet device, in which an IP permitted a toaster to be controlled over the Internet to allow the user, for example, to turn it on and off, was a feature invented during an Internet conference in 1990 [8]. After some years in the same century, other “things” were IP–permitted. For example, Carnegie Mellon University invented a soda machine in the United Kingdom that remained connected to the Internet until 2002. From these fanciful early stages, strong development and research into this field formed the groundwork for today’s IoT [7-8].

The IoT in the context of emerging sensors and electronics applications is about interrelating embedded systems. This brings together two growing technologies: smart sensors and wireless connectivity. Joining with current developments in low power microcontrollers, the connection of these new "things" can happen economically and easily, accompanying a second manufacturing revolution [8]. These associated embedded technological systems are based on small microcontroller computers, which do not need an interface for humans. Rather than connecting and interacting with humans, these types of systems have detection mechanisms that are technologically advanced and use different sensors [8]

These technologies and sensors gather data that have company value and are part of a huge system. These data are then connected as a fragment of a larger system. Though the term IoT suggests that these technologies and sensors are connected through the World Wide Web by means of Ethernet or WiFi, the networking could also be achieved by means of networking procedure, such as Bluetooth, a technology that does not use an IP address to connect to another device [9-10]. In this context, the networking protocol is designated on the distribution of network nodes and the amount of data to be gathered [9].

2.2. Innovation directions of the IoT

Research and development in this proposed area of enabling applications, tools and technologies, such as nano-electronics, sensors, phones, and their applications (particularly smart phones); embedded information systems or applications; communication; cloud networking; software; and network virtualisation, will be important to deliver to "things" the capability of being connected all the time universally [9-10].

This may also provide and support significant upcoming innovations in IoT products and services and this varies across businesses and sectors [10]. Many of the above-mentioned technologies [11-12], such as systems related to cyber-physical and embedded systems establishing the boundaries of the IoT and reducing the non-alignment gap among the physical world of actual things on the Internet and cyberspace, are sometimes critical in permitting the IoT to convey its visualisation and aims, and it has now become part of better systems services in an environment of systems for systems. Many researchers have identified empowering applications and technologies critical to many of the current and upcoming value chains of European economies, including innovative materials, photonics, advanced engineering systems, and biotechnology [10]

The IoT forms intelligent technologies and applications that are recognised on the supporting Key Enabling Technologies, shown in Fig. 1. For example, IoT applications report smart atmospheres at cyberspace or physical levels on the basis of run and real time [3-5, 7, 13]. Moreover, many researchers suggested that from a technology and application perspective, the unceasing increase in the incorporation solidity among different IoT devices reveals the following two important parameters [8, 10, 14]: Firstly, the issue of minimising the perilous dimensions whilst holding the electrical pitch constant, and secondly, minimising power consumption of electronic circuits. These two parameters have been widely addressed from the research point of view and have become driving forces of the smart and microelectronics commerce industry along with incorporation solidity [10, 12, 15].

Research from the International Technology Roadmap for Semi-conductors highlighted in its initial versions the concept of "miniaturisation" and its related advantages from the viewpoint of performances and the basic parameters in Moore's Law [1, 2, 7, 8]. This movement for augmented performances will remain, although performance can be continuously operated against electric power based on the individual technology and application, continued by the amalgamation into electronics devices in the context of new materials, and the technology of new transistor notions [10, 14]. Literature shows that these new directions have been considered as "More Moore" by different researchers. The second trend that the literature shows is the functional divergence of semi-conductor constructed electronics devices. These non-digital applications do add to the reduction of electronics applications or systems, though these types of applications do not essentially enlarge at a similar range to the one that labels the improvement of digital application or functionality [2, 3, 5].

On the other hand, the market for wireless communications and networking over the IoT is a rapidly growing segment in the incorporated circuit industry [4, 5, 8]. Amazingly fast and secure innovation, quick changes in networking and communications principles and standards, the emergence of new stakeholders, and the development of sub-segments in the market will lead to distractions across commerce [5, 8, 9, 16]. This is why the IoT field is built on the idea of aligning and supporting the IP protocol in order to limit the access of the Internet. On the other hand, the fact is that there are still many devices that are not able to support and maintain IP protocol stacks [5, 10, 15].

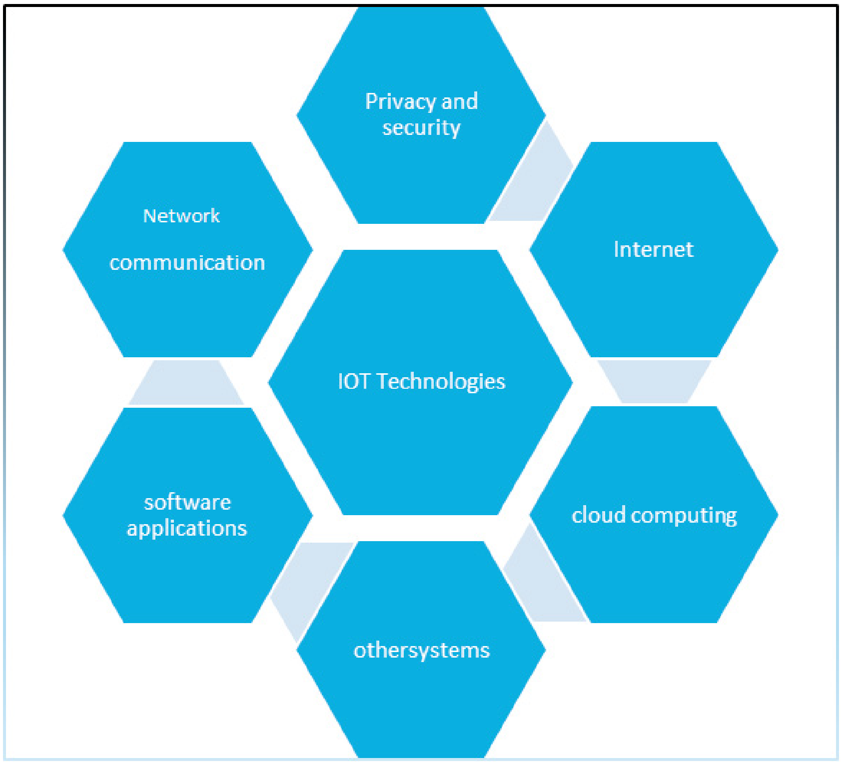

Fig. 1. Enabling technologies in IoT.

3. IoT applications challenges and existing solution and future directions

It is incredible to visualise all the possible IoT applications, having in mind the progress of information technology and the distinct requirements of potential operators. This section presents the numerous applications of the IoT. This section also presents the descriptions of the most-used applications and examines the challenges that have also been identified. IoT technology and related applications are focused on societal requirements; developments to permitting technologies, such as cyber-physical systems and nano-electronics, remain to be challenged by, for example, institutional issues, issues related to engineering and science, and economical issues.

3.1. Smart cities

Literature shows that by 2025, we will see the progress and development of mega-cities—networked, branded, and integrated cities [5, 10, 13]. It also shows that with more than 70% of the world's population predicted to live in municipal cities by 2035, development as a movement will have separating influences and impacts on personal mobility and lives [5, 6, 8, 9]. There is fast development of city boundaries, determined by increases in infrastructure development and population. This may force city boundaries to expand and consume neighbouring daughter cities, forming mega-cities, with each city having a population of more than 11 million people. By 2025, there will be 32 mega cities internationally, with 57% in developing economies, such as Latin America, India, Russia, and China.

This, as a result, will lead to the development of many smart cities around the world with many smart features, which include: smart planning, smart ICT development and infrastructure, smart energy, smart buildings, smart citizens, smart governance, smart economies, etc. [3, 5, 8]. This is why there will be about 50 smart cities internationally by 2030. The role of the cities' administrations will be vital for IoT arrangement and growth [5, 8, 9, 15]. Running of the city processes on a daily basis and the formation of city expansion strategies will determine the employment of the IoT and related applications [5, 8, 9, 16]. Therefore, cities and their facilities characterise an ideal stage for IoT study, taking into account city necessities and transporting them to resolutions enabled by IoT applications and technologies. For example, in Europe, the biggest smart city initiative entirely based on IoT is assumed by the project FP7 Smart Santander [1, 3, 5, 7]. The aim of this project is the deployment of an IoT infrastructure encompassing thousands of IoT devices, spreading across numerous cities, including Belgrade, Guildford, Luebeck, and Santander. This permits instantaneous development and assessment of services and implementation of numerous research tests, therefore enabling the formation of a smart city atmosphere [5, 6, 8, 10].

In this context, there are many significant study challenges for smart city IoT features and applications [2, 4, 5, 6, 8]. These include:

- Devices for cost effective placement and even more significantly, maintenance of such connections and desirable energy scavenging
- Confirming consistent readings from a glut of sensors and effective standardisation of a huge number of electronic sensors used ubiquitously from lamp-posts to over-flowing bins
- Stumpy energy algorithms and protocols
- Algorithms for processing and investigation of data developed in the big city and making feel of it
- Overcoming old-style silo constructed societies in cities, with every utility accountable for their individual, closed world. Though not technical, this is a key difference.
- Developing algorithms and structures to define information shaped by sensors in dissimilar submissions and services to allow valuable exchange of information among different countries' cities and their services

3.2. Smart energy and electric grid

There is growing public responsiveness regarding shifting societal strategies in energy supply, infrastructure, and energy consumption. For numerous reasons, societies' future energy management and supply may no longer rely on vestige resources [10, 15, 14]. Significantly, imminent energy supply requirements will rely largely on numerous renewable infrastructures and resources. Gradually, emphasis must be focused on people's energy consumption and societal behaviours. The unpredictable nature of energy consumption, such as in energy supply, demands a smart and reliable electrical grid that is able to respond to power variations through regulatory sources related to the electrical energy sources, such as storage and generation, and sinks, such as energy load and storage, with appropriate reconfigurations. Such applications and functions will be founded on networked intelligent applications and devices and electric grid infrastructure components, mostly grounded on IoT ideas [10, 15, 14].

3.3. Smart buildings, homes, and infrastructure

The growth of the Internet's and Wi-Fi's roles in home computerisation has mainly come about because of the networked nature of different installed electronic devices, such as mobile devices, LCDs, and TVs, that are an ongoing part of the home Internet Protocol network, and due to the growing rate of mobile phone use and the use of other computing devices, such as tablets and smartphones [4, 7, 8, 17]. The IoT in this context connects people and devices in the same home, in the same building, and even in the local area network. Networking characteristics include the fetching of network playback and the online running of applications and services while becoming the average control electronic devices and their functionalities over the network. Moreover, at the same time, tablets and mobile devices guarantee that customers have access to a transferrable 'controller' for the microchip technology coupled to the network [5, 8, 10].

3.4. Smart health in IoT

The marketplace for e-health monitoring devices is presently characterised by precise solutions that are equally non-interoperable and designed based on various architectures and platforms. Although distinct products are planned based on cost goals, the sustainable goals of attaining lower information technology costs across current and upcoming areas will be unavoidably interesting, except a more intelligible method will be used.

4. The IoT and future Internet technologies

It is widely accepted that information technology is nowadays used widely in our lives. Particularly, new ideas, concepts, tools, and techniques emerge very quickly in comparison to the past. This section presents the IoT and its related future Internet technologies and their analyses, as shown in Table 1 [4, 5, 6, 8].

Table 1. The IoT and future Internet technologies.

Related technology	Description
Cloud computing	Cloud computing is a type of Internet-based computing and hosted remote server for the storing, editing, managing, and processing of company data. In the past, this whole process was conducted on a personal computer or local server.
Semantic technologies	Semantic technologies play an important role in allowing the sharing and reengineering or re-use of virtual things as a service over the cloud. The semantic technologies in this context enrichment of virtual thing explanations will realise for IoT and who/what semantic explanation of website pages has allowed in the semantic web services.
Autonomy	The IoT will exponentially increase the complexity and scale of current communications and computing information systems. Autonomy is therefore an important part of IoT systems. However, there is still not much research on how to tailor and adapt current research on autonomic technology to the precise features of the IoT, for example high distribution and dynamicity, resource constraints, lossy surroundings, and real-time nature.
Situation awareness and cognition	Integration of computing, communication, and sensory devices such as GPS, tablets and smart phones into the Internet is becoming common. This is the ability to collectively extract “content” from where the data are produced and recognise them from the perspective of the broader application domain. This capability to extract content is always critical and complex, particularly when we study the quantity of data created.

5. Conclusion and limitations

The Internet of Thing is growing around vertical stages, precisely suited to given situations and espousing exclusive communications, resource control, and device protocols. The developing requirement for cross-domain IoT services and applications points out the requirement for interoperability across IoT stages for a combined and protected allocation of and access to detecting resources. Literature shows that researchers are still facing many challenges in this area, such as the establishment of safe and secure communication with different components at the network edge; how to save energy using robust and dependable smart electronic sensors in substructure; and guaranteeing an adequate level of secure sharing of information and trust among different vertical technology infrastructures. Therefore, it is important to research the topic in depth.

This reviewed presents electronics applications in the Internet of Things, which was further subdivided into the following factors: what is the IoT; innovation directions of the IoT; IoT applications in the context of electronics; the IoT and future Internet technologies. However, the paper is limited to the number of journal papers and conference proceedings available, which indicates future research required.

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