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Review Article

Internet of Things (IoT) for Sustainable National Economy Development

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Abstract

The Internet of Things (IoT) is a nascent network of things that communicate between themselves and other internet enabled devices over the internet, it remotely monitors and controls the physical world. Having been an essential incorporation of Radio Frequency Identification (RFID), mobile, wireless and sensor devices, it has also given a challenging but commanding opportunity to configure the existing systems by making them intelligent. IoT will yield several benefits for various establishments, but as applicable to other technology adoptions, it may also introduce unpredicted risks thereby requiring significant organizational transformations. This paper presents major enabling technologies, key IoT applications domains, impact on business, economy, job skills, society and identifies research drifts and challenges encountered in turning IoT to a reality.

Key words: Internet of things, radio frequency identification, network, sensor, economy development

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INTRODUCTION

Till date, billions of people around the world are using the internet to send and receive the e-mails, access the web content, use social networking and do a several activities. Gradually, a lot of people will be having access to the vast available information, thereby taking Internet to a higher level where appliances and smart devices will be interacting with each other. As time goes on, the Internet will grow as a huge network of networks and networked different devices. Required and valuable information and services will always be available, which will make it easier to design newer applications, introducing newer methods of working; newer methods of communicating; newer methods of entertainment; consequently, leading to newer ways of living[1]. This will give rise to a new concept of connecting 'smart' devices[2]. Deployment of IoT will silhouette the Internet in such a manner that it will become real Machine-to-Machine (M2M) learning[3]. Restructuring will occur by making physical devices 'smart'[4,5] and the Internet infrastructure will exist as a robust backbone thus, making them possessing self-configuring proficiencies based on standard and interoperable communication protocols where physical and virtual 'Things' have identities, physical features and virtual traits and make use of intelligent interfaces that are seamlessly integrated into the information system[6], giving rise to 'Internet of Things.' The IoT goals are to make the use of smart technologies by linking things anytime to accomplish anything at any place. The IoT concept came into being in 1998 and presented by Kevin Ashton[7] in 1999. It mainly allows for independent nonetheless secure connection for the interaction of real world devices[8,9]. The IoT reduces physical work by automating day to day tasks[10]. The things which are connected to Internet are increasing rapidly. The smart phones drive in several actuators and sensors which sense the data, perform computation operation on that data and transmit the valuable information with the aid of Internet[8,11,12]. It is anticipated to offer promising solutions to transform the operation and role of many existing industrial systems such as transportation systems, healthcare system and manufacturing systems. Example include when IoT is employed for forming intelligent transportation systems, thereby enable the authority to be able to track and monitor the movement of each vehicle's current location and forecast its imminent setting and possible road traffic[13]. Likewise, in healthcare, it will analyze the state of the patient in real-time and provide the detail information at interval and broadcast the information to the medical personnel for monitoring, this can also be monitored anywhere[14,15]. Xu *et al.*[6] referred to IoT as a uniquely identifiable interoperable connected object with Radio Frequency Identification (RFID) technology. Soon after, researchers relate IoT with more technologies like mobile devices, GPS devices, actuators and sensors. Unambiguously, the integration of sensors/actuators, RFID tags and communication technologies serves as the basis of IoT and explains how a variety of physical objects and devices around us can be associated to the internet and be allowed to cooperate and communicate with one another to reach common goals[8,16]. There are many benefits in implementing IoT, this will result in huge data offers and potential for organizations to obtain valuable perceptions. Nevertheless, risks and factors abound which may have significant impacts on the utilization of IoT. Newer applications can be created using network with various embedded sensors, this will result in great benefits[11]. Collected data over the Internet for processing by the processing unit is shared by the sensors. The result is communicated to decision making and action invoking system for appropriate action.

CONTEXTUAL AND SCOPE

Internet of Things (IoT) can be described as a comprehensive network framework that consist of numerous connected real world things, which depend on sensory, communication, networking and information processing technologies[16]. The center technology for IoT is RFID which works by allowing microchips to transfer identifying data to the reader via wireless medium. Through RFID, objects connected can be analyzed, traced and monitored with RFID tags[17]. Wireless Sensor Networks (WSNs) and their fundamental technology, mainly works on intelligent sensors for sensing and monitoring. The RFID finds its application in transportation of goods to consumers[18,19], production of pharmaceutical goods and retail since 1980s and WSN applies to traffic, industrial monitoring and healthcare[20,21]. The advancement in the technologies quicken the growth of IoT. A lot of other technologies and devices including barcodes, location based service, SoA, near field communication, Internet (IPv6), 3G/4G, Wi-Fi, ZigBee, Wimax, Cloud Computing etc., are also getting used to make a comprehensive network to empower IoT[6,22-25] (Fig. 1).

Divers descriptions of IoT co-exist since everyone gives it a meaning according to their own perspective leading to obvious fuzziness. The definition is a mix of two terms Internet and things. The former gives a network oriented idea whereas

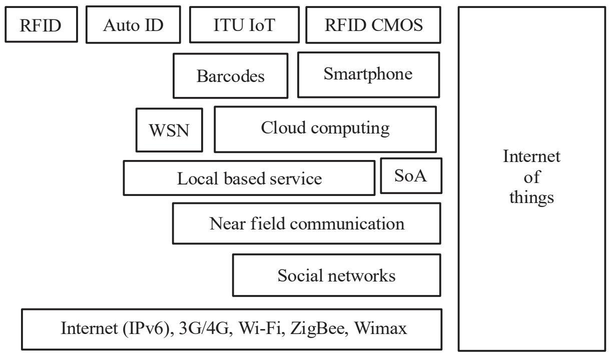

Fig. 1: Technologies associated with IoT
Source: Tan and Wang[26]

the latter pushes towards objects which are merged as a single architecture. IoT implies on world-wide network of interconnected things distinctively addressable based on standard communication protocols[26]. The biggest challenge in IoT is to exceptionally identify each object in parallel with representation and storage of the information that is exchanged among the objects. The three ideas of IoT[27] are: Things, Internet and semantic oriented.

Things oriented idea: Each objects tracked by sensors and technology using RFID is uniquely identified by Electronic Product Code (EPC). Data is collected through sensor based embedded systems and sensors. This depends on RFID based sensor and other networks that are sensor-based which integrate RFID based technologies, sensing, computing devices and global connectivity.

Internet oriented idea: Different physical devices interact with each other. Sensor based devices can be determine, controlled and monitored regularly. These smart embedded objects can be considered as microcomputers with computing properties.

Semantic oriented idea: The huge collected data is processed effectively. In order to make data consistent and least redundant, the raw data will be processed which is an advantage for better representations and interpretations. From the perspective of 'Things', IoT concentrates on the integration of smart devices in a single architecture. Where the Internet perspective gives IoT a network oriented meaning. With Internet Protocol (IP) being the worldwide acknowledged protocol to link the various communicating objects, it has the power to make IoT a reality.

Finally, the number of devices that will be connected through IoT will be enormous in number, so, the issues related to storage, search, representation, interconnection and management of the collected information will be quite challenging. To tackle this, vast information generated by IoT will be brought about by semantic technologies.

IoT ARCHITECTURE

The IoT connects several billions of devices together, in such a situation, generation of traffic is inevitable, to handle such huge data storage will be needed. Security and privacy issues also needs to be given a high priority when proposing the new architecture for IoT addressing interoperability, Quality of Service (QoS), scalability, reliability among others. The primitive architecture of IoT is proposed by Tan and Wang[26] and Gan *et al.*[28].

The five layered architecture of IoT shown in Table 1 is described below:

- **Perception layer:** The perception layer also called as device layer is consist of physical devices and sensors which includes RFID or barcodes based on identification of the objects. Device layer works on identifying and collecting the information through sensor devices. Depending on the nature of the sensors needed for data gathering, the data can be geographic, temperature specific, orientation specific etc. The collected data is thus sent to network layer for its secure transmission and processing
- **Network layer:** The network layer is also known as the transmission layer. This layer consists of secure transmission of information collected from sensors to the information processing system. The medium of transmission can be wired or wireless and the technology can be 3G/4G, UMTS, Bluetooth, Wi-Fi, Infrared, ZigBee, etc., based on the sensors. Therefore, the network/transmission layer is responsible for conveying the information from device layer to middleware layer
- **Middleware layer:** This layer consists of ubiquitous computing, data base, decision unit, service management and information processing. Each of the smart objects communicates with other devices only if they implement same service type. Data is taken from the network layer and stores it in the database. It processes information and decides the solution by analyzing the results

Table 1: Five layered architecture for IoT

Layers	Description
Perception	This layer is integrated with existing hardware to sense/control the physical world and data acquisition, it consists of Physical objects, RFID, Barcode, Infrared sensors
Network	This layer consist of secure transmission, 3G/4G, UMTS, Wi-Fi, Bluetooth, Infrared, ZigBee which provide basic networking support and data transfer over wireless or wired network. Network layer is responsible for transmitting the information from device layer to middleware layer
Middleware	Consist of ubiquitous computing, Data base, Decision unit, Service management, Information processing
Application	This layer is responsible for smart applications and management
Business	This later cost of Business model, Flowchart, Graphs and System management

- **Application layer:** This layer is responsible for smart applications and management globally which depend on the processing of information in the middleware layer. The numerous applications of IoT include smart city, smart transportation, smart home, smart agriculture and smart health etc.
- **Business layer:** The complete IoT system in terms of the applications and services is managed by this layer. It makes Business model, Flowchart, Graphs and System management based on data obtained from previous layer. Depending on the result analysis, this layer will predict the future actions

APPLICATIONS

Though IoT is an emerging technology, its applications are still in their nascent stages. Not withstanding its possible applications can be found in healthcare, logistics, inventory control, supply and chain, transportation, security and privacy. Some feasible applications of IoT in different domains are as follows:

- **Smart homes:** Smart home deployment ranks as highest IoT application on all measured channels by managing energy consumption, providing communication among the home appliances, ensuring safety, spotting emergencies. More establishments are active in smart home than any other application in the field of IoT
- **Natural disasters prediction:** The sensors can predict the natural disaster like hurricane, earthquake, volcanic eruptions, tsunamis among others through their interaction, coordination and simulation in order to initiate feasible actions in time
- **Smart grid:** Smart grid is an emerging application of IoT, it makes use of information about the performances of electricity suppliers and consumers in an automated manner to enhance the efficiency, improve its reliability and economics of electricity
- **Health care:** Digital health/telehealth/telemedicine is an essential of IoT application. The concept of healthcare system and smart medical devices bears huge potential. This can be of great help in healthcare delivery by monitoring metrics associated with health, managing medicines in inventory etc. For the well-being of people in general, large-scale startup successes and prominent use cases are yet to be seen
- **Smart cities:** Internet of Things (IoT) application can also be found in designing smart cities e.g., traffic management to water distribution, observing and controlling the good air quality, waste management, identifying emergency routes, urban security and environmental monitoring etc. Its acceptance is precipitated by the fact that many smart city solutions such as; traffic congestion problems, reduction in noise pollution among others will be alleviated
- **Smart farming:** Internet of Things (IoT) will revolutionize the way farmers work through monitoring the remoteness of farming operations and the large number of livestock. Various use case scenarios include smart wrapping up of seeds, fertilizers to cater to environmental conditions. This hasn't reached large-scale attention yet. Smart farming will become the important application field mostly in the agricultural product exporting countries because it will drastically enhance the productivity by averting the incorrect farming practices
- **Smart transport:** IoT sensors can be applied to transportation. Smart network of sensors will effectively and efficiently monitor the traffic and implement effectively the much required features such as alleviating traffic, law enforcement, electronic highway toll, rules breaching by vehicles among others
- **Smart security:** The IoT sensors also find their applications in the area of security e.g., inspection of spaces, maintaining infrastructure and equipment, alarming etc.

KEY CHALLENGES

Despite of the enormous applications of IoT which will keep increasing with time, it must overcome some challenges pertaining to privacy, sufficient spectrum, complexity, reliability in associating with large number of smart devices etc. A few possible main challenges are listed in the section below[25,27]:

- **Unique identity management:** The aim of IoT is to connect several billions of physical objects together which should be uniquely distinguishable over the Internet. Consequently, suitable identity management system is required which will systematically and dynamically assign and manage unique names for a wide range of physical devices
- **Standardization and interoperability:** Different technologies that are not known to everyone are employed through the introduction of different devices by many vendors. A standardized mechanism should be in place to ensure interoperability and interconnectivity of all the physical and sensor devices
- **Privacy of the information:** Because IoT uses various identification technologies such as; RFID, Barcode, Infrared sensors etc., which will be carrying tags, its therefore imperative to ensure privacy of the information and preventing unauthorized access
- **Protection of physical devices:** IoT devices need to be prevented against physical damage and unauthorized access irrespective of their geographic location in order to safe guard its safety
- **Information confidentiality:** The IoT sensor devices transmit the information through the information media to the information processing system. Sensors should follow the encryption mechanisms in order to ensure the integrity of the information processing system
- **Network security:** The sensor devices send data either over wired or wireless transmission media. The transmission unit should process the enormous data without any loss of information and should integrate strict measures, so that, no external interference occurs. There is a need for the establishment of a standardized security protocol to address the scope and diversity of the devices as the IoT market matures

IMPACT ON BUSINESS, ECONOMY, JOB SKILLS AND SOCIETY

- Jobs will be created in the field of IoT, because new products, services and revenue models will emerge, this will give attract investments once the business worth of the IoT domain is understood and deployed. There is every tendency of increasing imports and exports for such products and resolutions, which in turn could push up economies, this is similar IT revolution in China, India etc.
- The implementation of IoT could result in the emergence of auxiliary or supporting industries and establishments such as monitoring and measurement systems, manufacturing of smart and connected systems, decision control system and analytics systems and security solutions to guarantee safe use and address privacy concerns
- Policies, guidelines and regulation to govern the usage of IoT would be defined to when it comes to the nature of information received by IoT devices, who can access it, how it will be used. This will boast user confidence in the technology and increase implementation. Deployment of IoT will also give rise to adoption of large data and analytics technologies that can provide insight to take meaningful resolution
- Opportunity can be created by the large number of devices and structure of IoT information especially in the areas of security, storage management, servers and the data center network, data analysis, creative design for end user conception, immense data frameworks, programming and architecting huge accessible systems and knowledge of devices used in the IoT environments will be in demand coupled with understanding business specific usage patterns, customer behaviors and innovative marketing techniques

CONCLUSION

The rising idea of deploying IoT has the potential of improving our day to day life by integrating various devices equipped with sensing, identification, processing, communication and networking capabilities. Industries have robust interest in deploying IoT devices to develop industrial applications such as; automated monitoring system, control, management system and maintenance system. IoT would automate virtually all events around us. This paper presented a framework of this concept, technologies empowering, its idea and various possible applications. This would impart relevant knowledge and offer a ground for researchers and scholars who are keen to have an insight into IoT, its key technologies and architecture. Furthermore, the impact on business, economy, job skills, society and challenges are also briefly discussed to give an insight about the issues faced in making IoT a reality.

SIGNIFICANCE STATEMENT

This study discovers the major enabling technologies and key IoT applications domains that can be beneficial for business, economy, job skills and society. This study will help the researcher to uncover the critical areas of IoT that many researchers were not able to explore. Thus, a new theory on IoT deployment may be arrived at.

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