Internet of Things Challenges and Opportunities

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***Abstract* — Technology is evolving rapidly, and cheaper and smaller devices that vary in size, computational power using cloud technologies or operating mode become available. These devices are always connected to form a network in order to enhance communication and data transmission. Such devices are largely referred to as smart devices e.g., smart homes, smart cities, smart cars, etc. that are connected to a complex infrastructure known as the Internet of things. Internet of Things generates a huge amount of data that poses significant challenges for processing and analysis. This research paper outlines various challenges and opportunities that are in the field of the Internet of Things.**

Keywords — IoT, Internet of Things, Computer Science, Challenges and Opportunities

I. INTRODUCTION

Technology has been changing people's lives since there have been many emerging technologies that have positively impacted humans' daily activities. An example of emerging technology is the Internet of Things (IoT) that appears to shift the entire social fabric of society. This technology is also known as Machine-to-Machine (M2M) [1]. It uses smart devices to collect data, share the information with one another, process the information collaboratively, and automatically take action [3]. In general, IoT refers to the extension of network and computing capabilities to sensors and devices that are not considered as computers where the interaction of machine to machine occurs with minimal or no human input.

Therefore, IoT is a new paradigm that is offering both challenges and opportunities in the world of computing [2]. Also, it is a game-changing technique since it uses sensors to detect information that people cannot detect, collect, and analyze at anytime and anywhere [1]. Also, robots can enhance human act, thereby overcoming human physical limitations since they can be given greater strength than that of humans and may go where people cannot e.g., where there is heavy radiation. Further, IoT through wireless communication and broadband internet technologies have enhanced human communication capabilities; for example, 5G and 4G wireless and greater internet bandwidth are now widely available worldwide. Also, machine learning and cloud technologies have surpassed human analytic capabilities where IoT devices are expected to analyze information with more massive computations, and through more mature machine learning techniques, that could not be processed in the past.

Almost every technology user will keep on demanding for improved technology techniques that will improve their lives. People want technology that will help them save more money, eat better, and sleep better. Also, technology such as fire warning systems and fire detection systems will help people avoid being in troublesome situations to predict future events. Also, technology helps in connecting people through phones, Emails, and the Internet. Therefore the above human desires can be met by the emerging Machine to Machine and related technologies. In addition, technology will always drive towards cost reduction of provisioning, automation of equipment, and value-added services and management efficiency, therefore, creating services that were not possible before. This research paper will cover some of the IoT applications, challenges resulting from the applications, and the opportunities that are created by these challenges.

II. APPLICATIONS

The most common sensing, analytic, and communication technologies are sensor networks, the Internet of Things, and cyber-physical systems. In the future, communication, processing capabilities, and digital sensing are expected to be embedded into everyday objects, therefore, turning them into IoT. With the help of cloud computing [5] and other similar technologies, IoT devices are able to communicate collaboratively to perform a given task either through human interaction or by machine themselves. Today, there is more Internet of Things connected devices that exceed the number of connected people, and also the capabilities of computations per device are rapidly increasing. Below are the applications of the Internet of Things.

- **Smart home -** Homes are equipped with heating and cooling systems that are mostly controlled using smartphones to control heating and cooling efforts when there are no people in the rooms. Here, IoT devices such as sensors are used to adjust air temperature and lighting; therefore, conserving energy without human interaction. These devices more popular and using the Artificial Intelligence and Cloud computing [8] power makes them so effective.
- **Used in enhancing vehicles' safety -** vehicles are installed with sensors that help in predicting a potential risk, therefore preventing vehicles from running on each other. Thus, sensors and inter-vehicle communication will collaboratively interact and alert the driver on what he/she cannot see and, in turn, reducing the collision rate.
- **Economic Agriculture -** IoT devices are installed in many large farms to assist in predicting and detecting outbreaks of pests, analyzing the pests, and providing detailed information on the right amount of pesticides that should be applied. These processes will reduce crop damage and curb the chances of overspreading the pests on the farm.
- **Assisted living -** In every society, there is a group of aged people who require proper care and attention. Therefore

IoT devices use sensors to monitor the health condition of elders and provide help. For example, a notification can be sent whenever an elder misses a dose.

III. CHALLENGES

IoT devices have been widely used for at least a decade now, but what has recently changed is the ubiquity of cloud services, analytics, and connectivity options, which are among the greatest enablers of IoT [4]. Cloud services have been providing a large amount of data as well as hosting intelligent software and networking many IoT devices. However, some challenges arise during the IoT adoption period that limits its application, as discussed below.

First challenge is security vulnerabilities, including privacy, denial of service, and sabotage. The main challenge is the regular hacking of high-profile targets on IoT devices [11]. The results of denial of service and sabotage have always raised a more serious challenge than a compromise of privacy. For example, stopping a more common activity such as a cooling system at a nuclear plant could lead to a more dangerous consequence.

Secondly the regulatory and legal issues which mainly apply to insurance, banking, manufacturing, medical devices, and food-related equipment [9]. This means that it would take more time and cost for IoT devices related to this field to get into the market since they will have to comply with various regulations such as HIPAA, CFR 21 part 11, GAMP 5, and Directive 95/46/EC.

Third is the determinism of the network, which is an area of IoT application since it allows devices to operate in security manufacturing, transport, control application etc. This is because cloud services impose a delay of about two hundred milliseconds or more which impacts the huge transaction delays in finance tech [10]. However, it imposes a challenge to the security applications that require rapid and immediate response since a monitoring system to receive a trigger after 5 seconds could be too late and will reduce its efficiency.

Fourth challenge is the lack of common architecture and standardization. That is, continuous fragmentation in the implementation of IoT tends to decrease its value and increase the cost to the end-users. What has led to this fragmentation is the fear of privacy and security, to avoid issues with competitor's intellectual property and jostling for market dominance, therefore, most products such as Google's Brillo and Weave that targets a very specific sector.

Fifth challenge is the scalability that has been foreseen to affect the Internet of Things in the future because of the increasing number of cloud users and the increase of devices in operation. Therefore, there will be a demand for high data bandwidth and the time needed to verify a transaction or a process. Lastly, is the lack of dense and durable off-grid power sources. For example, Bluetooth, WIFI, Ethernet, and 3G solves the connectivity issues where they accommodate various form factors of devices. Still, the challenge arises from the very low battery life of the devices. Sensors and mobile phones need to be charged frequently; therefore, it could be effective if power could be broadcasted wirelessly or if the power sources could last for at least a year or more.

IV. OPPORTUNITIES

A. Low power wireless sensors

A low power wireless sensor does not require battery replacement over their lifetimes; therefore, the main challenge comes in when designing it. Hence, designing a low power wireless sensor becomes an opportunity that researchers should focus in. Generally, a wireless sensor is made up of four components, including a sensing unit, a processing unit, a receiving/transmitting unit, and a power unit. However, if the sensor is developed using highly accurate sensors, it will consume a high amount of power. Therefore an effective opportunity will be to implement low accuracy modules with low power consumption and has the ability to create high accuracy information using data fusion. Also, another opportunity to reduce power consumption is to design new video processing and encoding algorithms. This new design will ensure that encoders do not analyze the redundancy completely at the video sensor nodes [6]. Also, the sensors use analog circuits when transmitting information to the gateway. Therefore, the analog circuit does not scale well in wireless communication, and to enhance a low power sensor node, then it will be necessary to design low power transmitter circuits [7]. Another opportunity of extending the battery life of the sensor will be the use of energy sources from an ambient environment, including heat, vibration, light, etc.

B. Better connectivity

A challenge in the machine-to-machine network is connecting large, dense populations of stationary and moving devices with efficient energy. This turns out to be an opportunity since the existing wireless standards cannot support a large number of devices in a limited spectrum. But the field of technology is expecting more wireless sensors than the available spectrum. Several characteristics relate to machine-to-machine communication, such as low data rates, the information has a strong correlation, and messages do not need real-time delivery. Hence, a clear opportunity is to form a cluster of machines that will eliminate direct communication through base stations and allow the machines to communicate through nearby cluster heads that pass the information to the base station instead. This will reduce power consumption during the transmission process. Also, wireless communication consumes a large amount of bandwidth as well as power consumption [12]. Many connected devices to wireless communication are battery-powered, and the existing human-to-human communication design does not address energy efficiency. Therefore designing a hybrid distributed and centralized framework will be an opportunity to reduce signals overhead.

The most recent initiatives are Open Interconnect Consortium, The AllSeen Alliance, and the use of modified Bitcoin blockchains in IoT. Therefore, a blockchain maintains the growing list of data transactions in a distributed public database. When new blocks are added, then blockchain will continue to grow linearly and chronologically. Hence, blockchains will help in alleviating integration challenges. IBM company come up with the idea that it would help Bitcoin blockchains to increase the speed and scalability since they take a lot of computing power to generate. Similar to IoT, Artificial Intelligence also will be used in the devices like Google Assistance using the Software Engineering [13].

Therefore, the companies is partially replacing the proof of work, which is part of the block with a proof of stake which utilizes fewer computations.

CONCLUSION

The more devices are added to the internet; then the more machine-to-machine is transforming the way people live or work. Therefore, it is true that the Internet of Things is an exciting area for great innovations; that is, there are several challenges and the number of opportunities. IoT is around to stay, and the existing and upcoming technical and security [14] problems will be resolved as time goes. Though it will take extra efforts from different technology companies to come up with a generic framework and compelling business model on how to solve various problems, implement new opportunities, and monetize IoT.

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