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A Comprehensive study on Internet of Things Applications and Challenges

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***Abstract*—** The Internet of Things (IoT) is basically viewed as a system which consists of smart objects with various sensors, networks, & processing technologies. IoT transforms the way internet works and carries together the domains such as big data technologies, communication between different machines, artificial intelligence etc. to work underneath the similar canopy so that internet and humans are entangled together. Hence IoT offers pervasive computing giving growth to cyber systems. IoT is an integrated system and works collectively to offer smart services to the end-users. IoT gives several advantages to us by an environment where smart services are offered to use any activity anytime & anywhere. These smart services are offered through different applications executing in the IoT environment. IoT applications monitor & consequently assist in fast decision-making process for client management. In the present work, the different approaches of IoT and its applications unfolding the key components and features are presented. The present work also explores IoT challenges.

***Keywords*—** IoT, Smart applications, Wireless Sensor Networks (WSNs), Quality of Service (QoS).

I. INTRODUCTION

Big data technologies like machine learning [27, 28, 29, 30, 31, 32, 33] and IoT are vital, recent research domains in the present times. The term IoT can be defined as a technology that is a merger of human beings, physical objects such as sensors, actuators, controllers, computing devices, storages and internet. Now days IoT technology is in every field including homes, schools, universities, precision agriculture, healthcare systems, industries/different factories and smart cities [1]. Several smart features such as generation of data / consumption of data, different online services, enhance our day today life and various activities throughout the world with the help of IoT [2]. Facilities and smart services execute with the help of different applications executing in the IoT environment [3]. As user requests increase, advanced applications for monitoring, managing, & powering human activities are offered [4, 5]. IoT applications also implement the services of cloud computing in order to attain suitable composite services. It is done by composition of current simple services for service-based applications [6, 7]. IoT setups are applied to applications thru smart devices and users apply them to regular activities in various places. IoT applications also have the benefit of selecting the best chance for users, irrespective of whether they agree, manage, or supervise environmental cloud resources [8]. IoT is all about enhancing the quality of our life by providing smart services [9, 10]. The basic concern of IoT applications is fulfilling QoS metrics. All vital user requirements which cover QoS metrics like security, cost-effectiveness, good service time, low energy consumption, reliability & availability must be provided by IoT applications [26]. But still there are very few technical research & review articles that concentrate on IoT applications systematically [11, 12]. The main objective of the present work is to explore different IoT applications. The communication amongst IoT applications has People to People, Machine to People and Machine to Machine connections.

II. RELATED WORK

This section presents a brief account of applicable work studies for IoT applications. Authors have conferred prevailing networking standards for the IoT environment and demonstrated how to meet the QoS requirements of objects to permit a smarter IoT ecosystem [13, 14, 15]. Additionally, an analysis is presented on the risks involved with lack of cross domain integration in different applications and IoT environments to meet interoperability and QoS related requirements. Further the QoS requirements like availability, reliability, scalability, security, etc. were also focused. The aforementioned works presented an organization of the various recent standards at the network and application layers in different fields like architecture, business, smart cities, transportation & grid systems. But the aforementioned studies did not present statistical information on the conferred standards applied to various regulatory domains. IoT applications in ecological and industrial agriculture sectors were reviewed in [2]. The work addresses four areas viz. Prediction, monitoring,

control and logistics. The work focused on fundamental technical efforts required in designing IoT-based applications for agricultural and ecological sectors. It also addressed the initial infrastructure and technologies exercised in the solutions as mentioned. It was an important observation that the greatest number of articles focused upon monitoring (62%), then some articles focused on control (25%), and few articles focused on logistics (7%) and prediction (6%). The authors emphasized that most of the IoT applications designed for IoT agricultural industry and ecological sectors fall into categories, including storage approaches, visualization approaches, and edge computing [2]. Various issues addressed in [2] include issues on hardware and software reusability, robust standardization, enhanced power consumption, security, cost savings, appropriate compatibility with current infrastructure, and scalability issues. The IoT architecture for agricultural and ecological sectors are portrayed in [2]. An assessment on service configuration related issues of Internet Protocol (IP), smart IoT objects was presented in [21]. The authors provided a comprehensive review based upon various issues, consisting of smart IoT object systems for IP, service modeling, target applications and platforms, and service configuration methods. The major drawback of the work was that cost and scalability factors were not analyzed. A comprehensive review on key IoT technologies was provided in [16, 17, 18, 19]. The authors discussed the architecture layers, services, network, and interface layers. The studies presented brief discussion on different issues in IoT. But the authors did not analyze the compatibility of approaches in IoT applications. The major drawback of aforementioned works is that they don't provide any investigation on evaluation parameters like availability, consumption of energy, cost effectiveness, response-time and reliability as quality factors in this domain.

III. IoT APPLICATIONS

IoT has several applications that provide a better world. Smart cities using IoT services have better facilities of parking, road, lighting, congestion controlling strategies and efficient waste management practices etc. help in making city life resourceful and easy. Additionally, numerous ecological controlling applications like monitoring up of air pollution, early identification of earthquakes, identification of fire in forest etc. can be used to defend people and nature. One of the vital applications is the supply of water where intellect may be used to recognize the requirement of water and examine the type of water. This will help to attain the goal of sustainability but will also directly affect the human health. IoT meters are indispensable portion of numerous households. These are used to examine the household gas usage &electricity consumption. It will assist residents recognize the energy consumption and will permit the supplier to examine the customer needs in real time. IoT is also used in industry and factory setups. IoT is supposed to bring a fourth industrial revolution termed as Industry 4.0. In Industry 4.0, IoT and digital technology will help us and confirm maximum efficiency, reduction in the production cost with improved product quality. Precision agriculture & farming sector is one more vital area in which IoT will have significant influence in the upcoming years. The estimated population of the world is supposed to be nearly 8 billion in 2025 & 9.6 billion in 2050, the production of food is predicted to be scaled up to 70% by 2050 to satisfy the food requirements of the world [25]. IoT offers solutions & procedures for accurate examination of crops. IoT assists in identification of diseases through various vital sources of data through ground& remote sensing and crop images. The farmers can be assisted to obtain descriptive maps of landscapes & other resources through numerous sensors in the farms.

IV. IOT CHALLENGES

There are numerous challenges and for IoT, despite many IoT applications are available now days. IoT is still in premature stage now days. WSNs are one of the vital underlying empowering technologies for IoT. The present work sheds light upon some of the vital challenges that are presently hampering IoT to attain its maximum strength. The important IoT challenges are:

- Addressing schemes

Unique identification of objects is a serious issue for the implementation and accomplishment of IoT applications. The applications of IoT need to distinctively categorize numerous devices in order to manage and examine them distantly thru the World Wide Web. The recognition &addressing system for IoT devices was suggested [20]. The automatic IDs for IoT nodes were generated using distributed address allocation algorithm. The authors suggested addressing scheme by combining cluster tree algorithm by AODV routing procedure. The algorithm is used as successful addressing method for the wide & local area of IoT networks. Then too, an integrated addressing method for IoT is recent research area and is a great challenge.

- Big data

IoT pulls out very large volume of data and combines it through smart objects. It's an outstanding feature of IoT. It is mandatory to design methods that transform this data into practically required information. The data is increasing in size in every two years. It is supposed to be nearly 44 Zettabytes in the coming 4 years [21]. The "5Vs" viz. Variety, Veracity, Value, Volume and Velocity are vital IoT challenges.

- Consumption of energy

IoT creates & connects a large number of diversified networks and devices to the World Wide Web. The most vital source for IoT smart devices is energy. Most of the applications are monitored through battery or employs energy producing methods. Hence, it is not judicious to waste the energy by communication of un-required data and protocol overheads that prevailing protocols such as HTTP, TCP, etc., do. Therefore, developing intelligent

routing methods &energy efficient network architectures remains an important challenge in IoT networks [22].

- Heterogeneity of links/devices

One more vital feature of IoT is the variability of links &devices, since IoT works on different data formats, miscellaneous sets of collection of protocols etc. In case of WSNs, several sensors are similar that is having the similar communication, power& equal capacity in terms of computation. IoT uses extensive variability of links, devices &network connectivity to offer various services. Hence, variability of objects &links has an important role in the interconnection of IoT devices. Therefore, it's an important challenge that needs to be addressed.

- Transmission media

The transmission media is responsible for establishing the link between two computers/devices. It transfers the data from sender to the receiver. These networks exercise diverse technologies to transfer or pick up the data like Bluetooth, RFID, Sigfox, LoraWAN, Zigbee etc. IoT also suffers from old problems of transmission media for example fading inference, high error rate, bandwidth problems etc. There is a dedicated energy for every transmission medium. The network hardware, the bandwidth etc. have to be fine-tuned with the transmission medium. In order to withstand the applications of IoT & improve the life-time of networks, the optimization of transmission medium is a great challenge.

- Security

One of the major challenges with any network is resolving the security issues. One of the vital challenges for applications of IoT is resolving trust, privacy & security related issues. There are multiple issues when data packets are transferred from source to final receiver on the World Wide Web. Well defined steps should be followed for preserving the privacy & integrity of data. The cryptographic solutions that are already identified cannot be straightly used in the case of IoT as IoT devices are less power controlled devices. Also, the combination of different applications is based upon obtaining better functionality instead of completely considering the security requirements, while the application is being developed. These security flaws make IoT applications prune to attacks & hacking attempts. The experts in the field of Cyber security have cautioned that IoT technology is susceptible to security related attacks. They assume more targeted attacks on the present as well as on developing infrastructures in the future. The four vital IoT security challenges are:

1.To ensure trust and integrity of data
2.Several points of susceptibility
3.Protection of voluminous data
4.Privacy of data

- QoS

There is a need of distributed way of data collection in most of the applications within a specific time. The data should reach the projected terminus else the value of data will reduce. The QoS requirements address different services & efficient delay management methods, mechanisms to deal with packet loss, handling bandwidth measures on the network. These requirements lead to an effective end-to-end service. Subsequently QoS requires enough research and stabilization for execution, optimization and management.

- Humans in the loop

Some form of human interaction is needed for upcoming applications of IoT. The consequence of any event or process can be easily modified by the user thru Humans in the Loop. The best example for Humans in the Loop is self-driving car. It is a novel challenge for IoT.

- Massive scaling

The number of sensor nodes implemented in the world is supposed to be in order of tens of billions or much more. Massive scaling is one of the vital challenges that lay impact upon the routing protocols. Here scalability refers to the scaling of number of devices and associated networks. Therefore, any routing method selected should be appropriate & much-more scalable for these enormous number of sensor nodes [23].

- The 5G & 4G technologies enabled IoT

The fourth generation (4G) technology is broadly employed in the applications of IoT. The technology has endlessly grown &confirms the requirements of the upcoming networks [24]. Currently we are advancing towards the fifth generation (5G) technology. With every technology, novel features are supplemented and issues are resolved. Each new technology gives rise to new challenges for future IoT.

V. CONCLUSION AND FUTURE SCOPE

Substantial developments have been made in the field of IoT technology for a broad variety of applications. These applications use numerous qualifying & evolving technologies. IoT merges & connects huge number of devices using the recent infrastructure for communication & ability of computing. This permits to gather & transfer of data in an integrated way making valuable knowledge. IoT is a field that will transform the way internet works. It will join cyber and physical space in the best way. In the present work various IoT applications were discussed. Despite several benefits that IoT potentially has, it also has numerous problems & challenges. A brief summary of IoT problems & challenges is presented in the present work. For an effective acceptance of IoT and its future scope, various counter measures should be considered at the design & architectural level with a generalized approach.

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