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Internet of Things: A Deep Review

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Abstract:
Internet of Things (IoT) is a new paradigm that has changed the traditional way of living into a high-tech lifestyle. Smart city, smart homes, pollution control, energy saving, smart transportation, smart industries are such transformations due to IoT. A lot of crucial research studies and investigations have been done to enhance the technology through IoT. However, there are still a lot of challenges and issues that need to be addressed to achieve the full potential of IoT. These challenges and issues must be considered from various aspects of IoT such as applications, challenges, enabling technologies, social and environmental impacts etc. The main goal of this review article is to provide a detailed discussion from both technological and social perspective. The article discusses different challenges and key issues of IoT, architecture and important application domains. Also, the article brings into light the existing literature and illustrated their contribution in different aspects of IoT. Moreover, the importance of big data and its analysis with respect to IoT has been discussed. This article would help the readers and researcher to understand the IoT and its applicability to the real world.

Keywords: Internet of Things (IoT), IoT architecture, IoT challenges, IoT applications

Introduction

The Internet of Things(IoT) is an emerging paradigm that enables the communication between electronic devices and sensors through the internet to in order facilitate our lives. IoT uses smart devices and the internet to provide innovative solutions to various challenges and issuesrelated to various business, governmental, and public/private industries across the world. IoT is progressively becoming an important aspect of our life that can be sensed everywhere around us. On whole, IoT is an innovation that puts together an extensive variety of smart systems, frameworks, and intelligent devices and sensors. Moreover, it takes advantage of quantum and nanotechnology in terms of storage, sensing, and processing speed which was not conceivablebeforehand. Extensive research studies have been done and available in terms of scientificarticles, and press reports both on the internet and in the form of printed materials to illustratethe potential effectiveness and applicability of IoT transformations. It could be utilized as apreparatory work before making novel innovative business plans while considering security, assurance, and interoperability. A great transformation can be observed in our daily outine life along with the increasing

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involvement of IoT devices and technology. One such developmentof IoT is the concept of Smart Home Systems (SHS) and appliances that consist of internet-based devices, automation systems for homes, and reliable energy management systems.Besides, another important achievement of IoT is the Smart Health Sensing system (SHSS).SHSS incorporates small intelligent equipment and devices to support the health of humanbeings.Thesedevicescanbeusedbothindoorsandoutdoorstocheckandmonitorthedifferen thealth issues and fitness levels or the number of calories burned in the fitness canter etc. Also,itisbeingusedtomonitorcriticalhealthconditionsinthehospitalsandtrauma centersaswell.Hence, it has changed the entire scenario of the medical domain by facilitating it with hightechnology and smart devices. Moreover, IoT developers and researchers have been activelyinvolved to uplift the lifestyle of the disabled and senior age group people. IoT has shown adrastic performance in this area and has provided a new direction for the normal life of suchpeople. As these devices and equipment are very cost-effective in terms of development costand easily available within a normal price range, hence most the people are availing of them. Thanks to IoT, they can live a normal life. Another important aspect of our life is transportation. IoT has brought up some new advancements to make it more efficient, comfortable, andreliable. Intelligent sensors and drone devices are now controlling the traffic at different signalize dintersections across major cities. In addition, vehicles are being launched in markets with pre-installed sensing devices that can sense the upcoming heavy traffic congestions on the map and may suggest you another route with low traffic congestion. Therefore, IoT has a lot to serve in various aspects of life and technology. We may conclude that IoT has a lot of scopes both in terms of technology enhancement and facilitating humankind. IoT has also shown itsimportance and potential in the economic and industrial growth of a developing region. Also,in the trade and stock exchange market, it is being considered a revolutionary step. However,the security of data and information is an important concern and highly desirable, which is amajor challenging issue to deal with. The Internet is the largest source of security threats and cyber-attacks have opened the various doors for hackers and thus made the data and information insecure. However, IoT is committed to providing the best possible solutions to deal with security issues of data and information. Hence ,themost important concern of IoT in trade and the economy is security. Therefore, the development of a secure path for collaboration between social networks and privacy concerns is a hot topic in IoT, and IoTdevelopersareworking hardonthis.

Major key issues and challenges of IoT:

The involvement of IoT-based systems in all aspects of human lives and various technologies involved in data transfer between embedded devices made it complex and gave rise to several issues and challenges. (Kumar,2019) These issues are also a challenge for the IoT developers in the advanced smart tech society. As technology is growing, challenges and the need for advanced IoT system is also growing. Therefore, IoT developers need to think of new issues arising and should provide solutions for them.

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Security and privacy issues:

One of the most important and challenging issues in the IoT is the security and privacy due to several threats, cyber-attacks, risks, and vulnerabilities. (Abomhara&Kiem ,2015) The issues that give rise to device-level privacy are insufficient authorization and authentication, insecure software, firmware, web interface, and poor transport layer encryption. Security and privacy issues are very important parameters to develop confidence in IoT Systems concerning various aspects. Security mechanisms must be embedded at every layer of IoT architecture to prevent security threats and attacks. Several protocols are developed and efficiently deployed on every layer of a communication channel to ensure security and privacy in IoT-based systems. Secure Socket Layer (SSL) and Datagram Transport Layer Security (DTLS) are the cryptographic protocols that are implemented between the transport and application layers to provide security solutions in various IoT systems. However, some IoT applications require different methods to ensure security in communication between IoT devices. Besides this, if communication takes place using wireless technologies within the IoT system, it becomes more vulnerable to security risks. Therefore, certain methods should be deployed to detect malicious actions and for self-healing or recovery. Privacy on the other hand is another important concern that allows users to feel secure and comfortable while using IoT solutions. therefore, it is required to maintain the authorization and authentication over a secure network to establish communication between trusted parties. Another issue is the different privacy policies for different objects communicating within the IoT system. Therefore, each object should be able to verify the privacy policies of other objects in the IoT system before transmitting the data.

Interoperability/standard issues:

Interoperability is the feasibility to exchange information among different IoT devices and systems. This exchange of information does not rely on the deployed software and hardware. The interoperability issue arises due to the heterogeneous nature of different technology and solutions used for IoT development. the four interoperability levels are technical, semantic, syntactic, and organizational.(Kumar, Tiwari, Zimbler) Various functionalities are being provided by IoT systems to improve the interoperability that ensures communication between different objects in a heterogeneous environment. Additionally, it is possible to merge different IoT platforms based on their functionalities to provide various solutions for IoT users. Considering interoperability an image important issue, researchers approved several solutions that are also known as interoperability handling approaches. These solutions could be adapters/gateways based, virtual networks/ overlay based, a service-oriented architecture based, etc. Although interoperability handling approaches ease some pressure on IoT systems e are still certain challenges that remain with interoperability that could be a see for future studies.

Ethics, law, and regulatory rights:

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Another issue for IoT developers is the ethics, law, and regulatory rights. There are certain rules and regulations to maintain the standard, and moral values and to prevent the people from violating them. Ethics and law are very similar terms the only difference being that ethics are standards that people believe and laws are certain restrictions decided by the government. However, both ethics and laws are designed to maintain the standard, and quality and prevent people from illegal use. With the development of IoT, several real-life problems are solved but it has also given rise to critical ethical and legal challenges. Data security, privacy protection, trust and safety, and data usability are some of those challenges. It has also been observed that the majority of IoT users are supporting government norms and regulations concerning data protection, privacy, and safety due to the lack of trust in IoT devices. Therefore, this issue must be taken into consideration to maintain and improve the trust among people for the use of IoT devices and systems.

Quality of Service (QoS):

Quality of Service (QoS) is another important factor for IoT. QoS can be defined as a measure to evaluate the quality, efficiency, and performance of IoT devices, systems, and architecture. the important and required QoS metrics for IoT applications are reliability, cost, energy consumption, security, availability, and service time. A smarter IoT ecosystem must fulfill the requirements of QoS standards. Also, to ensure the reliability of any IoT service and device, its QoS metrics must be defined first. Further, users may also be able to specify their needs and requirements accordingly. Several approaches can be deployed for QoS assessment, however, as mentioned by White et al. there is a trade-off between quality factors and approaches. therefore, good quality models must be deployed to overcome this trade-off. There are certainly good quality models available in the literature such as ISO/IEC25010 and OASIS-WSQM which can be used to evaluate the approaches used for QoS assessment. These models provide a wide range of quality factors that is quite sufficient for QoS assessment for IoT services. Table 2 summarizes the different studies concerning IoT key challenges and issues discussed above.

Retail and Logistics:

Executing the IoT in Supply Chain or retail Management has many benefits. Some include observing storage conditions throughout the supply chain, product tracking to enable traceability purposes, and payment processing depending on the location or activity period in public transport, theme parks, gyms, and others. Inside the retail premises, IoT can be applied to various applications such as the direction in the shop based on a preselected list, fast payment processes like automatically checking out with the aid of biometrics, detecting potential allergen products, and controlling the rotation of products on shelves and warehouse to automate restocking procedures. The IoT elements mostly used in this setting include wireless sensor networks and radio frequency identification. In retail, there is a current use of SAP (Systems Applications and Products), while in logistics numerous examples include quality consignment conditions, item location, detecting storage incompatibility issues, and fleet tracking among others. In the industry domain, IoT helps in detecting levels of gas and leakages within the industry and its environs, keeping track of toxic gases as well as the oxygen levels within the confines of chemical plants to ensure the safety of goods and workers and observing levels of oil, gases, and water in cisterns and storage tanks. The application of IoT also assists in maintenance and repair because systems can be put in place to predict equipment malfunctions and at the same automatically schedule periodic maintenance services before there is a failure in the equipment. This can be achieved through the installation of sensors inside equipment or machinery to monitor their functionality and occasionally send reports.

Service Computing and IoT:

Initiated around a similar time as the Internet of Things, service computing (or service-oriented computing) has been established as an important paradigm to change the way of design, delivery, and consumption of software applications. Service computing relies on service-oriented architecture (SOA) and aims to organize software applications and infrastructures into a set of interacting services, which are then used as fundamental elements to support the low-cost and efficient development of distributed applications. Technologies on service computing (e.g., RESTful services and service composition methods) can help address several fundamental challenges presented by IoT including communication and management of IoT objects. However, marrying service computing and IoT presents challenges due to their technical constraints and unique characteristics. On the one hand, IoT objects may be resource-constrained and the traditional service computing standards and techniques (e.g., SOAP, WSDL, BPEL) might be too heavy to be applicable in IoT. On the other hand, existing service composition models cannot be directly used for IoT interoperation, due to their architectural differences. More specifically, traditional service composition models are mostly single-typed and single-layered (i.e., services), while IoT components are heterogeneous, multi-layered that include not only services but also IoT devices and other components. One important research direction centers on IoT services discovery, aiming to be able to find the right IoT services at the right time and the right location. There are two possible techniques. The first technique is semantic annotation for IoT service descriptions and their associated sensory data. Some typical efforts in this direction include the Open IoT project 6, which exploits a semantic sensor network (SSN) ontology from W3C, and the Hydra project 7, which adopts OWL (an ontology for Semantic Web) and SAWSDL (a semantic annotation of WSDL). However, it is challenging to reach an agreement on a single ontological standard for describing IoT services, given the diversity and rapid IoT technological advances. The second technical direction is to use the textual descriptions associated with IoT devices to locate IoT services. Some typical efforts in this direction include MAX and Micro search. One research challenge in this direction is the natural order ranking of IoT contents. Natural order ranking sorts of contents by their intrinsic characteristics, rather than their relevance to a given query, thereby being able to deliver the most relevant results. One well-known example of natural order ranking is PageRank, which orders Web pages based on their importance via link analysis. Given the size of IoT (50 to 100 times bigger than the current Internet), one promising direction is to develop a new natural order ranking mechanism for the IoT contents to provide an effective and efficient IoT service discoveryWhich leads to the form of a social network among each other by establishing social relationships autonomously concerning the rules set by the owners. On the same research line, several studies have focused on proposing architectures. Relationships exist among smart objects. Objects can start establishing these relationships for several reasons such as when these objects come close to each other and satisfy relationship rules specified by their owners. Proposed five types of relationships. Some of these relationships are dynamic and they are established when smart objects come in contact at the same place and at the same period to cooperate to achieve a common goal. Other relationships are static, and they are created once objects join the network. In addition, Roopa et al. suggested extra relationships that can be established among objects. Along with the previous research aspects, the IoT paradigm has gone through intensive research. Several IoT areas such as service discovery, network navigability, and trustworthiness management have been studied in the literature. Furthermore, recent work has considered how the IoT resulted in the network would evolve since the IoT network is dynamic where it can grow and change quickly over time where objects (nodes) and their relationships (links) appear or disappear. However, the IoT paradigm is still in an early stage, and many aspects need to be investigated. Most importantly, the perspective of the IoT paradigm needs to be thoroughly unified. In the future, IoT will be integrated more into daily life things and will have an interesting role to make decisions for humans. The couch in the living room could be able to sense the body temperature of the owner and based on this the room temperature gets adjusted accordingly. In another scenario, a smart medicine cabinet could monitor the consumption level of medicine and whenever the amount becomes low, this cabinet could ask the smart toilet to perform a chemical analysis and report to the smart home to arrange a doctor visit or a refill from the pharmacy.

Edge Computing and IoT:

Over the past decade, an unprecedented increase in the deployment of IoT devices coupled with the demand for real-time computing power and low latency requested by state-of-the-art applications continues to drive the case for edge-computing systems. Such applications include, but are not limited to, smart cities (with autonomous driving being its integral constituent), healthcare, augmented reality, robotics, and artificial intelligence. Edge computing is primarily a part of the distributed computing topology which has an intent to bring both computation and storage near to the devices. This is quite beneficial for applications requiring stringent latency requirements for humans to communicate with the machines using natural language, thus giving rise to the field of Conversational AI. It refers to the use of either text-based or voice-based applications that enable machines to stimulate human conversations and create a personalized experience for the users. These conversational agents can be envisaged as a natural interface for the IoT devices as it hides all the complex applications, services, and hardware such as sensors and actuators, presenting a daunting challenge of gaining technical knowledge to interact with the various components. The convergence of IoT and Conversational AI is regarded as successful as we have seen many applications already making their way to people’s customized smart spaces such as smart offices, smart homes, and smart vehicles. The first in the line of transformation of a regular home into a smart IoT home is ‘Google Home’, which is flexible to work with and provides a centralized solution to control compatible smart home devices. Another state-of-the-art device is Amazon’s Echo which provides more improved features than Google Home. An

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echo can guard a home in the owner's absence by listening to the surroundings for unusual noises or alarms. A 'Home and Away' feature can be set up to trigger specific actions. It helps shop from Amazon and notifies the owner when the parcel arrives. In a multi-user environment, each user can register their account using voice activation. Though these devices and alike (Alibaba Group's Tmall Genie etc.) overcome interoperability issues to make life an effortless, seamless experience, they suffer from several limitations due to which a huge performance gap is easily observable in managing the smart spaces. These limitations can be considered as potential research challenges which include but are not limited to Self-Disclosure in a Multi-User Environment: the increase in the number of interactions between the system and end-users would result in increased disclosure about users' activities and personal information. This disclosure of information helps the system in understanding the user and thus aids in providing a more personalized experience. However, in a multi-user scenario, this disclosure of personal information may pose high risks to one's privacy and thus, requires a model where multiple users can co-exist without having to worry about security or data breach Lack of Complexity and Completeness: the available IoT conversational agents work on simple commands like "turn on the TV" or "what is the temperature of the room?". However, these systems struggle with rules or complex sentences such as "turn off the heater when the room is warm" or "turn on the TV when Prison Break is on" unless the user decomposes them into separate simple sentences. Thus, extensive research is required to make the systems tackle incomplete or complex sentences without having to decompose them to keep the conversation natural Inability to Reason: Commonsense reasoning is considered a key factor to the success of many natural language processing tasks specifically in question answering and conversation dialog. The machine should be able to provide rational answers to questions like "Why is it so cold today?" to establish effective interactions.These data come from texts, audio, and videos, which provide a more comprehensive view. Multi-modal data processing enables models to fuse data from different sensors and sources, but it will inevitably incur exponentially increasing data to be processed. Under this circumstance, summarization algorithms to process multi-modal data can be adopted to fuse information semantically. Despite the advantages of the combination of summarization techniques and IoT, it is still a new area, with very few existing works. Deep neural networks with conventional text and video processing techniques can be investigated since deep neural models have strong non-linear mapping abilities and traditional approaches contain much prior knowledge, which would facilitate the model optimization process. We foresee that the summarization of IoT will be one of the next intensely researched topics.

CONCLUSION:

The Internet of Things (IoT) has been an extremely active area of research and development for more than two decades. Although a wealth of exciting activities including standardization, commercial developments, and research have been conducted, many challenges remain open due to the large scale and diversity of IoT devices, the openness of the IoT environment, and the security and privacy concerns. In this paper, we identify 10 key research topics on IoT and hope to stimulate further research in this vibrant area.

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