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Internet of Things (IOT): Research Challenges and Future Applications

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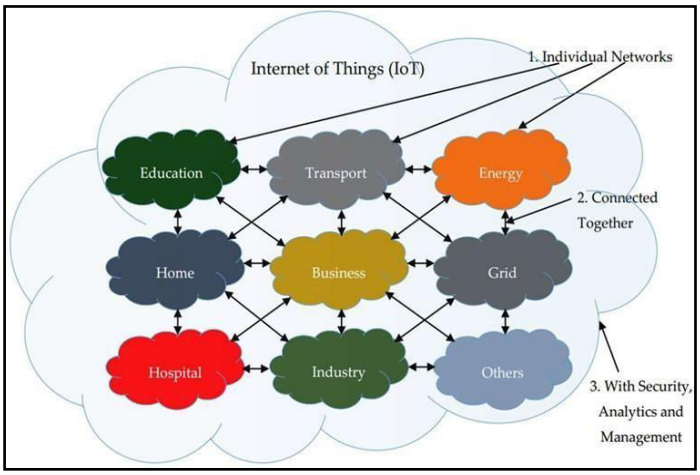
ABSTRACT: With the Internet of Things (IoT) gradually evolving as the subsequent phase of the evolution of the Internet, it becomes crucial to recognize the various potential domains for application of IoT, and the research challenges that are associated with these applications. Ranging from smart cities, to health care, smart agriculture, logistics and retail, to even smart living and smart environments IoT is expected to infiltrate into virtually all aspects of daily life. Even though the current IoT enabling technologies have greatly improved in the recent years, there are still numerous problems that require attention. Since the IoT concept ensues from heterogeneous technologies, many research challenges are bound to arise. The fact that IoT is so expansive and affects practically all areas of our lives, makes it a significant research topic for studies in various related fields such as information technology and computer science. Thus, IoT is paving the way for new dimensions of research to be carried out. This paper presents the recent development of IoT technologies and discusses future applications and research challenges.

I. INTRODUCTION

The Internet can be described as the communication network that connects individuals to information while The Internet of Things (IoT) is an interconnected system of distinctively addressable physical items with various degrees of processing, sensing, and actuation capabilities that share the capability to interoperate and communicate through the Internet as their joint platform

Thus, the main objective of the Internet of Things is to make it possible for objects to be connected with other objects, individuals, at any time or anywhere using any network, path or service. The Internet of Things (IoT) is gradually being regarded as the subsequent phase in the Internet evolution. IoT will make it possible for ordinary devices to be linked to the internet in order to achievecountless disparate goals. Currently, an estimated number of only 0.6% of devices that can be part of IoT has been connected so far

Fig:1



IoT plays a crucial role in improving the smartness of cities and enhancing general infrastructure. Some of IoT application areas in creating smart cities include; intelligent transportation systems

smart building, traffic congestion [7, 8] waste management [9], smart lighting, smart parking, and urban

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maps. This may include different functionalities such as; monitoring available parking spaces within the city, monitoring vibrations as well as material conditions of bridges and buildings, putting in place sound monitoring devices in sensitive parts of cities, as well as monitoring the levels of pedestrians and vehicles. Artificial Intelligence (AI) enabled IoT can be utilized to monitor, control and reduce traffic congestions in Smart Cities [6].Moreover, IoT allows installation of intelligent and weather adaptive street lighting and detection waste and waste containers by keeping tabs of trash collection schedules. Intelligent highways can provide warning messages and important information, such as access to diversions depending on the climatic conditions or unexpected occurrences like traffic jams and accidents.

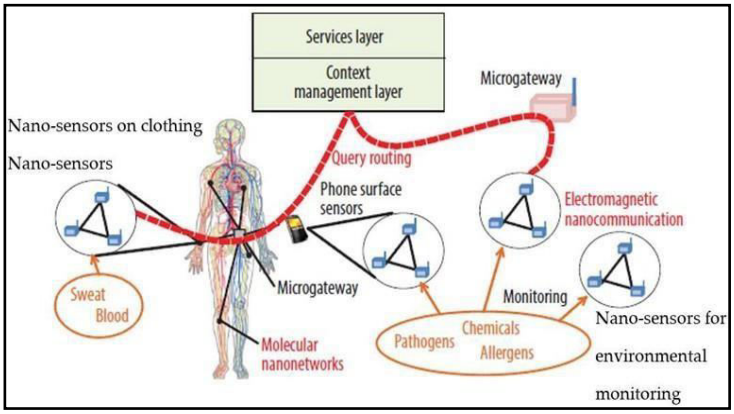
Healthcare

Most healthcare systems in many countries are inefficient, slow and inevitably prone to error. This can easily be changed since the healthcare sector relies on numerous activities and devices that can be automated and enhanced through technology. Additional technology that can facilitate various operations like report sharing to multiple individuals and locations, record keeping and dispensing medications would goa long way in changing the healthcare sector .

The applications of Internet of Things (IoT) and the Internet ofEverything (IoE) are further being extended through the materialization of the Internet of Nano-things (IoNTThe notion of IoNT, as the name implies, is being engineered by integrating Nano-sensors in diverse objects (things) using Nanonetworks. Medical application, as shown in Fig. 2, is one of the major focuses of IoNT implementations. Application of IoNT in human body, for treatment purposes, facilitates access to data from in situ parts of the body which were hitherto in accessible to sense from or by using those medical instruments incorporated with bulky sensor size. Thus, IoNT will enable new medical data to be collected, leading to new discoveries and better diagnostics.

Smart Agriculture and Water Management

The IoT has the capacity to strengthen and enhance the agriculture sector through examining soil moisture and in the case of vineyards, monitoring the trunk diameter. IoT would allow to control and preserve the quantity of vitamins found in agricultural products, and regulate microclimate conditions in order to make the most of the production of vegetables and fruits and their quality. Furthermore, studying weather conditions allows forecasting ofice information, drought, wind changes, rain or snow, thus controlling



explain, in water management, the role of IoT includes studying water suitability in seas and rivers for both drinking and agriculture use, detecting pressure variations in pipes, and liquid presence outside tanks as well as monitoring levels of water variation in dams, rivers and reservoirs. These IoT applications utilize Wireless sensor networks. Examples ofexisting IoT applications in this domain include; SiSviA, GBROOS, and SEMAT.

A. Retail and Logistics

Executing the IoT in Supply Chain or retail Management has many benefits. Some include; observing storage conditionsthroughout the supply chain, product tracking to enable trace ability purposes, payment processing depending on the locationor activity period in public transport, theme parks, gyms, and others. Inside the retail premises, IoT can be applied to variousapplications such as 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 warehouses in order to automate restocking procedures 12

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Smart Living

In this domain, IoT can be applied in remote control devices whereby one can remotely switch appliances on and off hence preventing accidents as well as saving energy [1, 3]. Other smart home appliances include refrigerators fitted with LCD (Liquid Crystal Display) screens, enabling one to know what is available inside, what has over stayed and is almost expiring as well as what needs to be restocked. This information can also be linked to a smartphone application enabling one to access it when outside the house and therefore buy what is needed. Furthermore, washing machines can allow one to remotely monitor laundry. In addition, a wide range of kitchen devices can be interfaced through a smartphone, hence making it possible to adjust temperature, like in the case of an oven. Some ovens which have a self-cleaning feature can be easily monitored as well. In terms of safety in the home, IoT can be applied through alarm systems and cameras can be installed to monitor and detect window or door openings hence preventing intruders [3].

Smart Environment

The environment has a vital role within all aspects of life, from people, to animals, birds and also plants, are all affected by an unhealthy environment in one way or another. There have been numerous efforts to create a healthy environment interms of eliminating pollution and reducing wastage of resources, but the existence of industries, as well as transportations wastes coupled with reckless and harmful human actions are common place elements which consistently damage the environment. Consequently, the environment requires smart and innovative ways to help in monitoring and managing waste, which provide a significant amount of data that forces governments to put in place systems that will protect the environment.

RESEARCH CHALLENGES

For all the above potential applications of IoT, there has to be proper feasibility into the different domains to ascertain the success of some applications and their functionality. As with any other form of technology or innovation, IoT has its challenges and implications that must be sorted out to enable mass adoption. Even though the current IoT enabling technologies have greatly improved in the recent years, there are still numerous problems that require attention, hence paving the way for new dimensions of research to be carried out. Since the IoT concept ensues from heterogeneous

technologies that are used in sensing, collecting, action, processing, inferring, transmitting, notifying, managing, and storing of data, a lot of research challenges are bound to arise. These research challenges that require attention have consequently spanned different research areas

Privacy and Security

Owing to the fact that IoT has become a vital element as regards the future of the internet with its increased usage, it necessitates a need to adequately address security and trust functions. Researchers are aware of the weaknesses which presently exist in many IoT devices. Furthermore, the foundation of IoT is laid on the existing wireless sensor networks (WSN), IoT thus architecturally inherits the same privacy and security issues WSN possesses Various attacks and weaknesses on IoT systems prove that there is indeed a need for wide ranging security designs which will protect data and systems from end to end. Many attacks generally exploit weaknesses in specific devices thereby gaining access into their systems and consequently making secure devices vulnerable [16, 17] . This security gap further motivates comprehensive security solutions that consist of research that is efficient in applied cryptography for data and system security, non-cryptographic security techniques as well as frameworks that assist developers to come up with safe systems on devices that are heterogeneous.

.Processing, Analysis and Management of Data

The procedure for processing, analysis and data management is tremendously challenging because of the heterogeneous nature of IoT, and the large scale of data collected, particularly in this era of Big Data Currently, most systems utilize centralized systems in offloading data and carrying out computationally intensive tasks on an international cloud platform. Nevertheless, there is a constant concern about conventional cloud architectures not being effective in terms of transferring the massive volumes of data that are produced and consumed by IoT enabled devices and to be able further support the accompanying computational load and simultaneously meet timing constraints Most systems are therefore relying on current solutions such as mobile cloud computing and fog computing which are both based on edge processing, to mitigate this challenge.

Another research direction as regards data management is applying Information Centric Networking (ICN) in the IoT. Since these information centric systems offer support in the efficient content retrieval and access to services, they appear to be quite valuable not just in accessing but also transferring as well as managing generated content and its transmission. This solution, however, brings about various challenges such as; how to extend the ICN paradigm competently over the fixed network edge, how to take in IoTs static and mobile devices as well as how to apportion the

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functionality of ICN on resource constrained devices

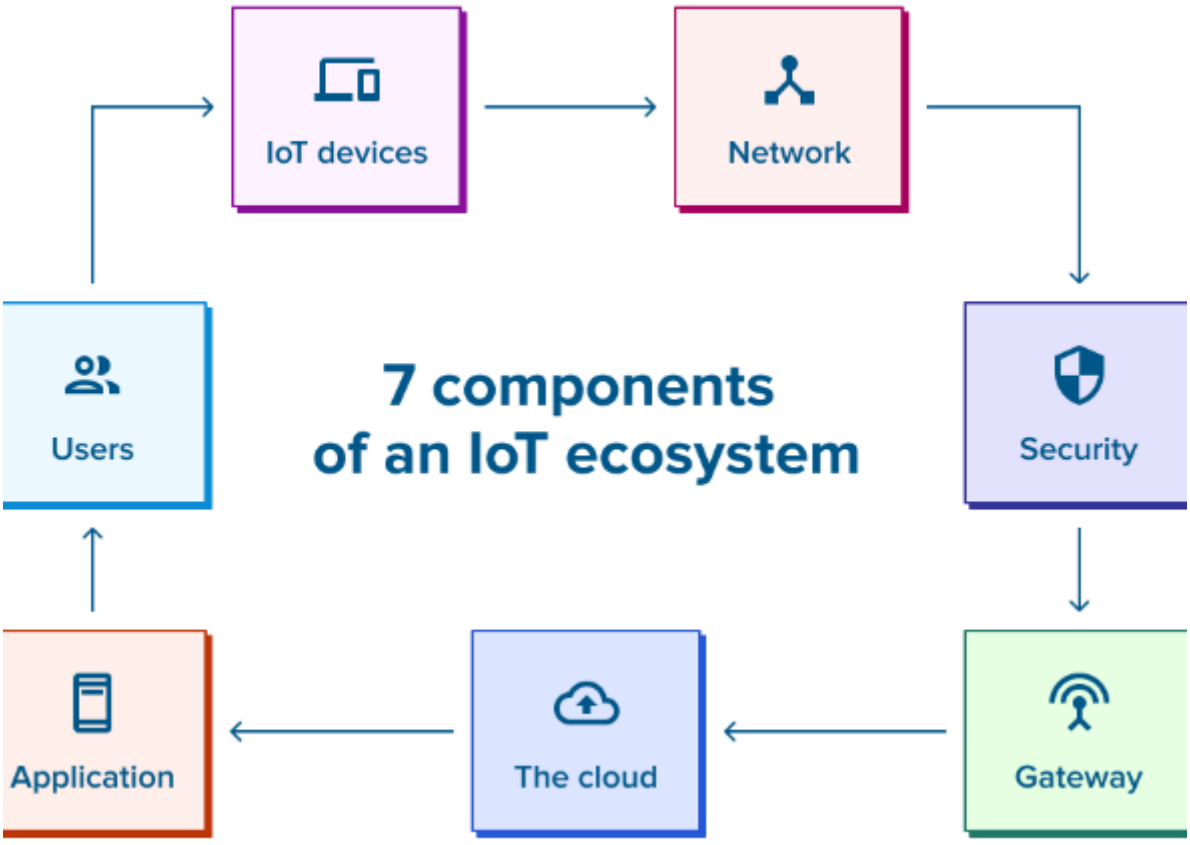
Data analysis and its context not only plays a crucial role inthe success of IoT, it also poses major challenges. Once data has been collected it has to be used intelligently in order to achieve smart IoT functions. Accordingly, the development of machine learning methods and artificial intelligence algorithms, resultant from neural works, genetic algorithms, ==

Blockchain of Things (BCoT): Fusion of BlockchainandInternet of Things

Similar to IoT, blockchain technologies have also gained tremendous popularity since its introduction in 2018. Even though blockchain was first implemented as an underlyingtechnology of Bitcoin cryptocurrency, it is now being used in multifaceted nonmonetary applications Miraz argues thatboth IoT and Blockchain can strengthen each other, in a reciprocal manner, by eliminating their respective inherentarchitectural limitations The underlying technology of IoT is WSN. Therefore, analogous to WSN, IoT also suffers from security and privacy issues. On the contrary, the primary reasons for blockchain's implementation trend in non-monetary applications is due to its inbuilt security, immutability, trust and transparency. These attributes are powered by blockchain's consensus approach and utilization ofDistributed Ledger Technologies (DLTs) which require extensive dependency on participating nodes. Therefore, the fusion of these two technologies Blockchain and Internet of Things (IoT) conceives a new notion i.e. the Blockchain of Things (BCoT) where blockchain strengthens IoT by providing anextra layer of security while the "things" of IoT can serve as participating nodes for blockchain ecosystems Thus, blockchain-enabled IoT ecosystems will provide enhanced overall security as well as benefit from each other.

Fig 4

Component:



I. **Cloud Infrastructure:** The cloud plays a crucial role in IoT by providing storage, processing power, and scalability. Cloud infrastructure allows for centralized management, storage, and analysis of IoT data. It enables

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organizations to store and

II. **Devices/Things:** IoT devices, also known as "things," are physical objects or sensors that are equipped with connectivity capabilities, allowing them to send and receive data over the internet. These devices can include a wide range of objects, such as sensors, actuators, wearables, appliances, vehicles, and industrial machinery.

III. **Connectivity:** Connectivity is a crucial component of IoT, enabling devices to communicate with each other and exchange data. This can be achieved through various communication technologies, such as Wi-Fi, Bluetooth, Zigbee, cellular networks (3G, 4G, 5G), or even satellite communication, depending on the specific use case and requirements.

IV. **Gateway:** IoT generates massive amounts of data from connected devices. Data processing and analytics involve collecting, storing, analyzing, and deriving insights from the collected data. This can be done locally on the device itself (edge computing) or in the cloud. Advanced analytics techniques, such as machine learning and AI algorithms, are often applied to extract valuable insights from IoT data.

II. LITERATURE SURVEY

This survey is performed to know the present scenario of internet of things, so may that scope of IOT can be visualized in a proper manner. As being the latest technology it is widely used everywhere to make the connectivity advanced i.e. things will be looked in a drastic manner.

1. P.P. Ray: In this author introduce a novel conceptt-“”Io<*>”” is also proposed that is based on various theoretical nomenclature and external inputs. Different from other IoT survey papers, a main contribution of this paper is that it focuses on area specific architectures of IoT applications and highlights the challenges and possible research opportunities for future IoT researchers who would work in architectural as well as in IoT as a whole.[1]

2. Sinan T. Shukur et al: Author in this paper gives an overview of the key issues related to IOT services and technologies. A number of research challenges have been described, which are expected to become a major research trend in the coming decades.[2]

3. J. Sathish Kumar et al: In this author presented Internet of Things with architecture and design goals. They surveyed security and privacy concerns at different layers in IoTs.[3]

4. Pallavi Sethi et al : In this survey paper Author’s presented a survey of the current technologies used in the IoT domain as of 2016. The technologies in the core infrastructure layers are showing signs of maturity. However, a lot more needs to happen in the areas of IoT applications and communication technologies. These fields will mature and impact human life in incredible ways over the next decade [4]

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5. Mayra Samaniego et al: In this paper basically, the management of resources in the Internet of Things is addressed. This is achieved by proposing a virtual-resource edge layer, which enables access and configuration to constrain physical resources. The architecture presented focuses on the use of virtual resources as a management concept and identifies different approaches in the performance evaluation on edge computing devices. Using the IoT protocol CoAP, virtual resources are exposed in the edge network. An evaluation of a Go CoAP virtual resource is presented [5].

III. CONCLUSION

The IoT can best be described as a CAS (Complex Adaptive System) that will continue to evolve hence requiring new and innovative forms of software engineering, systems engineering, project management, as well as numerous other disciplines to develop it further and manage it the coming years. The application areas of IoT are quite diverse to enable itto serve different users, who in turn have different needs. The technology serves three categories of users, individuals, the society or communities and institutions. As discussed in the application section of this research paper, the IoT has without adoubt a massive capability to be a tremendously transformative force, which will, and to some extent does already, positively impact millions of lives worldwide. According to [25], this hasbecome even more evident, as different governments around the world have shown an interest in the IoT concept by providing more funding in the field that is meant to facilitate further research. A good example is the Chinese Government.

Countless research groups have been, and continue to be, initiated from different parts of the world, and their main objective is to follow through IoT related researches. As more and more research studies are conducted, new dimensions to the IoT processes, technologies involved and the objects that can be connected, continue to emerge,

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further paving way for much more application functionalities of IoT. The fact that IoT is so expansive and affects practically all areas of our lives, makes it a significant research topic for studies in various related fields such as information technology and computer science. The paper highlights various potential application domains of the internet of things and the related challenges.

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