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A Survey of Specific IoT Applications

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ABSTRACT: Internet of Things (IoT) is the prototype in which physical objects are connected through various mediums for purposeful interactive communication. The implementation of IoT in various applications, such as communication and connectivity, environment and infrastructure, healthcare, home and living areas, automation and augmented reality, is mentioned in the research paper, which also discusses the various challenges encountered in the application of IoT that are related to security, enterprises, consumer privacy, data, storage management, server technologies and data center network. The main vision of IoT is to enable living objects with computing and communicating abilities to facilitate interactions amongst themselves. The main objective of this paper is to impart knowledge about Internet of Things (IoT) in a wider perspective.

Keywords: Internet of Things (IoT), RFID, NFC, M2M, V2V

I. INTRODUCTION

Internet of Things (IoT) is a basic archetype that involves the interconnection of various devices (mostly computerized) through a common channel called internet, along with the exchange of data. The data transfer and communication through devices forms the basic platform for IoT. The IoT application is commonly found in all domains including agriculture, engineering, smart parking, medical and various other fields. This paper deals with a survey conducted and processed through various techniques like collecting and exchanging data. Major researches are being conducted about IoT as the issues associated with the concept need to be solved [1]. IoT leads to a path that involves the introduction and practical implementation of the concepts of smart environments. As commonly found in every new innovation, the IoT concept too has several challenging issues, which need to be sorted out to maximize the usage of smart applications. As expected by users and beneficiaries, IoT results should provide high security and privacy; and, the concepts of computer networks and other networking security mechanisms are involved in these processes (ITU Internet Reports).

Around 20 million devices are estimated to work on the concept of IoT in a span of three years. A large number of experts have agreed that it could have a widespread impact. Countries like UK spend a lot of money on IoT research [2]. Coupling devices with internet require Internet Protocol (IP) addresses. IP version 6 is preferred because IP version 4is capable of providing only four billion unique addresses. These devices have sensor and actuation capabilities. Intelligent shopping systems sense users' activities, preferences and habits and accordingly provide offers on their phones. A gamut of applications is based IoT which includes energy management, environment monitoring, infrastructure, healthcare, traffic control, etc.

The architecture of IoT is not universally agreed and different researchers have suggested different IoT architecture. Three layered, middle-ware based layered, service-oriented architecture (SOA) based layers and five layered are some of the IoT architecture. The three layered IoT architecture consists of the application layer, network layer and perception layer. The middle-ware based layer consists of the application layer, middleware layer, coordination layer, backbone network layer, existed alone application system, access layer and edge technology. The SOA based layers consists of applications, service composition, service management, object abstraction and objects. The five layers comprise of business layer, application layer, service management, object abstraction and objects, which are analyzed in this paper.

The five layers are object layer, object abstraction layer, service management layer, application layer and business layer.

A. Object Layer

Sensors play a major role in IoT. The object layer is also known as the perception layer. The sensors and actuators comprise the perception layer and are involved in identifying various functionalities like motion, rainfall, temperature, speed, humidity, position, etc. These data are then digitized and passed on to the object abstraction layer. The big data generated by the IoT is processed and initiated by the perception layer, which transfers the data through channels that are more secure.

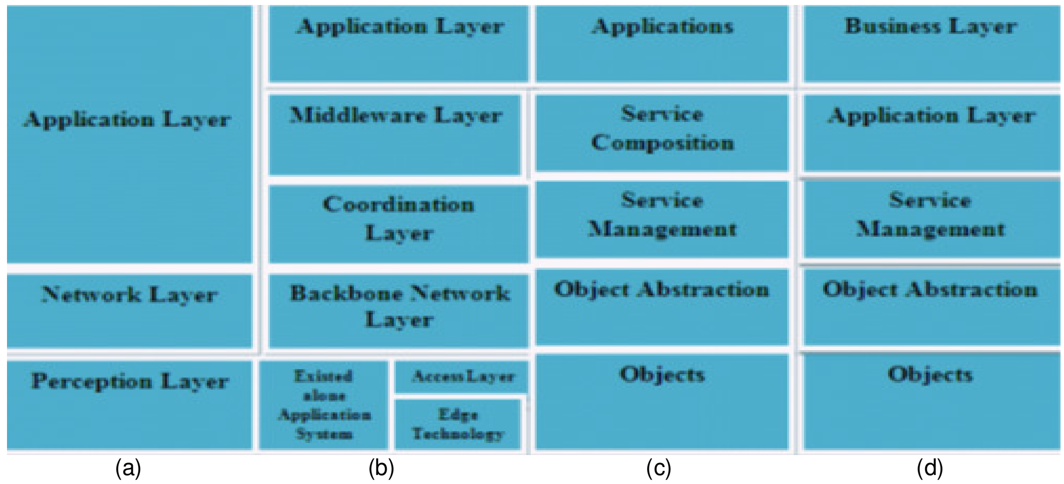

Fig. 1. The IoT Architecture (a) Three layers (b) Middle-ware based layers (c) SOA based layers (d) Five layers [3].

It gathers useful information from sensors, which are converted into digital signals. The network layer then receives these signals and processes them. The sensors involve Radio Frequency Identification (RFID) tags and other sensors like Infra-Red (IR) sensors [4].

B. Object Abstraction Layer

The data that reach the object abstraction layer through the perception layer via secure channels is transferred to the service management layer. This data transfer can occur through various means like Wi-Fi, GPS, Bluetooth or even 3G [5].

C. Service Management Layer

The service management layer is also called a middle layer. Providing services is considered important in any system. The service management layer uses the addresses and names to pair the service with its corresponding requester. The consideration of a particular hardware platform is not necessary as the programmers of the IoT application are allowed to work with heterogeneous objects by the service management layer [6].

D. Application Layer

The request of customers is fulfilled by the application layer. For example, it provides the speed and the measurement of distance to users. This involves providing high quality services to customers, thus satisfying their needs. The application layer is being used for large scale IoT applications [6].

E. Business Layer

The overall IoT system services, activities and notations are managed by the business layer. The business layer deals in the construction of business model, flowcharts and bar diagrams. The business layer processes big data models. The business layer generates different business models for effective reach in a variety of scenarios.

II. TECHNOLOGIES INVOLVED

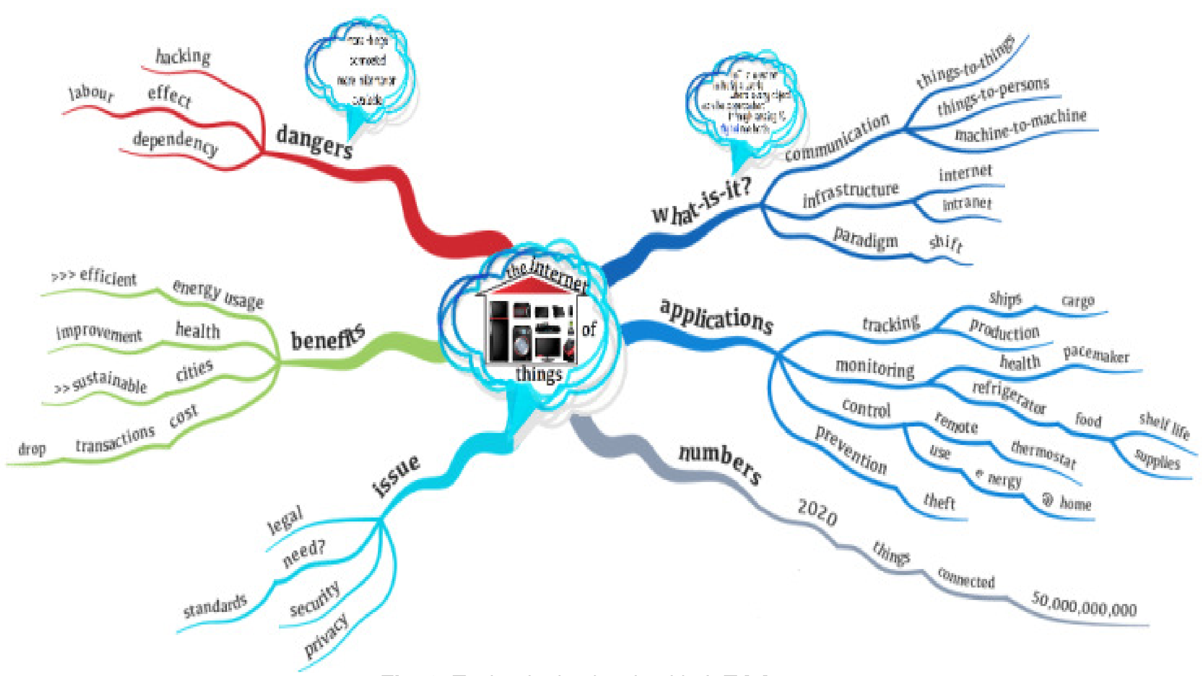

Fig. 2. Technologies involved in IoT [7].

There are several technologies involved in the implementation of IoT, which are as follows:
A. Radio Frequency Identification (RFID)
B. Near Field Communication (NFC)
C. Machine to Machine (M2M)
D. Vehicle to Vehicle (V2V)

A. Radio Frequency Identification

Radio frequency identification (RFID) is comprised of several RFID tags and one or more reader(s). RFID tags are small microchips that are used with an antenna. The signals emitted by an RFID reader are compiled, modified and returned by the antenna. A specific address characterizes the RFID tags that are applied to physical objects. The data of an object is transferred through radio frequency electromagnetic fields used by RFID tags. The RFID reader is able to access the electronic data stored in the tags when an object comes close to it. Objects can be monitored through RFID on a real-time basis [8].

Due to the unprecedented increase in internet connectivity of physical objects, a growing number of people have begun to realize the concept of IoT. Thermostats and HVAC (Heating, Ventilation and Air Conditioning) controlling and monitoring systems can be cited as examples of such objects. The quality of human life is remarkably improved by IoT in other environments and domains, such as industrial automation, healthcare and transportation. The role of IoT is crucial in emergency situations where human responses to natural and man-made disasters may prove to be inadequate [9].

The coordination of decisions, the sharing of information and the interaction among physical objects is enabled by the IoT. The fundamental technologies, such as internet protocols and applications, sensor networks, communication technologies, embedded devices, ubiquitous and pervasive computing, are exploited by the IoT for transforming the traditional physical objects to contemporary smart ones. Domain specific applications (vertical markets) are constituted by smart objects along with their supposed tasks; whereas, domain independent services (horizontal markets) are constituted by ubiquitous computing and analytical services [10].

The application of IoT is anticipated in several home and business applications resulting in the growth of the world economy and enhancement of life quality. For instance, residents of smart homes can control the automatic execution of various chores like controlling appliances, preparing coffee, opening doors, etc. [11]. The devices, service applications, existing technologies and emerging technologies must be potent enough to satisfy the customers' and the markets' dynamic requirements at any given place or time.

B. Near Field Communication

Near field communication (NFC) is evolved from RFID and the technology involved in NFC is misleadingly simple. An NFC chip acts as a part of a wireless link and gets activated by another chip, leading to the transfer of small quantities of data between two devices that are positioned a few centimeters away from one another. Pairing code is not required in NFC. The chips are power-efficient when compared to other wireless communication types as they consume less power. Basic identification of individuals and advanced identification of their personal information can be executed through NFC.

It is now common to find NFC chips placed in credit cards to facilitate contactless payments. Recently, smartphones are used as digitized wallets through NFC. Android users are now able to transfer contacts, photos and directions through a feature called Android Beam, which works by holding two smartphones together. Android Beam was executed as a simple process in Ice Cream Sandwich 4.0. The future development of IoT is dependent on the NFC technology, as it offers a platform for wireless connection to smart objects. Smartphones can be used as virtual payment cards through mobile NFC [1].

C. Machine to Machine (M2M)

Machine to machine (M2M) is a technology that allows networked devices to interact and work without any manual intervention. Communication through M2M is generally employed for remote controlling. For instance, in the restocking of products, the shortage of a specific item can be intercepted by a vending machine and communicated to the distributor. M2M forms the basis for the IoT concept and is a vital aspect in several fields, such as robotics, supply chain management, telemedicine, fleet management, logistic services, traffic control, warehouse management and remote control [12].

M2M assists a networked device in interpreting data and making decisions and is comprised of vital components, namely, a cellular communications link or a Wi-Fi, RFID and software (Hardy and Rukzio, 2008). Telemetry is used to transmit operational data since the last century and is the most widely known type of M2M communication. The measurements of performance collected from monitoring instruments in remote locations were transmitted by M2M pioneers first through telephone lines and later through radio waves. The utilization of telemetry has expanded from a science, manufacturing and engineering context to common daily usage of products, such as online appliances, electric meters and home heating units, through improved wireless and internet technologies. Products enabled with M2M communication are generally sold as 'smart' products [13].

M2M systems are either task-specific or device-specific and presently do not possess a standardized platform for connected devices. It is anticipated that the standards for communication among devices would be changed as M2M becomes universally accepted.

D. Vehicle to Vehicle (V2V)

Vehicle to vehicle (V2V) communication facilitates the transfer of information from one automobile to another through a wireless network. The exchanged information includes location, travel direction, speed, loss of stability and braking. International bodies, such as International Standards Organization (ISO) and Federal Communications Commission (FCC), have established a standard called dedicated short-range communications (DSRC) to be used in V2V technology.

It would be appropriate to describe V2V as similar to Wi-Fi, as it latently uses a frequency of 5.9 GHz that is similar to the one used by Wi-Fi. The range is up to 1000 feet or 300 meters or about 10 seconds at highway speeds [14].

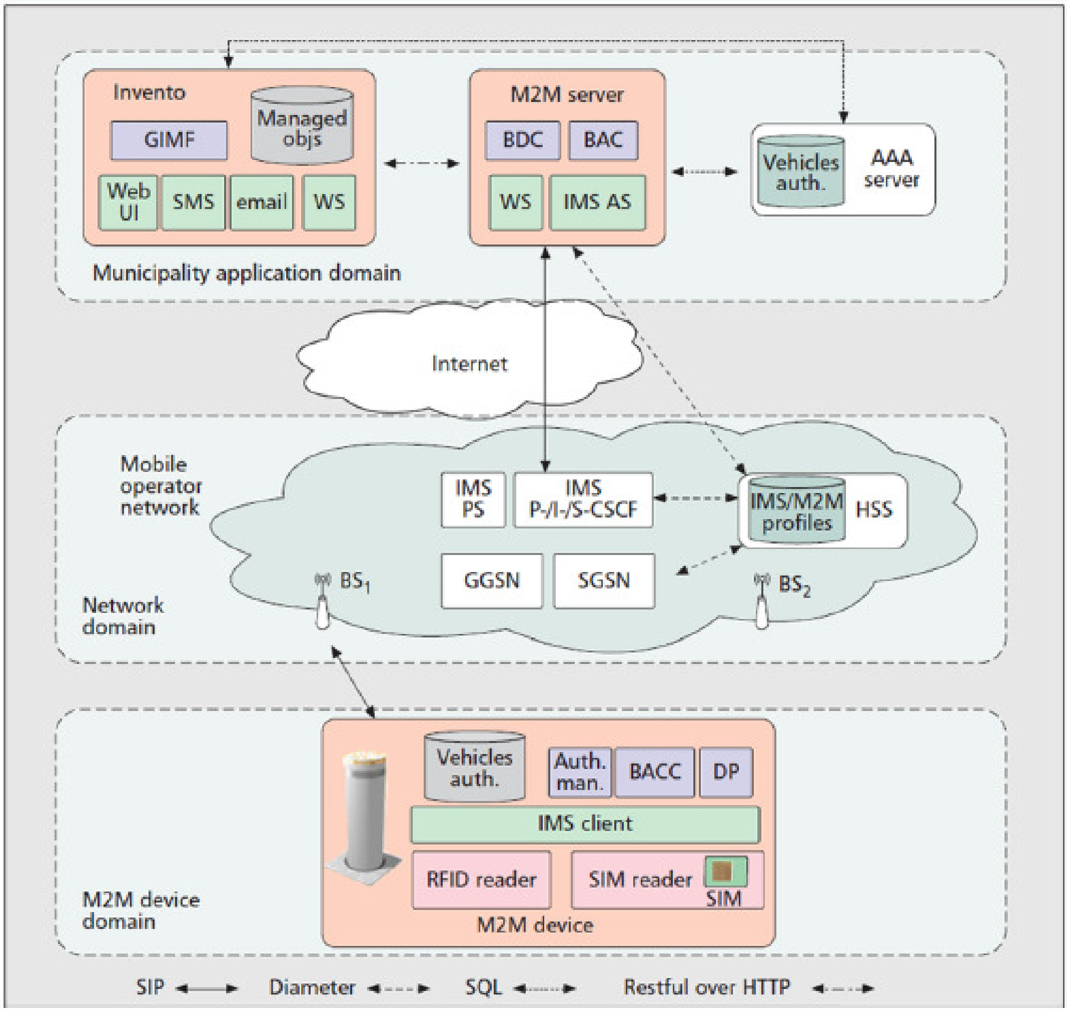

Fig. 3. M2M based Architecture.

Every node (smart traffic signal, smart vehicle, etc.) transmits, captures and retransmits signals through V2V, thereby rendering it to be a mesh network. Distracted drivers may be alerted by traffic-related information gathered through V2V.

A red colored light in the instrument panel flashes and alerts the driver and a combination of amber light and red light is used for escalating a problem and possibly for indicating the direction of the threat. However, it is important to note that V2V is still a developing concept and the aforementioned perceptions are currently unstable. Most of the V2V fitted prototypes and test cars brake and sometimes steer around hazards since people prefer to look at a car to stop or swerve than watch its lamp flashing [11].

Vehicle to infrastructure (V2I) constitute either the traffic signals or other stationary devices. In order to avoid the usage of several three letter acronyms, V2I is generally considered under V2V. Proprietary terms (like Car-to-X) that encompass other vehicles and infrastructure are used by some auto manufacturers. Several terms, such as 'talking car', 'connected car' and 'internet of cars', are used in relation to IoT, among which V2V seems to be the outstanding one.

III. APPLICATIONS

There are various applications in which IoT can be applied and utilized. Applications, such as communication and connectivity, environment and infrastructure, healthcare, home and living areas, automation and augmented reality, are discussed in the present paper.

A. Communication and Connectivity

Collecting data about individuals is a primary task. Big data is the preferred means to accumulate and analyze the patterns, trends and behavior. Instead of conveying information using conventional means, user specific data can be delivered through optimization. Tailored messages and advertisements sent to the customers are usually fetched through data mining [15]. This in turn leads to more business and a competitive environment. When it comes to social media, the automatic transmission of the displayed messages and the visibility control by the users is possible through RFID sensors.

B. Environment and Infrastructure

The prediction of environmental parameters, such as quality of air, soil fertility, wildlife monitoring, and catastrophe, is possible.

Wireless sensors will definitely help in revolutionizing this area. Food items that are transported from farther areas can be checked for quality using pervasive computing and sensors are used to ensure that they are safe for consumption [15].

In the infrastructure domain, structures like bridges, dams, and railway tracks can be monitored for any latent flaws and any possible situation that cause accidents or loss of life can be averted. IoT increases efficiency and emergency response ratio. Repairing and maintenance activities can also be performed alike.

City sense is a wireless device used to control the lightings and minimize power usage by adjusting the lights according to the presence of pedestrians.

C. Healthcare

The area of healthcare has widely benefitted from IoT. Patients can be monitored and work flow in hospitals can be assessed by using IoT technologies that include monitoring devices, such as wristbands, blood pressure and heart rate monitoring systems. Smart beds are becoming popular as they enable the detection of patients' bed occupancy and provide support without the manual intervention of nurses [19].

IoT also helps to maintain a proper database and records, resulting in the reduction of discrepancies and mismatches. Wearable devices are small in size and are known for less power consumption and accurate readings. Medical dispensing devices by Philips help old people to maintain their intake of medicines through alerts about tablet timings, missed dosages and tablet replenishments. Biological sensors are also being developed to study DNA molecules.

D. Home and living areas

Energy consumption can be managed to a sizeable extent by using IoT sensors. Automatically switching off lights when not needed and observing the daily usage can help in reducing power consumption and money. Alarms and security cameras can be put to proper use and monitored, thereby avoiding thefts and losses. IoT gives users the control to customize devices according to their needs. Nest thermostat, an electric appliance, incurs only half of the normal electricity bills. Air quality egg uses sensors which detect the carbon dioxide and nitrogen dioxide content in homes. Amazon echo has seven inbuilt microphones, can sense the slightest of noises, and is capable of playing music, answering and reading news.

E. Automation

RFID tags help in the automation process, which is done by referencing the tags with the production parts. The person reads the data and the corresponding tag number, which is stored in the network. The robot or the machine picks up the parts with the tag and processes it further after verifying the data.

Libelium is known for the industrial automation services which help devices to be connected to cloud storage for communicating. It is used in varied sectors like military applications and manufacturing.

F. Augmented reality

Users can virtually try apparels without going to shops through augmented reality (AR). The physical environment around people becomes more receptive and interactive. It provides users with real time and real word information. Augmented maps use sensors with NFC that can provide users with information about things around them. Apple is working on AR technologies [15].

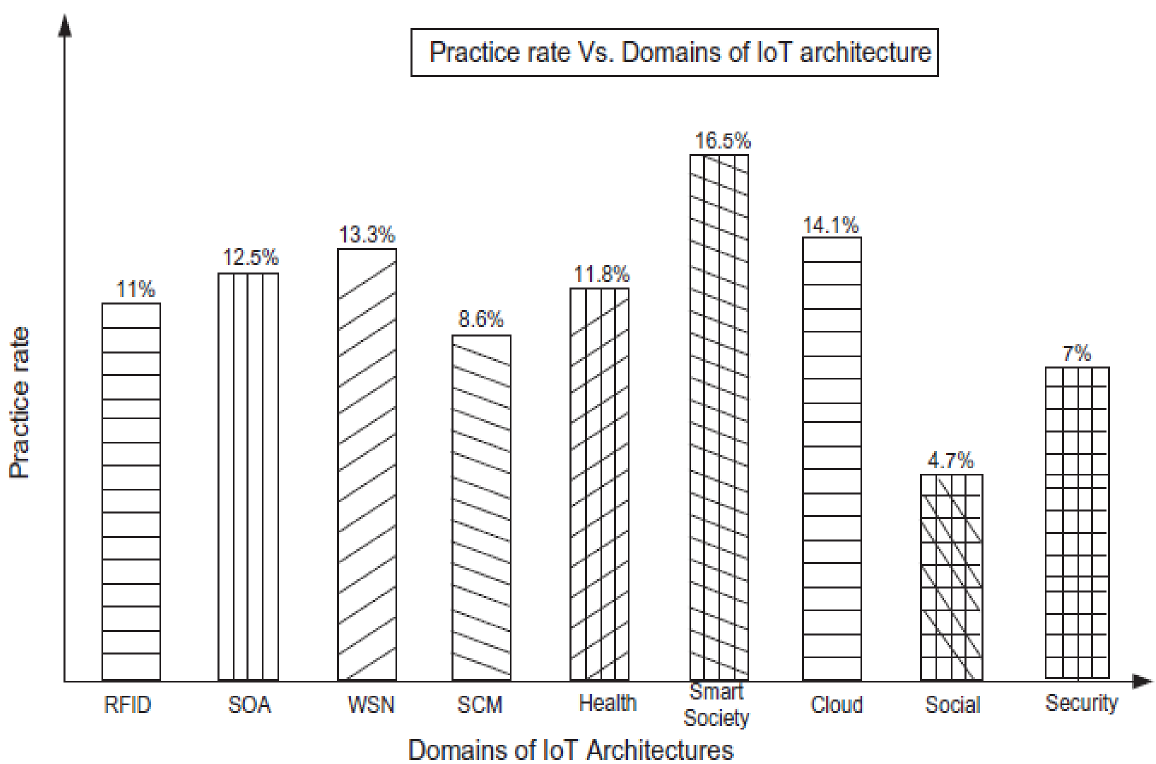

Fig. 4. Chart Depicting the Practice Rate of IoT in various Domains.

These are the various domains in which IoT technology is being practiced. Since Smart City is getting most popular, it has the highest application of IoT. The cloud technology and networking are gaining the IoT application at equal rate. Health care predominantly uses IoT for maintaining records and safeguarding the medical information. SOA is gaining popularity that its research is increasing at a faster rate. It is surpassing the RFID based research using the usage of IoT. Social related research using IoT is still at the naïve stage.

IV. ISSUES

The major challenges faced by IoT include security challenge (network security), privacy issues, storage issues, data management issues, barriers and enterprise challenges. These major difficulties are to be handled in a more personalized and intelligent way [18].

A. Security

An entire range of security landscape would be created by the digitalization and the automation of devices. This would in turn generate opportunities for the service providers of operational security technology as more and more enterprises would seek to protect themselves.

In order to cater to specialist areas, such as medical equipment, industrialized systems and air and defense sectors, several industry-specific security platforms are being developed. In several cases, these security platforms are integrated into the platforms that are formulated for such specialist industries. Such solutions are intended to tackle platform-specific vulnerabilities and to secure different aspects of specific devices like smart meters [16].

B. Enterprise challenges

The increasing quantity of data with infinite devices poses significant security challenges and increases the complexities. The real-time business processes are put at a risk due to the impact caused on the requirements of availability by such complexities.

C. Consumer Privacy

As the consumer goods become increasingly digitized, the challenge of securing the personal information of customers is also posed. Issues about digitalized automobiles and metering equipment are already prevalent.

Security needs to be integrated as a vital part of the IoT infrastructure as the IoT generated data is intended for the management of internet enabled devices and the delivery of better services.

D. Data management

Personal data (consumer driven) and big data (enterprise-driven) are the two types of data that are impacted by IoT. The method of gathering and storing big data in key verticals, such as healthcare and financial services, is being transformed.

The onus of storing, protecting and retrieving the incoming data lies with the IT administrators, who are already in charge of handling the storage centers. The physical capabilities of storage servers need to be maximally used as Gartner estimates that only 30 percent to 50 percent of the storage capacity is used. The management of the stored data is altogether a different issue [16].

E. Storage Management

Nevertheless, in spite of the current availability of the storage capacity, the demand would be prevalent in the future. The issues regarding the storage and management of data need to be addressed. The economics of storage would be weighed against the value of IoT information by organizations as retrieving the stored information is crucial for them.

F. Server Technologies

Organizations require IoT either for adding value or for increasing profits. The proliferation of IoT and the need for sophisticated server technologies results in the increase of investment of key vertical industries.

Enhanced server budgets and additional computing capacities may be required in cases where organizations manage and consume data generated from a wide range of devices.

G. Data Center Network

Moderate bandwidth is currently being utilized by the data center Wide Area Network (WAN) links. However, expanded bandwidth would be required in future to cater to the potential increase in transfer of data. Owing to the scale of data being generated, it would not be economically viable to store data at a solitary location [17].

Table 1: Key IoT issues and their appropriate Solutions.

IoT Issues	Solutions/Protocols
Reliability	RELY on IT, PERUM
Scalability	IoT6, SENSEI, IoT-iCore
Performance	Smart Santander, RELY on IT
Interoperability	PROBE-IT, Open IoT, Link Smart, IoT-iCore
Architecture	VITAL, IoT-A, IoT @ work
Management	OMA-DM, NETCONF Light
Security	BUTLER, Codo, SVELETE

Table 1 presents the various issues related to IoT and the protocols proposed to resolve the issue. The factors like performance and scalability are given importance so that future IoT devices could easily operate without any further challenge.

V. CONCLUSION

IoT has changed the way in which objects and devices interact with each other. The daily human needs are affected by IoT applications. The concept of IoT and its architecture is explained in this paper, which also consists of a brief description of the five layers of the IoT architecture. The technologies that are involved in the application of IoT are explained. Awareness on IoT utilization is increasing among people. A lot of improvement is anticipated in communication technology and in the implementation of IoT. Data collection, storage and retrieval methods are vital for IoT applications. The major challenges faced by IoT include security, enterprise challenges, consumer privacy, data management, storage management, server technologies and data center network. The computational and communication abilities of devices, cost effectiveness and the utilization of IoT collectively play a significant role in selecting the IoT architecture. Despite causing widespread impact in various areas, there are many hurdles that need to be overcome, which include security breach, loss of privacy and leakages in data transfer. The overall performance of the IoT in various fields needs to be vibrant to facilitate the enhancement of the quality of human lives.

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