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The Internet of Things: An Overview

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Abstract: *Our daily activities are governed by information and communications technology (ICT). With the integration of heterogeneous devices in various areas, it becomes a crucial component of our infrastructure that supports our daily lives. Among them are personal computers, sensing, surveillance, smart homes, entertainment, transportation, and video streaming merely a few. As a vital living system, the Internet is always transforming and developing, giving rise to fresh technologies, applications, protocols, and algorithms. The growth of mobile broadband and Internet access is being driven by the acceleration of wireless communication trends.*

Keywords: **IoT, M2M, ICT, Heterogenous Devices, Smart Devices**

1. INTRODUCTION

Nowadays, we cannot imagine a world without the Internet. It is challenging to envision a. The Internet is becoming increasingly significant in everyone's personal and professional lives today. Everyday, we interact with a variety of gadgets, including mobile computers, sensors, smart phones, and other intelligent objects. New ICT and enterprise system technologies are greatly impacted by these and other IoT-related technologies [1]. Initially referred to as the "Internet of Computers," it was then renamed the "Internet of People," and more recently, with the rapid advancement of ICT, it has been dubbed the "Internet of Things." For the Internet to grow, become more accessible, and be uniquely identified, various technologies and smart items are used. As opposed to being "anytime, anywhere" for "anyone," the connectivity is now "anytime, anywhere" for "everything"[2]. A lot of attention has been given to IoT-related technologies in recent ICT advances and economic developments, where it is widely regarded as one of the most crucial infrastructures for their promotion and one of the methods with the most promise for the future. The primary goal is to facilitate interaction and integration between the real world and the internet [3]. IoT was defined as "a worldwide network of networked things uniquely addressable, based on standard communication protocols" in [4], which makes semantic sense given that the term's origin expression consists of the terms "Internet" and "Things". IoT's true value, however, lies in its capacity to connect a wide range of heterogeneous devices, such as commonplace objects, embedded intelligent sensors, context-aware computations, conventional computing networks, and smart objects that vary in design, systems, protocols, intelligence, applications, vendors, and sizes.

2. Architecture of IoT

The fundamental architecture of IoT is given in Figure 1.

1. Sensing Layer: Sensors, devices, actuators, and other components are part of the IoT's initial stage. These components gather data from the physical world, process it, and then transfer it over the network.
2. Network Layer: Network Gateways and Data Acquisition Systems make up the IoT's second level. The analogue data (gathered from sensors) is transformed into digital data using DAS. Additionally, it manages data and detects infections.
3. Data Processing Layer: This layer is the most crucial layer. Data is pre-processed here according to its variety and separated as necessary. It is then delivered to data centres. Edge IT is used in this scenario.
4. Application layer: Cloud/Data Centers are the fourth stage of the Internet of Things, where data is maintained and used by applications for agriculture, defence, healthcare, and other industries.

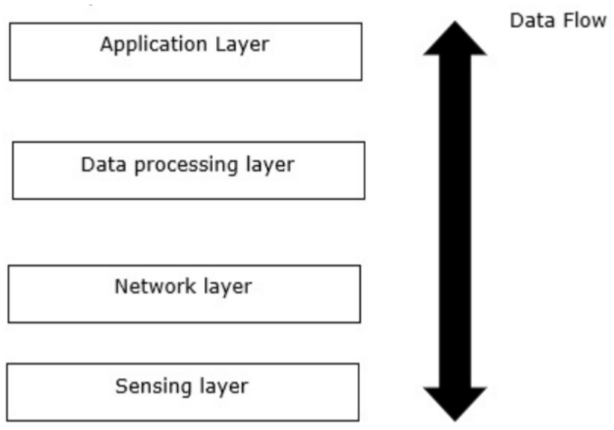

Figure 1. Architecture of IoT

3. Protocols for IoT

The Internet of Things (IoT) is often a very large-scale network made up of diverse limited devices and intelligent objects. The design of various protocols is significantly impacted by such a limited network.
However, keeping this in mind generally makes it possible to develop a large collection of standards and protocols.
These protocols are designed to enable effective and scalable communications as well as the creation and implementation of applications and services suitable for a range of contexts.

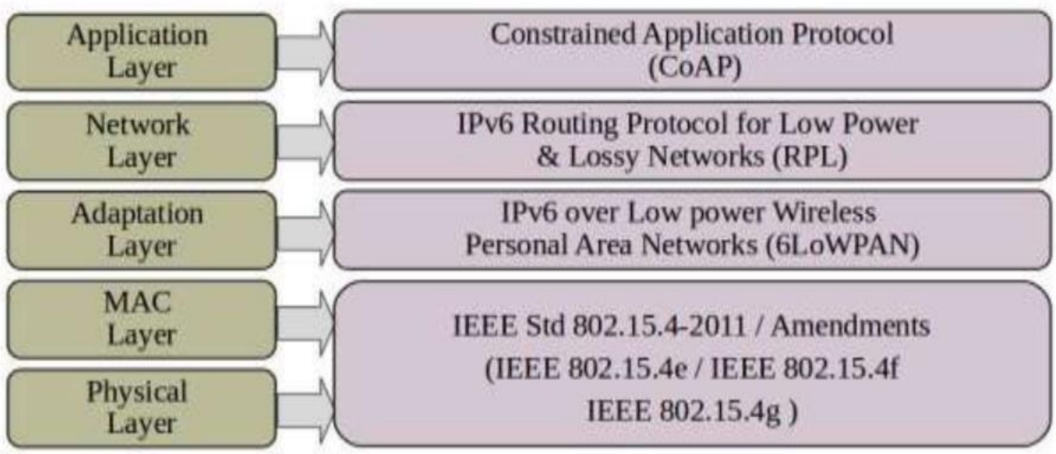

Figure 2. Protocols for IoT

A. IEEE 802.15.4

The physical (PHY) and media access control (MAC) layers for low data rate, low power, and short-range wireless personal area networks are defined by the IEEE 802.15.4 standard, which was developed by the IEEE 802.15 working group in the IETF (LR-WPANs). The initial release was made available in 2003 and supported data rates of 20, 40, and 250 kb/s with a 10-meter communications range for universal device connectivity. The PHY layer is then improved with EEE 802.15.4a/c/d, which adds a number of new frequency bands and transmission methods. The 2011 iteration of IEEE Std 802.15.4, which focuses on the technical criteria for interoperability and supports a maximum data rate of 850 kb/s, replaces the earlier amendments. Later, a number of amendments are introduced such as IEEE 802.15.4e, IEEE 802.15.4f, and IEEE 802.15.4g. The IEEE 802.15.4e is released in order to improve and add functionality to the MAC sub-layer. A channel hopping strategy is adopted to enhance the support for industrial markets, and improve the robustness to overcome the multi-path fading and external interference. In IEEE 802.15.4f, the PHY is improved to support flexibility and better performance in the high dense deployments of autonomous devices, and active RFID systems wherever in the world. This update enables a broad range of applications with a number of limitations, including affordability, power efficiency, long battery life, dependable communications, pinpoint position, and reader alternatives. With guaranteed time slots, secure communications, transfer reliability, CSMA/CA, link quality indication (LQI), and energy detection, IEEE 802.15.4 offers real-time appropriateness. Additionally, it offers a relatively low cost of production and operation and technological simplicity. The IEEE 802.15.4 serves as the basis for a number of protocol stacks, including those for ZigBee, WirelessHART, MiWi, RPL, and 6LoWPAN.

B. 6LoWPAN

An adaptation layer standard called IPv6 over Low power Wireless Personal Area Networks (6LoWPAN) enables IPv6 packets to be delivered and received over links based on IEEE 802.15.4. It implements the concept of using Internet protocol to communicate with tiny autonomous devices as the sole option for LLNs or smart object networks. allowing such limited devices to connect to the Internet in a very large number. Furthermore, 6LoWPAN supports mobility in which the devices move continually and are only ever deployed ad hoc and without defined locations.

The three main tasks that 6LoWPAN does for mapping from IPv6 network to that of IEEE 802.15.4 are as follows: (i) IPv6 header compression, (ii) IPv6 packet fragmentation, and (iii) layer-2 forwarding.

When required, a separate 6LoWPAN header is inserted for each. In the first, the IPv6 header is condensed so that just the fields that can be derived from the context are sent, while the rest is sent as-is. The second method involves fragmenting packets bigger than IEEE 802.15.4 MTU at the sender and reassembling them at the destination. The third function, known as mesh-under and appropriate for tiny and local networks, does not include IP routing. The packets are forwarded by the adaption layer over a number of radio hops to the destination. This routing is developed based on the 6LoWPAN header and IEEE 802.15.4 frame at the link layer level.

C. RPL

The IPv6 Routing Protocol for LLNs (RPL) is a network layer protocol designed for low power and lossy networks. RPL has been developed with the objective of meeting application-specific requirements for LLNs identified by ROLL (Routing Over LLNs) working group in IETF. These requirements are specified for the following application areas, but are not restricted to them: industrial, building automation, home automation, and urban sensor networks. The examination conducted by ROLL revealed that the current protocols, including OSPF, IS-IS, AODV, and OLSR, fall short of meeting all the requirements. When determining the optimal or quickest path, these protocols, which exclusively employ static connection metrics, do not take into consideration device stats like processor power, memory, remaining energy, or hardware faults.

The RPL is an expandable proactive IPv6 distance vector protocol that supports MP2P, P2MP, and P2P traffic types as well as mesh routing environments and shortest-path constraint-based routing (on both links and nodes). It takes goals for route optimization into account. It can operate over a variety of different link levels independently of packet processing and forwarding. That covers constrained connection layers or those used with extremely confined hardware, including but not limited to low-power WPAN (802.15.4) or PLC (Power Line Communication) technologies. The RPL also contains power-saving features including adjusting the rate at which control messages are delivered and changing the topology only when data packets need to be sent. RPL can be operated in multiple instances at once on a network. Each of these cases could take into account a variety of opposing limitations or optimization goals. Based on these requirements, the RPL creates a DODAG (destination oriented directed acyclic graph) that is free of loops.In order to design such a network, such constraints and objectives are defined by Objective Function (OF), which is outside the scope of this article.

D. CoAP

The Constrained RESTful Environments (CoRE) working group at the IETF created the Constrained Application Protocol (CoAP), a web-based application layer protocol. Through the regular Internet, it provides interactive M2M communications for autonomous machines and intelligent things. It's designed to be utilised in low power, limited networks like LLNs/IoT and 6LoWPAN that call for remote monitoring and control. In such confined situations and devices, CoAP is a lightweight form of HTTP that enables simplicity, low message overhead, decreased parsing complexity, and little requirement for packet fragmentation. Additionally, it is a platform that offers a request/response interaction model between apps and makes it simple to integrate embedded networks with current web infrastructure. Additionally, it supports proxy mode, multicast, dependable delivery, built-in discovery, and asynchronous message exchanges, among other M2M features. The CoAP packets are substantially smaller, easier to construct, and require less memory to parse. CoAP is a datagram-based protocol that uses UDP rather than TCP. However, it can be utilized on top of packet-based communication protocols like SMS and others.

4. Requirements of an IoT Operating System

The requirement that an IoT operating system (OS) should satisfy are given below −

1. The Operating System specifically for IOT Purpose should be portable which means it can be easily ported to different hardware platforms.
2. Operating systems should consume little power, have little memory usage, and have little OS overhead.
3. It should support connectivity with different protocols like Ethernets, Wi-Fi and BLE.
4. OS scalability should be there so that we need to know only one OS for both nodes and gateways.
5. Secure Boots and SSL Support should be used to protect the OS.
6. All certifications for various applications should be met by it.

5. Technologies supported by IoT

The technologies supported by IoT are as follows:

- Big Data Analytics
- Cloud
- Wireless Sensor Networks
- Embedded Systems

6. Applications of IoT

The adoption of the Internet of Things by a variety of businesses has made its ubiquity a reality. It wouldn't make sense to ignore IoT because of how many enterprises, organisations, and government agencies find it to be a desirable alternative. Following are some examples of IoT applications in various industries:

1. Agriculture: IoT enables monitoring and managing microclimate conditions for indoor planting a reality, which in turn boosts output. IoT-enabled devices can monitor soil moisture, nutrients, and meteorological information to better manage irrigation and fertiliser systems for outdoor planting. For instance, this prevents resource waste if sprinkler systems only release water when necessary.
2. Consumer Use: IoT gadgets like wearables and smart homes make life simpler for average people. Accessories like Fitbit, cellphones, Apple watches, and health monitors, to mention a few, fall under the category of wearables. These gadgets enhance network connectivity, health, and fitness as well as enjoyment. Environmental controls are activated in smart homes so that your home is at its most comfortable when you go home. Dinners that call for an oven or crockpot can be started from a distance so that it will be ready when you get there. The consumer's ability to remotely operate lights and appliances, as well as turn on a smart lock to let the right individuals into the house even if they don't have a key, makes security more accessible.
3. Healthcare: First and foremost, wearable IoT devices enable hospitals to keep tabs on their patients' health while they are away from the hospital, cutting down on length of stay while still supplying up-to-the-second real-time information that could save lives. Smart beds reduce the wait time for available space in hospitals by keeping the personnel informed of availability. The addition of IoT sensors can make the difference between life and death by reducing malfunctions and boosting reliability. IoT makes providing care for elderly people much more comfortable. Sensors can identify whether a patient has fallen or is having a heart attack in addition to the previously described real-time home monitoring.
4. Insurance: The Internet of Things revolution can even help the insurance sector. Insurance firms may provide discounts to policyholders for IoT wearables like Fitbit. Fitness tracking enables the insurance to provide personalised coverage and promote better lifestyle choices, which ultimately benefits both the insurer and the consumer.
5. Manufacturing: Another significant winner in the IoT competition is the manufacturing and industrial automation sectors. RFID and GPS technology can assist a manufacturer in tracking a product from its initial placement on the factory floor to its final placement in the target retailer, or the entire supply chain. These sensors can collect data on the distance travelled, the state of the product,

and the environmental factors the goods was exposed to. Sensors affixed to manufacturing machinery can be used to locate production-line bottlenecks, minimising downtime and waste. Other sensors that are put on those same devices can monitor their operation, forecast when they will need maintenance, and stop expensive breakdowns.

6. Retail Industry: The retail industry has a lot to gain from IoT technology. Sales data from both online and offline retail can manage warehouse robotics and automation using data from Internet of Things sensors. This is dependent in large part on RFIDs, which are currently widely used. Mall locations are risky investments because their company is prone to ups and downs, and because of the rise of online shopping, there is less demand for physical stores. IoT, on the other hand, can assist in analysing mall traffic to let mall-located retailers make the required adjustments that improve the client shopping experience while lowering overhead. IoT enables merchants to target customers based on previous purchases, which is related to customer engagement. A business might create a targeted promotion for their devoted clients using the data offered by IoT, doing away with the requirement for pricey mass-marketing promotions with low success rates. Customers' smartphones can be used for many of these campaigns, especially if they have an app for the relevant store.

7. Transportation: Most people have heard by now about the advancements being made in self-driving automobiles. But that only scratches the surface of transportation's enormous potential. The GPS, another example of IoT, is used to assist transportation companies in planning quicker and more effective routes for vehicles delivering freight, reducing delivery times. Navigation has already made great strides, a nod once more to a phone or vehicle's GPS. However, those statistics can also be used by municipal planners to plan road building and upkeep, as well as traffic patterns and parking space demand.

7. Advantages and Disadvantages

6.1. Advantages

- **Mobility and Agility:** Employees can work without any limitations from any location at any time thanks to the Internet of Things (IoT).
- **Cost Reduction**: IOT devices detect any issue much faster than traditional troubleshooting methods. In addition to saving time, it also lowers the price of major repairs.
- **Efficiency and Productivity:** The hassle of PDF editing and archiving will be eliminated by an automatic PDF conversion and production tool. Consequently, efficiency and productivity have increased.
- **Customer Experience:** The most important factor in running a business nowadays is the customer's experience. The customer experience has been significantly improved through IoT. Home automation is an illustration of a good customer experience. The fact that everything is connected means that clients do not need to worry about appliances. Through a mobile device, the appliance can be turned off.
- **Business Opportunities:** IOT offers sophisticated analytics and intelligent utility grids that enable Small Management Businesses to provide their clients more worthwhile products and services.

6.2. Disadvantages

There are a number of disadvantages to employing IoT:

- **Security** − The information is dispersed throughout the Internet. Thus, protecting its privacy remains a Significant Challenge. In the IoT, end-to-end encryption is essential.
- **Safety** − Imagine a doctor who neglects to check on a patient. Additionally, a notorious character altered the medication or the health monitoring equipment failed. The patient could then pass away as a result.
- **Complexity** − The majority of the gadgets continue to have some software flaws. Each device must be able to communicate with other devices in the network without any interruptions.
- **Compatibility** − The equipment monitoring is not governed by any international standards.
- **Policies** − To combat the Black marketing of IoT devices, governmental authorities must take some action to create IoT-related regulations and standards.

8. Conclusion

The Internet of Things (IoT) is a cyber-physical system that connects billions of different gadgets and intelligent objects. Different technologies, including identification, embedded sensors, intelligent management, protocols, data storage/processing/analytics, etc., make these things possible. Over the past few years, a variety of IoT applications have been adopted and put into use. An overview of the Internet of Things is offered in this paper along with its vision, concepts, characteristics, and promising future.

There are brief explanations of the IoT's primary technology, recently created protocols, and most popular applications.

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