Journal of Science and Engineering Research
Vol. 2, No. 1, 2023, pp.9-16
eISSN: 2957-7187

IoT: A Review of Architecture, Key Machinery, Application and Security Attacks

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DOI: http://dx.doi.org/10.56828/jser.2023.2.1.2
***Article history**: Received (February 25, 2023); Review Result (April 4, 2023); Accepted (June 3, 2023)*

Abstract: The Internet of Things (IoT) is a novel technology that connects several things to heterogeneous access networks and communicates intelligently using different kinds of sensors and Radio Frequency Identification (RFID) to meet new challenges. It gained a lot of attention and is implemented in various sectors like healthcare, transportation, smart homes, and educational environment. Now a day's IoT technology plays a crucial role in day to day life-transforming real-world objects into intelligent virtual objects improving business productivity and government efficiency. This paper provides an overview of current research work highlighting architecture; critical technologies used for IoT and systematically identifying security threats.

Keywords: Internet of Things (IoT), Wireless sensor networks, Radio frequency identification sensors, Actuators, Security attacks

1. Introduction

IoT can be considered a global innovation technology. It can connect, add and monitor any physical object which has existed to the Internet of Things that can be controlled remotely. Nowadays, as the number of objects is increasing, they are linked via Radio Frequency Identification (RFID) tags and IP addresses electronically. Application of IoT to objects augmented with critical capabilities, namely: sensors, actuators, and networking add smartness to everything in this world and the user's life becomes impressive.

2. Related Work

Muhammad et al. [1] explored the privacy and security challenges of IoT and identified a few issues to perform future research work in IoT. Linda Nur Afifa et al. [2] reviewed the layered architecture of IoT, the technologies involved, and some problems or challenges associated with IoT. Somayya Madakam et al. [3] displayed methodically the condition of stylish belongings and their submissions that help new researchers, who are interested in pursuing their research work in the IoT area. Krishan Kumar Goyal et al. [4] highlight the architecture, technology, and applications of IoT. Similar trends and details are presented in a systematic manner which is helpful for further research. Amine Rghioui et al. [5] presented the scope and vision of the Internet of Things, summarizes the problems and challenges, and also provides solutions to overcome them. Shubhalika Dihulia et al. [6] analyzed the existing protocols and mechanisms to secure communications in IoT. A brief report of open

challenges and strategies for future research work in the IoT domain is presented. Pritpal Singh et al. [7] discussed the overview of the Internet of Things architectures, technologies their usages in daily life that facilitate knowledge accumulation efficiently.

3. Basic Layered Architecture of IoT

The underlying architecture of IoT has implemented five layers, namely: Perception layer, transport layer, processing layer, network, and application layer that work for the development of IoT devices as shown in Figure 1.

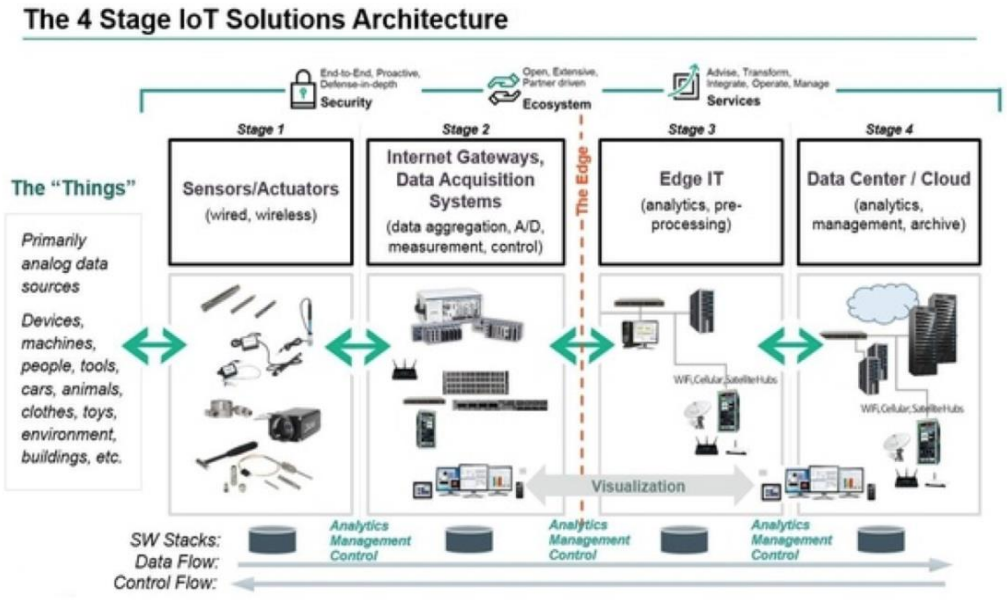

Figure 1: IoT solutions model

The layer-wise details are tabulated as follows in Table 1.

Table 1: Layer-wise details of IoT architecture

S.No	Name of the Layer	Description
1	Perception Layer	It gathers and recognized information in the real world. It receives sensors data from the different objects to perform specific operations by the corresponding objects
2	Transport layer	Receives the data from the perception layer and passes the data to the next layer for further processing and vice versa. The technologies used in this layer are 3G, 4G, LTE, and RFID.
3	Processing layer	The data is stored using technologies like DBMS and cloud computing. The stored data is analyzed and processed to complete the desired task.
4	Application layer	It works like software sensors, actuators, and other virtually intelligent objects.
5	Business layer	It manages the working of the entire system, along with many other features like privacy and security are provided.

Significant essential steps in the working of the IoT Architecture models are the following:

a. Data Collection Models and Gateways of Internet
b. Actuators and Sensors
c. Cloud and Center for Data Storage and Processing
d. Edge of the IT Models

3.1. Data Collection and Gateways of the Internet

To process the working of any device or to understand the working of a designed model in a better way, the processing of data and the results were studied in detail. To process or analyze the working f any device, the collection of data from various sources will play a key role. The IoT-based designed systems or models will always have a more number of applications or tasks to be performed based on various data sources being collected from various locations by the use of various sensors placed at various locations. As the data collection is being done in the form of the device, later on, the collected data can be formatted or changed based on the required format such that to process the data in the right way. The data that was being collected may be in different ways or different formats. It is the duty of the engineers or the people who were working on such systems to take care of the data to be collected and to be formatted for further detailed processing of such data. The sensors are used for collecting such data from various locations based on the type of data to be collected. The example cases may be like the temperature can be collected in the form of centigrades, and the speed of the vehicles can be calculated in the form of the motion of the wheels or some other components of the vehicles. The weight of an article can be calculated in the form of grams, and the motion of any object can be calculated with the movement of the object or any human being.

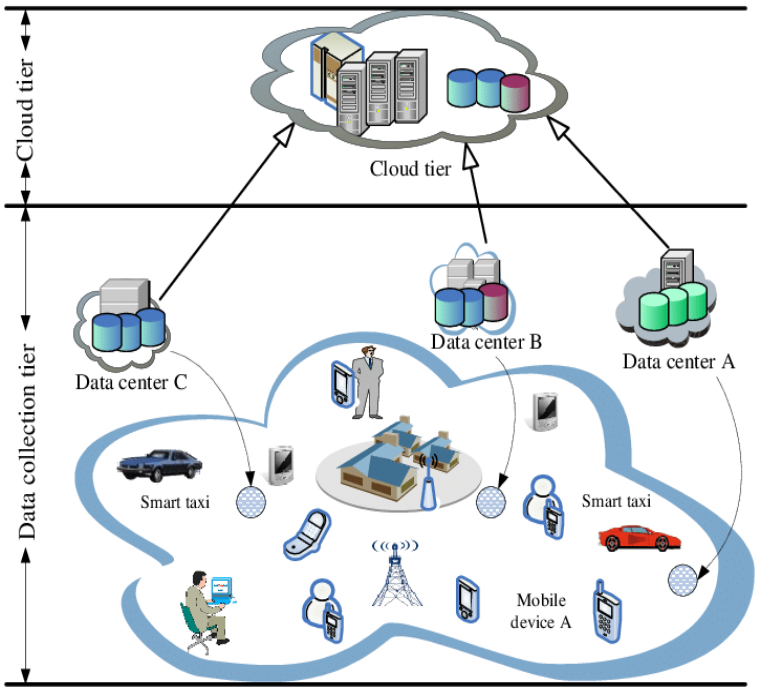

Figure 2: Data collection model [9]

The second most crucial point was the flow of data or the provision of the amount of data being transferred from one location to the other locations with the help of local connectivity networks or internet connectivity. If the users might use the Internet for transferring data and also for receiving the data, a connection with high speed is required for faster and speedy communication and speedy transfer of data from various locations to other locations located at various distances. These distances may sometimes be in meters or some other cases, and they might be in thousands of kilometers also. Here, the distance is not the matter; the amount of data being transferred or the amount of data being transferred at what rate of transfer are the most important things to be considered as severe considerations. To provide the proper security and proper control over the data being transferred in the network must have a controlling authority to perform such tasks. These tasks can be controlled by the Gateways, which will have the programming units with full control of the data transfer.

3.2. Actuators and Sensors

Both sensors and actuators play a crucial role in the functioning of IoT devices which are performing various tasks at various locations and various addresses with more specific and more accurate required applications. Sensors are the units or devices which can be used to observe or collect data about the climate or the surroundings based on the changes in the environments around the objects and other instruments. Several types of sensors are used in the market based on the requirements of the devices and applications. Some devices need changes in time, changes in temperature, changes in actual values, changes in velocity, changes in vehicle speeds, etc. Based on the type of value or the type of parameters to be calculated or need to be identified will be based on the type of sensor to be used. These sensors will be used in various locations like aircraft, vehicles, space vehicles, industries, power plants, water plants, and control systems.

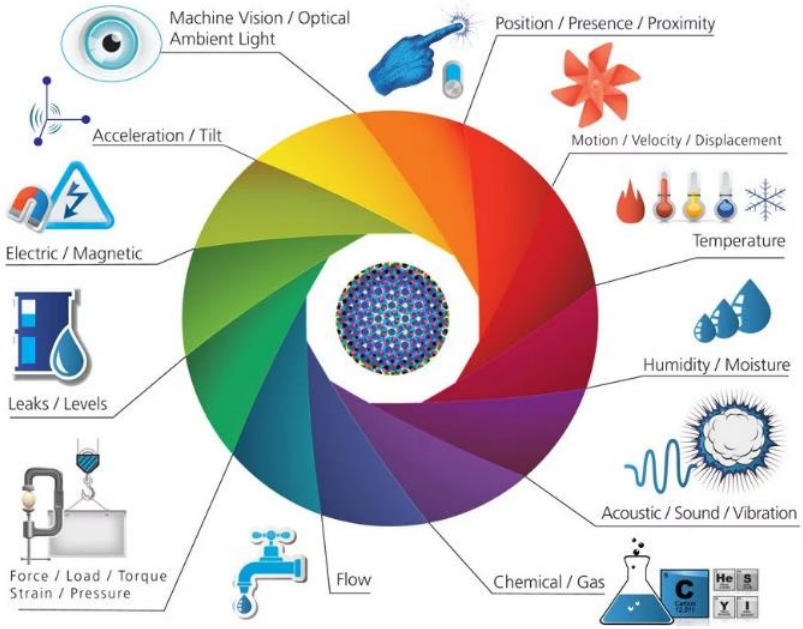

Figure 3: Types of various sensors and actuators [10]

The other important part of these devices is the actuators. These actuators will have a little difference between the sensors in terms of working. The sensors are used for the only collection of data, and they cannot process further any actions required based on the collection of data. But, these actuators will do that, these actuators will collect the data, and if any action needs to be performed based don't the data collected, these devices will work accordingly and can be observed performing such tasks.

3.3. Cloud and Center for Data Storage and Processing

Once the data from various sensors and actuators is collected which were located at various locations, the data needs to be stored and should be processed at proper intervals of time by the data scientists or the engineers located at various companies or various engineers working in various laboratories. The data that may be collected might be small in size in some cases and in some cases, it might be huge like it might be in some terra bytes also. Ordinary devices or storage devices cannot be enough to store such massive data and also for processing. Hence, a separate location and the processing of such data to be processed is more important for the engineers who were working on such data.

3.4. Edge on IT Models

Once the data is collected from various sources by the systems or the machines, the data should be formatted in the required format by the users. Then the data can be started for processing and for analyzing such data for the detailed verification and the detailed analysis of the models. The model can be understood in a better way, and the data needs to be given for better functioning of the applications.

4. IoT Technologies

The cyber-world enables users to use physical objects equipped with different tagging IoT technologies. The details of a few IoT technologies are described as follows:

(1) Radio Frequency Identification (RFID): Object and person identification wirelessly using radio waves can be performed using RFID.
(2) Internet Protocol (IP): The entire network that might be either local or non-local networks might work based on a single protocol like Internet Protocol.
(3) Electronic Product Code (EPC): Electronic Product Code (EPC) is intended to design and improve the barcode system.
(4) Barcode: They are defined and worked based on laser scanners and cameras, which is a different way of encoding.
(5) Wireless Fidelity (Wi-Fi): The father of Wireless Fidelity is Vic Hayes. It connects offices, homes, hotels, cafes, airports, and entire cities.
(6) ZigBee: It is a low-power wireless network protocol that ranges around 100 meters and bandwidth of 250 kbps.
(7) Near Field Communication (NFC): It is complementary to Bluetooth which works in a dirty environment and is quickly and simply connected.
(8) Wireless Sensor Networks (WSN): Remarkable attention has been received in many areas like military, security, healthcare and agriculture monitoring, and forest fire.

5. Applications of IoT:

The deployment of IoT across various sectors has a wide range of benefits that are illustrated as follows:

(1) Smart Traffic System: An intelligent traffic monitoring system can improve the traffic situation in major cities by considering the automatic Identification of vehicles and other traffic factors. The features that can be provided through a smart traffic system are Congestion control, traffic accidents, environmental pollution, unexpected traffic jams, and parking space availability.

(2) Smart Environment: Environmental intelligence is possible through innovative IoT technologies. The features include natural disaster prediction, air pollution monitoring, and the study of weather conditions in the environment.

(3) Intelligent Living: Smart home automation performs controlling household appliances like energy, utility, water, and power supply, thereby saving resources in a simplified and effective way as per user needs. Smart living can cut down on monthly bills and limit resource usage, energy, and water supply consumption.

(4) Hospital Management: The security of hospitals can be monitored with RFID tags that are provided to patients on their arrival, through which monitoring of underlying health conditions of patients can be monitored without the intervention of nurses. Medical emergencies can be handled effectively using drone cameras, and Patients Surveillance.

(5) Smart Agriculture: Agriculture which is the backbone of a country's economy, can be automated with the application of IoT. The features include measuring humidity, soil moisture, temperature, light, and adjustment of fertilizers, Green House Control micro-climate conditions can be handled effectively according to the needs of the user.

(6) Smart Retailing and Supply-chain Management: The application of the IoT retail sector helps in stock management by equipping RFID tags to products. Stock tracking in the store to prevent out-of-stock and placing orders automatically. Effective sales strategies generation of sales chart is helpful for retailers.

(7) Security & Emergencies: Few emergencies like radiation levels in nuclear power stations, Identification of unauthorized people, and gas leakages in industrial environments [8].

(8) Industrial Control: Temperature monitoring, ozone presence, toxic gas monitoring to ensure workers' safety, Machine auto-diagnosis of the problem, and Indoor Air Quality can be handled.

6. Security issues for the Internet of Things

The backbone of IoT is the Internet which is a global network, so, there is a possibility of some prominent security issues may occur. Some of the security problems that can occur are listed as follows:

- Protecting Sensor Data through cryptographic algorithms is applied to internet security protocols.
- The DoS attacks occur in the network layer.
- Hello, flood attack occurs because of congestion control in the channel.
- A wormhole attack causes the relocation of bits of data from its original position.
- Unauthorized RFID tag disabling.
- Dishonest readers can perform Unauthorized RFID tag tracking.

- Attacks on network availability and authentication.
- Replay attacks in RFID technology.
- Node tampering attacks by extracting sensitive information.

7. Conclusion

The technological changes obtained gradually by IoT turned the life of people more square and comfortable. The current state of IoT is discussed in detail in this paper. The application of IoT technologies in various sectors like health care, education, industrial automation, transportation, and mining has brought many benefits. An effort is always required to provide security measures by employing the latest innovative technologies. The best part of IoT is that it brings quality life to human beings by improving operational efficiency. In the future, the emphasis has to be more on maintaining global standards, security, deployment, and ethical issues.

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