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IJSRNSC

Volume-8, Issue-5, October 2020

Research Paper

Int. J. Sc. Res. in Network Security and Communication

E-ISSN:2321-3256

Study on IoT Architecture, Application Protocol and Energy needs

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Received: 09/Sep/2020, Accepted: 20/Oct/2020, Published: 31/Oct/2020

Abstract—In this digital world Internet of Things plays major role in different fields. These IoT devices are extended from Wireless Sensor Network (WSN). This paper we discussed three areas of IoT the architecture, protocols and their energy requirements. Because energy is very most emerging part of IoT devices. Architecture of IoT is very complex one it provides most of the services over the Internet. As far as the application protocols have vital role in end-user level. The IoT device energy efficiency of the nodes is a key factor in the network performance and increasing the life time. In this paper, we discuss the architecture and protocols energy importance for IoT. In this paper we focused IoT application layer comparative study of existing protocols and highlighted some standard IoT application protocol, importance of energy requirements in IoT and existing algorithms are what proposed in some researcher aspects for consuming the energy. This paper focus on analyze the IoT application architecture based lifetime of IoT devices energy management or consuming is future trends in most research challenges that lie ahead. Finally, we provide our conclusion about IoT application layer architecture based on the study that we have conducted.

Keywords— IoT Architecture, MQTT, XMPP, CoAP, AMQP, DDS, Energy

I. INTRODUCTION

In future, people may feel somewhat difficulty to live without IoT in their routine day to day activity; moreover Internet of Things (IoT) has become a new buzzword in this digital era of wireless telecommunication and researchers. All the fields are going to update in IoT for functioning in a smart way. This smart world is wonder thing that things are going to become a smart device communication between other devices and transfer data to any thing is called "connectivity for anything" in 24/7 over the Internet. The term 'IoT' technologies coined in the year of 1999, we understood the primarily level development was not by applications or end-user needs. The original problem accelerated from development of modern cities[1].

Now a day radical smart way improvement is need for all fields like home appliance, healthcare system, agriculture, environment, transport, and etc…The connection between devices could be wired or wireless based protocols are defined as per the end-user requirements. IoT network plays main roll to connect the things to outside of the world by using Internet. Moreover IoT hardware needs on network infrastructure in intelligent manner[2]. This devices are have few constrains in data processing and store the data due to size of the device, energy utilization and computational are limitation in sensor for communicating remote server or other devices. IoT devices are installed at geographically in isolated locations. The wireless channels focusing on data communication might be avoiding many retransmissions; some action should be taken based on data processing after data received from source device[3].

So many authors are proposed different IoT architecture up to 7 layers but basic principle IoT only requires 3 layers. In this paper organized as follows: Section I review the architecture of IoT. Section II presents the IoT protocol in application layer. Section III presents the application protocols in IoT and Section IV problem definition in existing IoT energy requirements ones.

II. ARCHITECTURE

An IoT has been launched as the third wave of the web after static pages web (World Wide Web) and social networking web technology. In order to attain IoT key features, multiple interest groups and research people are attempted to define a universal architecture for IoT[4]. Among many researchers are proposed architectures, the usual IoT architecture has been categorized into three layers, i.e. application layer, network layer, and perception layer. Now a day some researchers proposed the four-layer architecture. They are thought, due to enhancement in IoT, the architecture of three layers cannot satisfy the current requirements of applications. Due to a challenge in IoT regarding security reason and privacy of network, the architecture of five layers has also been proposed by some research people. It is considered that a recently proposed architecture could be satisfy the requirements of IoT regarding security and privacy of IoT network[5]. So we are

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consider category the IoT architectures as 3 layer as class I, 4 layers as class II and 5 layers as class III.

A. Class I – Three Layer Architecture

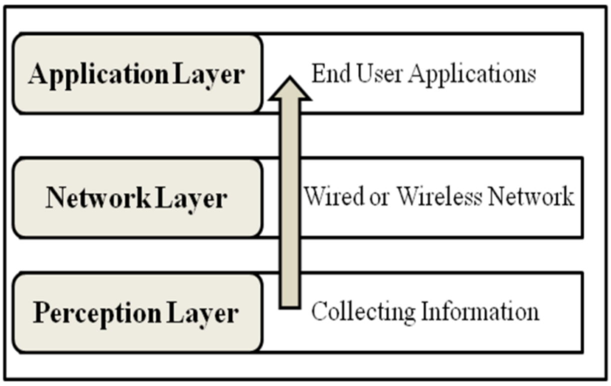

Figure 1. The three-layered architecture of IoT.

It is a very low level fundamental architecture and fulfills the basic thought of IoT. It was proposed in the last era of development of IoT [6]. It has three layers. The names of these three layers are perception, network and application layer as shown in Figure 1.

Perception Layer

This layer is the bottom most layer in three layered architecture. It is also known as a sensor layer. It works like human sense organs. It has the responsibility to identify the connected objects or things and collect the information from them. The sensing as a service (SaaS) model consists of four different layers: (i) sensors and sensor owners; (ii) sensor publishers (SPs); (iii) extended service providers (ESPs); and (iv) sensor data consumers[1]. The IoT sensors are collecting the data according to the requirement of applications. The collected data is from real world IoT based applications, example changes in the air, environment, motion, vibration, home appliance etc[5]. Its basic principle is to identify unique objects and to deal with gathered data. Network layer is used to transmit collected data through an existing communication network from perception layer. The main of aims this low level layer to take automated actions predicated on processed data, and provides storage capabilities to backup the sensed data into a database. Consequently, it is fundamental to identify and address each object communicate to uniquely connected device like RFID, NFC, and Bluetooth are utilized [7] .

Network Layer

The communication layer middle layer of three layers IoT architecture it considered as the brain of the IoT device. It is the main channel between the application layer and presentation layer the IoT system. The whole physical system is loaded with collected data and information that wants to be send or receive with other nodes. This second layer it's needed to set up an appropriate connection network among connected nodes through a communication protocol. The communication could be wire-connected or wireless based on the protocol defined in the IoT device. Moreover, networks are very vital components in IoT to connecting objects to the outside world by using internet. IoT network layer requires an clever network infrastructure[2]. The very simple manner of understanding network layer is responsible for connecting to other smart objects, network devices, and servers. The main features are also used for transmitting and processing sensor data[3]. This network layer performs the listed functions; Gateway – Routing & Addressing – Network Capabilities – Transport Capabilities – Error detection & Correction. Also, it takes care of data packet routing. As per the demand needed to serve a wider range of IoT services and applications such as data transactional services, multiple networks with different technologies and access protocols are needed to work with each other in a heterogeneous network configuration. These networks can classified into private, public or hybrid models and are built to support the packet data communication requirements for latency, bandwidth or security[8].

Applications Layer

The Application layer is the top most layer in IoT three layered architecture. This layer can receives the data from network layer and send it to specific service application of end user. The end user application in the terms of various applications in which the Internet of Things can be deployed, for example, smart vehicles, smart homes, smart cities, and smart health[3]. This part focuses basically on message exchange between applications and the Internet. Without this application layer communication in the IoT world is non-existent. That means that the IoT devices are cannot communicate with end user applications. IoT devices have protocols that makes only data transfer possible. The most gentle protocols are using for data transmissions like Constrained Application Protocol, or CoAP, and Message Queuing Telemetry Transport, MQTT or XMPP[9].

B. Class II – Four Layer Architecture

In three-layer architecture is basic requirement architecture for processing in the IoT device. This three-layer architecture was could not fulfill all the complete requirements of IoT. Later researchers proposed a new architecture with four layers. The researchers are introduced a layer with existing three-layer architecture with the name of support layer. In Figure 2. presents the four-layered architecture along with recommended security mechanisms used to make it secure from intruders[5]. Rest of three layers has the same functionality as the three-layer architecture that we have already pointed out.

Support Layer

The internet of things four-layered architecture is illustrated as supposed by the ITU-T (International Telecommunications Union - Telecommunication Standardization Sector) and is composed with existing three-layers; the top or first layer is IoT application layer which contains the application user interface what we discussed in pervious section, after the applications layer is

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the services and application support layer, the network layer is third layer is the network layer which contains the networking and transport capabilities same what we discussed in pervious section, the bottom most layer is the IoT device layer, which contains the gateways and the hardware and sensors and RFID tags and others. Along these four layers, the security and management capabilities, security functionality and distribution are improved[8].

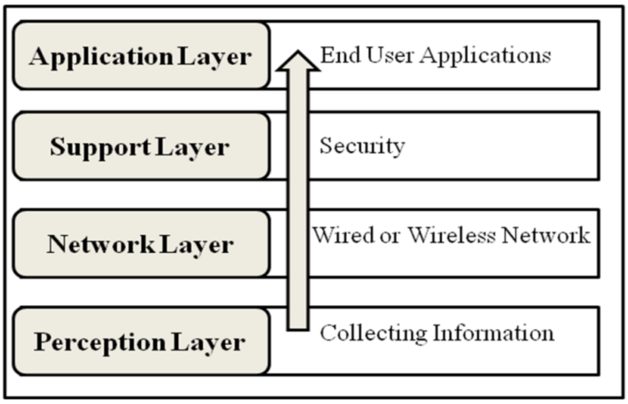

Figure 2.The four-layered architecture of IoT along recommended security mechanisms.

C. Class III – Five Layer Architecture

The representation of IoT architecture can be divided into five layers as described below as shown in figure 3. IoT devices are used in various fields like commercial, industrial, engineering, and scientific many unpredictable ways. This reason business people are expecting different type result to predict their data from IoT device. At the same way instrument, IoT will enable fields to connect smart technology with a universe of data-emitting objects. After researcher as designed new five-layered architecture for field communication are integrated into situational based decision making, asset management and new services for field improvement. Establishment of this architecture framed with two new layers middleware layer and business layer, the remaining three are working nature are already discussed in previous sections.

Middleware layer

The IoT system has generated various types of services when they are connected and communicated with others with network. The Middleware layer has two major functionalities of service management and store the lower layer information into the database and also capability to retrieve, process, compute information, and then automatically decide based on the computational based results[10].

Business layer

Now a days the IoT end-users are expecting visualization or graphical manner representations of understanding the data quickly and very easily to understanding of their fields like industries, agriculture, transport, production unit and so on. This layer supports different types of Graphs, business models, flow charts etc. are proceed with the received information from middleware layer.

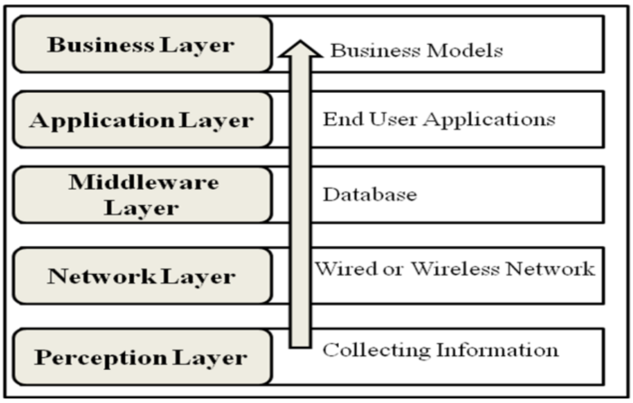

Figure 3.The Five-layered architecture of IoT along recommended business layer.

This result in making better strategy to understand based on the amount of accurate data received from the application layer and helpful data analysis process. Based on the excellent analysis results, it will help the functional managers, filed officer or executives to make more accurate and flexible decisions about the business strategies and roadmaps for future plans[10].

III. APPLICATION PROTOCOLS

This IoT data protocols are mainly used connect with low power IoT devices. These protocols are providing point-to-point communication to the physical hardware at the user end. IoT devices transfer data from sensors over the Internet. In direct to perform the IoT communication with high level quality in a large-scale network for real-time data collections; protocols should need on appropriate features such as low packet loss, high packet creation time and low packet response time etc. In accordance with this purpose, the lists of following protocols are applied employing embedded systems. At the bottom of the IoT communication stack live the application layer that supports the exchange of formatted message data between point to point, typically clients servers, or client to client. On the bottom of lower-layer communication protocols, application layer protocols shown in Figure 4. (MQTT, COAP, DDS, AMQP and XMPP) run and provide the capability for both clients and servers to data to exchange[11].

A. MQTT

MQTT (Message Queuing Telemetry Transport) is a lightweight messaging protocol it's provides constrained network clients with a simple way to distribute telemetry. MQTT is a TCP-based publish-subscribe protocol invented by IBM and then open-source for simple messaging communication applications. In working technique of publish-subscribe format of an asynchronous communication procedure in which message or data are exchanged between applications without knowing the sender and receiver identity, clients can either "publish"

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data on a specific topic to the server or "subscribe" to a topic where the server automatically will send new data on the topic to the subscriber registered. MQTT capabilities of one-to-one, one-to-many and many-to-many publish-subscribe format with TCP based communication. TCP provides message reliability with simple bidirectional connections between connected nodes[12].

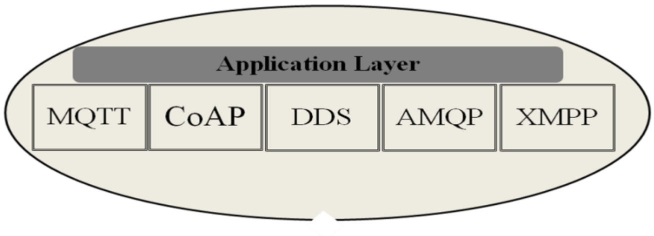

Figure 4. Application Layer Protocols

B. CoAP

An IoT supports Constrained Application Protocol (CoAP), and it is defined in RFC 7252. The functionality of CoAP is similar way to Hyper Text Transmission Protocol (HTTP) it is specifically designed for constrained based devices. The nodes constrained devices to communicate with the wider Internet using UDP protocols in addition, the communication between Server and Client is peer-to-peer and Server or Client can response unicast and multicast requests[12]. Constrained Application Protocol (CoAP) is used as a web transfer protocol. Constrained 8-bit microcontroller nodes with small random access memory (RAM) and read only memory (ROM) whereas constrained network results are having high packet error rate commonly used for machine-to-machine (M2M) applications [13].

C. DDS

DDS (Data Distribution Service) this is designed by OMG (Object Management Group), DDS is an another protocol for application layer which provides M2M communications in real time system in IoT devices. It has two sub layers (i) data-centric publish- subscribe (ii) data-local reconstruction. DDS send/receive data in between publisher and subscriber as called topic. On the topic(data) is generated by the DataReader in subscriber, and DataWritter in publishers[9]. The data-centric publish – subscribe do the process of topic delivery to the subscribers while the second is optional and allows a simple integration of this protocol (DDS) in the application layer. Publisher layer is responsible for sensory data distribution.

Data writer interacts to the publishers to accept about the data and changes to be sent to the subscribers. Subscribers are acted as receivers of sensory and data to be delivered to the IoT application.

Data readers are reads the published data and transmit the data into subscribers and the topics are known as data are being published. In the other term, data writers and data reader had the responsibilities of the broker in the broker-based architectures [14].

D. AMQP

The Advanced Message Queuing Protocol (AMQP) is open-source applications are free protocol in IoT with binary data designed to professionally support a wide variety of messaging in application layer protocol previous to AMQP, developers are used different message brokering and transferring applications their own, on this case they more difficulty work with another. AMQP have the functionality in networking takes place and the same message broker applications work of two processes. This protocol supports different transport protocols for transmitting large amount of data it an underlying reliable transport protocol such as TCP. AMQP takes responsibilities of asynchronous publish/subscribe communication in data transfer. The main advantage of AMQP is store-and-forward feature that ensures reliability after network interrupt. It gives ensured message-delivery guarantees with at-most -once: the sent once whether message delivered or not, at-least-once: one time definitely the message will be delivered or possibly more. Exactly-once: only one time the message will be delivered. Security issues are handled by TLS/SSL protocols over TCP[15].

E. XMPP

Over a decade ago IETF Standardized this Extensible Messaging and Presence Protocol (XMPP) for message exchanging and charting in decentralized client/server architecture. It is well-proven protocol which works over the internet by TCP and also provides asynchronous (publish/subscribe), synchronous (request/response) messaging technique. Supports and small message with low latency message exchange in real-time communications. Implementation part XMPP supports different programming languages and device platform which includes Java, JavaScript and iOS, Android. Different manufactures devices can communicate with standard protocols it is called federation. It also work in sleeping mode of nodes which leads to extend the lifetime of IoT device. The text based messaging only supports there is no option for end to end encryption, stability also very limited[16]. The table 1 summarizes comparisons key point among IoT application layer protocol standard

Table I. IoT Application protocol layer standard comparisons

Protocols	**MQTT**	**CoAP**	**DDS**	**AMQP**	**XMPP**
Transmission	TCP	UDP	TCP/ UDP	TCP	TCP
Architecture	Pub/ Sub	Req/ Res	Pub/ Sub	Pub/ Sub	Req/ Res - Pub/ Sub
Security	Yes	Yes	No	Yes	Yes
QoS	Yes	Yes	Yes	Yes	No

IV. ENERGY

Energy efficiency becomes a standard issue in future Internet of Things. To overcome this issue researcher are approaching different algorithms has been initiated for

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different effective solutions. The research people are promoting and promising with new vision of G-IoT(Green-IoT) for different power-down mechanisms[17]. Typically the IoT network is using AODV protocol it takes shortest path data transmission and Adaptive Duty Cycle Algorithm also used for energy consumption. This approach controls the duty cycle through the queue (first come first server) management to achieve high performance under network condition changes. The IoT network system are communicate with RFID,WSN and RSN(RFID sensor network) the nodes are distributed in a certain range of data transmission for specific purpose and gather the required information. The packet forwarding of source node, utilizing high energy consumption of the nodes and thus increasing network partitioning. Therefore, the energy efficiency of the nodes is the core factor that affects the network performance in IoT distributed network. The researcher are facing different conflict like ADOV protocols delay time is increased slightly and the probability is decreased[18]. In authors[19] proposed to evaluate the performance merit of IoT devices in the agriculture domain on path selection approach based on the residual energy and compared with performance of various algorithms that are widely used for research studies using No Duty Cycling (NDC), Duty Cycling (DC) and the proposed Improved Duty Cycling algorithms (IDC) they are missed in hardware base station in the domain[19]. IoT preferably used LPWAN by authors[20] in out-performance in terms of PER, throughput, collision, and consumed some level of energy it leads to Green-IoT. They plan to propose adaptive techniques to ADC (Adjust Duty Cycle) and channel allocation using adaptive reinforcement learning algorithms for reset of the field with Green IoT environments. In other area of IoT device security with energy using encryption methodology discussed by[21] in LoRaWAN and proposed new Secure Low Power Communication (SeLPC) method to reducing the power up to 26.2% in applications layer alone but they missed in dynamic connection of end user, means if the new end users(nodes) are not able to utilize this proposed power consumption with encryption for enabling security.

V. CONCLUSION

An IoT is not a single component which includes concepts of network, power, data transmission, delay time, bandwidth and etc... Which generate an enormous amount of data, and among the devices they are shared the data. Various types of fields seamlessly need these IoT devices for forthcoming automation process with low power consumption. Also processed information is used for critical and non-critical decision-making so it will leads to new Internet world. Which generate an enormous amount of data, and among the devices they are shared the data.

This paper we presented basic overview architecture of IoT, followed by available application layer standardized protocols functionalities. Moreover, were discussed in importance of energy requirements in IoT based on some research work. Identified various applications of IoT have been to ensure the better use of our real time applications. Also presents a different representation of research work has been provided. Application layer alone will not support 100% energy consumption we are planned in different adaptations, tests, and experiments have been new proposal to try different methods on improving shortest routing algorithms for data transmission, encryption mechanisms for improving the QoS with high level security and minimizing the delay time of data transmission with optimized constrained energy IoT applications will be constitute our future studies.

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