International Journal of Emerging Research in Management &Technology
ISSN: 2278-9359 (Volume-6, Issue-8)
Research Article | **August 2017**

A Study of Internet of Things: Architectural Perspective

Prasant Sharma*, Alka Agrawal
Department of Information Technology, BabasahebBhimraoAmbedkar University, (A Central University) Lucknow, Uttar Pradesh, India

Abstract:

Be it industry or academia, Internet of the Things (IoT) has become buzzword today. Everyone is expecting a system of gadgets controlled by web without human intervention. The concept has opened many possibilities and a fear of failure too. All over the world the research is going on and few organizations have already started implementing the concept at a small level. But the available research is still immature and undirectional. The area is very young, the research too. Hence there is a need to develop an IoT architecture which is universally acceptable by various IoT objects as well as server. To facilitate with the need, the paper presents a novel IOT architecture. In addition, the interaction of IoTobjects with each other has been discussed alongwith connection of a server's infrastructure with another server's infrastructure through API gateway.

Keywords: Internet of Things (IoT), IoTSystem Architecture,Cloud, Networking,Ubiquitous Computing and Big Data.

I. INTRODUCTION

The term Internet of things (frequently condensed IoT), is the system of physical gadgets installed with sensors, actuators, programming, hardware and system network that enabling them to send and get information from our general surroundings, and after that share the information over the web where it can be prepared and used for different intriguing purposes. A Sensor changes over the physical parameter into a flag which can be measured electrically.

An Actuator is only responsible for moving and controlling the object. It receives the signalfrom external sources and move the object[1].

Programming is an accumulation of guideline that empowers the IOT items and clients to collaborate with a PC or server. Without programming, IOT question can't associate with the web and carry on intelligently. Hardware is the art of controlling electrical vitality electrically, in which the electrons have a major part. Gadgets manage electrical circuits that include dynamic electrical segment, for example, vacuum tubes, transistors, diodes, coordinated circuits, related latent electrical segments, and interconnection advances. Normally, electronic gadgets contain hardware comprising principally or solely of dynamic semiconductors supplemented with inactive components.System network is likewise a sort of metric to talk about how well parts of the system associate with each other.

The IoT enables physical gadgets to be detected or gather information and send that information to the server for further control or controlled remotely crosswise over existing system foundation, making open doors for more straightforward connection of the physical world into PC based frameworks, and bringing about enhanced productivity, precision and monetary advantages notwithstanding diminished human intercession. At the point when IoT is enlarged with sensors and actuators, the innovation turns into an occasion of the more broad class of digital physical frameworks, which likewise incorporates advancements, for example, brilliant lattices, virtual power plants, savvy homes, canny transport and shrewd urban areas and so forth. Everything is remarkably identifiable through its installed processing framework however can interoperate inside the current Internet foundation. Specialists evaluate that the IoT will comprise of just about 50 billion protests by 2020[2].

A Thing, in the Internet of things, can be a man with a heart screen embed, a creature with a biochip transponder, a vehicle that has worked in sensor to caution the proprietor of the auto about their area and condition or whatever other common or man-made question that can be doled out an Ipv6 deliver and to give the capacity to exchange the information over a system or web[2].Each gadget which is associated with the web is doled out an IP address for recognizable proof and area definition. With the fast development of the Internet, it wound up noticeably clear that significantly a larger number of locations than the Ipv4 address space has accessible were important to interface new gadgets later on.

Ipv6 was imagined in light of the way that the old web (Ipv4) had outgrown itself.Individual has a need of unique IP address. Ipv4 is not capable to assigned unique IP address to each object thats why Ipv6 comes into existence[3].

Experts foresee that there will be 50 billion associated "objects" by 2020, yet the Ipv4 address space just obliges 4.3 billion[3].The Ipv6 gives precisely what we require. It gives more than 340 trillion, trillion, trillion locations[3].These gadgets gather the information for the reason they are implicit with the assistance of sensor and self-governingly stream the information between different gadgets with the assistance of servers, which are in some other area. The Internet of thing about associating gadgets to the web, as well as these gadgets can be basic leadership. These gadgets comprehend the thing that is associated with the web. Internet of things is rapidly turning into a reality. We can see the verification of it around us. Our gadgets are getting more intelligent every last day from cell phones to keen TV to brilliant auto to

savvy kitchen. Everything is presently getting associated with Internet. Everything which is associated with the Internet and bodes well is savvy.
The Internet of things is probably going to hugeaffect our everyday lives and turn into an innate piece of territories, for example, power, transportation, businesses control, retail, utilities administration, medicinal services, water assets administration and oil. It can enormously enhance profitability and our lives. What's more, obviously, its extraordinary market potential is pulling in ventures from governments, telecom administrators, fabricates, and industry clients. Internet of Things(IoT) instantly triggers inquiries around the protection of individual information. Regardless of whether ongoing data about our physical area or updates about our weight and pulse that might be open by our human services suppliers, having new sorts and more nitty gritty information about ourselves gushing over remote systems and possibly around the globe is a conspicuous concern[4].The innovation is not profoundly strong, any specialized glitches in the framework can bring about genuine physical or potentially money related harm.
Rest of the paper, in Section 2 we discussed various research work done by various authors in IoT, in section 3 given Novel Architecture of IoT,section 4 shows that application areas of Iot and in section 5 given conclusion.

II. RELEVANT WORK

As IoT is a very young area, the literature available is not concrete. J. Gubbi et al have given IOT architecture. There architecture includes RFID, WSN, addressing schemes, data storage and analytics and visualization. The application area of IOT includes Personal and Home, Enterprise, Utilitie and mobile. They have discussed cloud centic Internet of things in which two persepective are given: 'Internet' Centric and 'Thing' Centric and also discussed cloud computing services Iaas(Infrasturcture as a service), Paas(Platform as a service) and Saas(Software as a service). They have also discussed open challenges and future direction such as architecture, enenergy efficient sensing, secure reprogrammable networks and privacy, quality of service, new protocol participatory sensing, data mining, GIS based visualization, cloud computing and internation activities [9].
Y Liu et al have given concept of Combination of Cloud Computing and Internet of Things (IOT) in Medical Monitoring Systems. This research paper summarizes the health information technology in the field of cloud computing and Internet of things, especially in health monitoring and management application fields of the current study situation and also discussed wide set of applications that are made possible or significantly improved thanks to the CloudIotParadigm.In this paper authors proposed remote monitoring cloud platform architecture model(RMCPHI), monitoring algorithm using particle swarm optimization (PSO) and given experimental analysis by using two approach the Simulation Enviroment and the Result Simulation Analysis[10].
M. Kovatsch et al have given the concept in which they shows that how application logics are moving from firmware to cloud with the help of IOT.Authors given designgoal in which they discussed various aspects of designs like Full web integration, Intuituve APIs, Decoupling of Infrastructure and applications as well as end user their programming and also given architecture in which they discussed thin server model, interface model, app model,infrastructure integration and discovery. With this approach application could be developed without any knowledge of embedded domain and detail of the system on the devices. Author also given the concept in which thin server runs on the device and application logic will be developed on the server side.With the help of this only authorized person remotely can control the device[11].
H. Ning et al have compared the Future IOT architecture with mankind neural system or social organization framework. In this paper author introduced Unit IOT architecture and Ubiquitous IOT architecture and compared Unit IOT architecture with Man like nervous system and Ubiquitous IOT architecture with Social organization framework. Author explain that Unit IOT architecture is the part of Ubiquitous IOT architecture and combination of unit architecture forms Ubiquitous IOT architecture[12].
R. Khan et al have given generic architecture for IOT in which they discussed various layers like perception layer,networklayer,middlelayer,application layer and business layer. They all are discussed about future possible IOT applications: Prediction of natural disasters, industry applications, water scarcity monitoring,design of smart homes,medical applications, agriculture application,intelligent transport system design ,design of smart cities and also discussed IOT key challenges which are naming and identity management,interoperability and standardization,informationpolicy,object safety and security,data confidentiality and encryption, network security, specturum and greening of IOT[13].
T. Yashiro et al used uID-CoAP Architecture. With the combination of these two architecture authors given their own framework called uID-CoAP software framework. This framework can be considered as ubiquitous ID(uID) architecture enhanced with concrete network mechanism using CoAP(Contrained application protocol). This frameworkis designed to be adapted to existing embeddedsystems, not only for sensor nodes with very simple functionsand extremely limited resource.Authorshavedesigned this software framework for embedded system nodes to allow IoT service development with minimal efforts. As thisframework supports application-layer API, which do not affectthe existing codes and hides network-layer functions, productmanufacturers only need to append a simple CoAPservicedefinition, network driver, and physical network adapter tostartIoT services on nodes[14].
P. Desai et al have discussed IOT interoperability crisis. Author discussed three kinds of interoperability: Network layer interoperability, Interoperability between messaging protocol, and Interoperability at data annotation level and discussed key standardization efforts that have sought to establish sensor data models for sensor to be accessible and controlled via web include:OGC sensor web enablement, semantic sensor network ontology and semantic sensor observation service and also given sementic IOT architecture, semantic gateway as service, multi-protocol proxy, semantic data annotation and gateway service interface[15].

In this paper, we have shown that how ubiquitous computing is possible through IoT. In the novel architecture, we have shown that how multiple IoT servers or clouds will interact with each other through API gateway and use other servers' Iot infrastructure.

III. THEARCHITECTURE

Architecture which is mentioned in figure 1 is very simple,flexible,portable, interoperatable and scalable. In this architecture four components are used:Application, Network gateway, Server/Cloud and Objects(IOT devices) briefly discussed in next section. N numbers of objects(IOT devices) connectedtoasingle server mentioned in figure 1 but it is totally depends upon server'shardwareconfiguration that at same time how many objects' request server can receive and respond efficiently.

With the help of API gateway we can use other servers' IOT infrastructure also and vice versa when needed.This is the main benefit of this architecture.But at any instance other servers can deny to give their IOT infrastructure services to different other servers.Objects (IOT devices) connected with one server cannot connect with other servers directly at the same timebecause it create ambiguity in the functioning of objects (IOT devices) it can be only though API gateway.We have to manufactured(objects) IOT devices in the manner that it can only be connected to one server at a time not two different servers simultaneously.

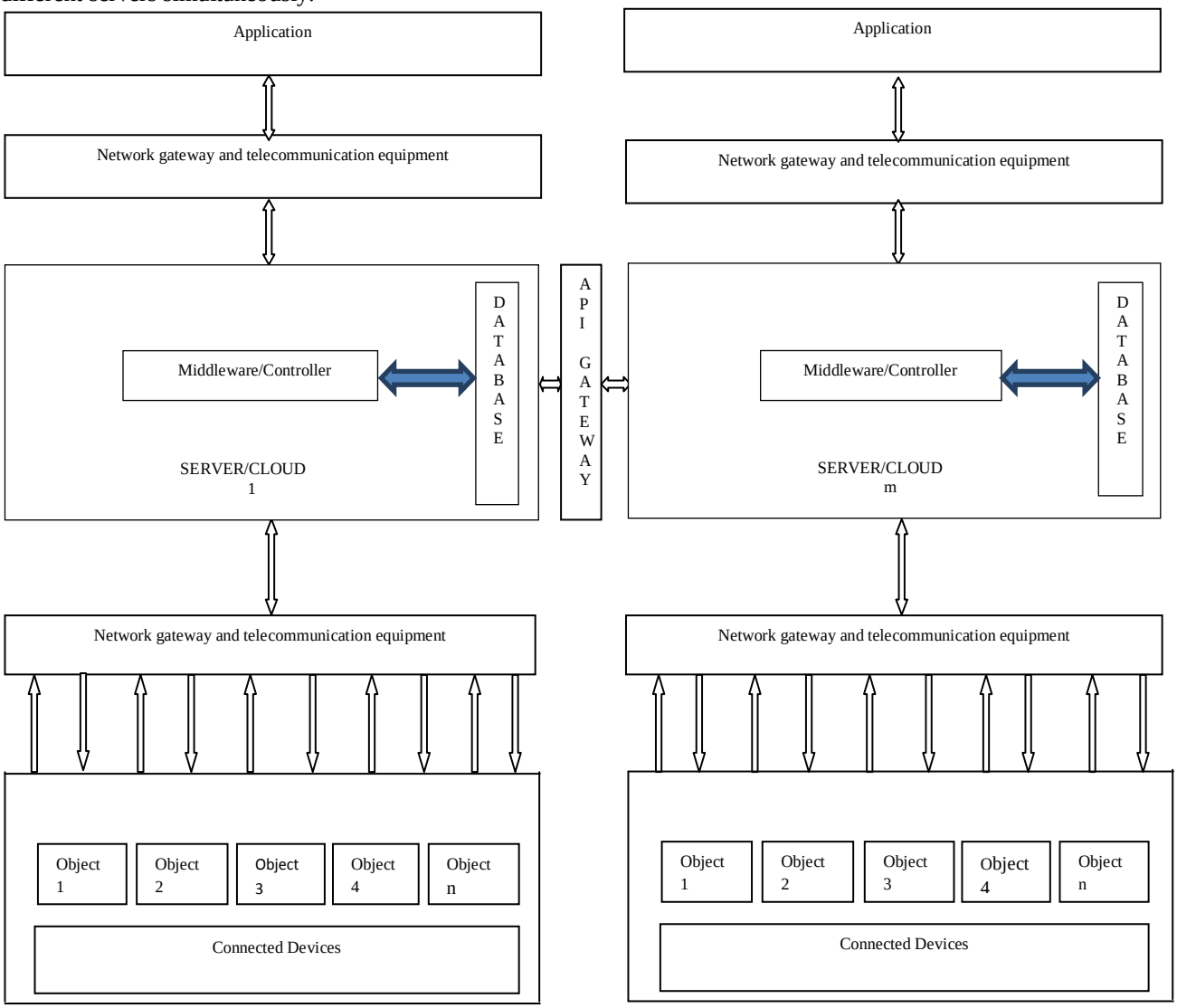

Figure 1: Novel Architecture of IOT

Middleware/Controller are basically used for calculation or manipulation of objects (IOT devices)sensor's data. Manipulation or Calculation is done by any of the server side 353heir353mming language like nodejs, php, asp.net, java and ruby etc. Every (IOT devices) objects' request first goes to middleware it performs calculation on it and send back response to that object (IOT device) and other objects(IOT devices) also and stored this activity in database also. Any changes in the database also gives response to the corresponding objects(IOT devices) and that Objects(IOT devices) displayed that response or started actuating as per response because it works on real time environment.

Application is basically a medium through which we can interact with Objects(IOT devices) and also control the Objects(IOT devices) remotelty.Object(IOT devices) and applicatoninteract with server, without network gateway it is not possible.

3.1 Components of the IOT Architecture

Basically there are four components used in IOT (Internet of things) architecture; these components are objects, network gateway, server/cloud and application. These components are collaborating with each other when required.

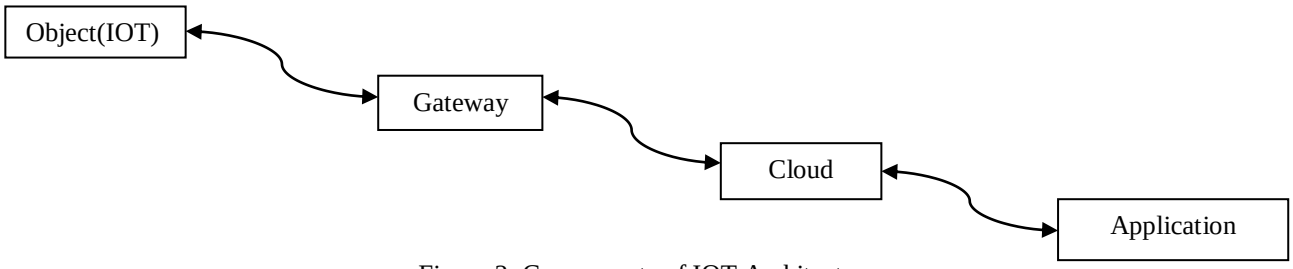

Figure 2: Components of IOT Architecture

3.1.1.Objects

Objects are self-governing, physical protest enlarged with detecting/impelling, handling, putting away and organizing abilities. These Object can detect/incite, store and decipher data made with themselves and around the neighboring outer world where they are arranged, air conditioning all alone, participate with each other, and trade data with different other Objects.[5]

3.1.2. Network gateway

Network gateway gives the useful and procedural methods for exchanging variable-length information arrangements from a source to a goal have by means of at least one system, while keeping up the nature of administration capacities.
Functions of the network gateway component include:

i. Connection Model

There are two systems utilized as a part of data communication to exchange information. Every system is utilized according to their necessity and furthermore has its own leverage and drawback.

- **Connectionless Communication**

It is like the postal administrations, as it conveys the full address where the message (letter) is to be conveyed. Each message is steered freely from source to goal. The request of message sent can be not the same as the request got[6].In connectionless the information is moved in one bearing from source to goal without watching that goal is still there or not or on the off chance that it arranged to acknowledge the message. Verification is not required in this. Case of Connectionless administration is UDP (User Datagram Protocol) convention. [6]

- **Connection Oriented Communication**

There is a sequence of operation to be followed by the users of connection oriented service. These are:

- Connection is built up
- Information is sent
- Connection is abort.

In Connection Oriented Service, we need to set up a connection before beginning the correspondence. At the point when connection is built up we send the message or the data and afterward we discharge the Connection.Connection Oriented Service is more dependable than connectionless Service. We can send the message Connection Oriented Service if there is a blunder at the collectors end. Case of Connection Oriented is TCP (Transmission Control Protocol). [6]

ii. Host Addressing

Each host in the network must have a unique address that find out where it is.With the help of this unique address everyone can connect to a particular host. On the Internet, locations are known as Internet Protocol (IP) addresses. [7]

iii. Message Forwarding

Since many network are apportioned into subnetworks and interface with different network for wide-region interchanges, network utilize particular hosts, called gateway or routers, to forward bundles between network. This is likewise important to portable applications, where a client may move starting with one area then onto the next. Version 4 of the Internet Protocol(Ipv4) was not enough in view of this element, Ipv6 has a superior planned arrangement[7].

3.1.3. Server/Cloud

Server is a PC program or process (running project). It refers to a device used to (or a device devoted to) running one or a few server programs. On a system, such a device is known as a host. Notwithstanding server, the words serve and administration (as noun and as verb) are as often as possible utilized, however servicer and worker are not.[a] The word benefit (thing) may allude to either the unique type of usefulness, e.g. Web benefit. On the other hand, it might refers to a PC program that transforms a PC into a server, e.g. Windows benefit. Initially utilized as “servers serve clients” (and “clients utilize servers”), in the feeling of “comply”, today one regularly says that “servers serve information”, in an indistinguishable sense from “give”. For example, web servers “serve [up] information to clients” or “administration their solicitations” [8].

The server is a piece of the client–server show; in this model, a server serves information for clients. The way of correspondence between a client and server is demand and reaction. This is interestingly with distributed model in which the relationship is on-request response. On a fundamental level, any electronic procedurethat can be used or called by another procedure (especially remotely, especially to share an asset) is a server. Therefore any broadly useful PC associated with a PC can have servers. For instance, if documents on a device are shared by some procedure, that procedure is a record server. Thus, web server programming can keep running on any proficient PC, thus a portable PC or a PC can have a web server[8].

3.1.4. Application

Basically application provides interface through which an interaction with the web server can be made. The IoT services can be availed either through web application or mobile application.

i. **Web Application**
Web application basically runs on web browser. We send request through web browser to the server and in response server returns html content to the web browser. It is client server architecture; through which we can interact with web server from anywhere.

ii. **Mobile Application**
We installed apps on mobile and tablets. It is also one of the form through which we can interact with the server. Mobile apps also provide real time environment. Any new activity in the server it gives notification to the app. It works on request & response concept as well as works on real time concept in which we don't have any need to request for any response, real time concept automatically gives notification to the app without any request.

3.2 Communication among IoT Components

This section discuss the working of IOT architecture which is mentioned in figure 1. This architecture basically used four components are discussed below. Main component of this architecture is Server/Cloud through which all the objects(IOT devices) are connected. Network gateway provide facility to objects(IOT devices), server and application through which they can interact with each other.There are m number of serversandn number of objects are used. It creates the network of objects(IOT devices). Objects (IOT devices) can work independently means sense and actuate both simultaneously or can work dependently means one object sense and others actuate and vice versa.

Each server maintain a table in the database that shows how many objects(IOT devices) are connected to them and all the objects (IOT devices) which are connected to the serverhas its own database table which maintain a record of their activity. Every Object(IOT device) equipped with unique IP address. With the help of this unique IP address server can identify the objects(IOT devices).

These objects(IOT devices) sense and send flag to the server, server on the basis of this flag performs some calculationand return response to the associated objects(IOT devices) and also stored these objects(IOT devices) activity in 355heir own database table.

If one server want to access other servers' IOT infrastructure then it can only be possible through API gateway. Every server developed their own API. Server API gateway gives only limited resources permission accessed by other servers.

IV. APPLICATION AREAS OF IoT

Though IoT encompasses every area. Some pertinent one, where research is currently going on, are shown in figure-3:

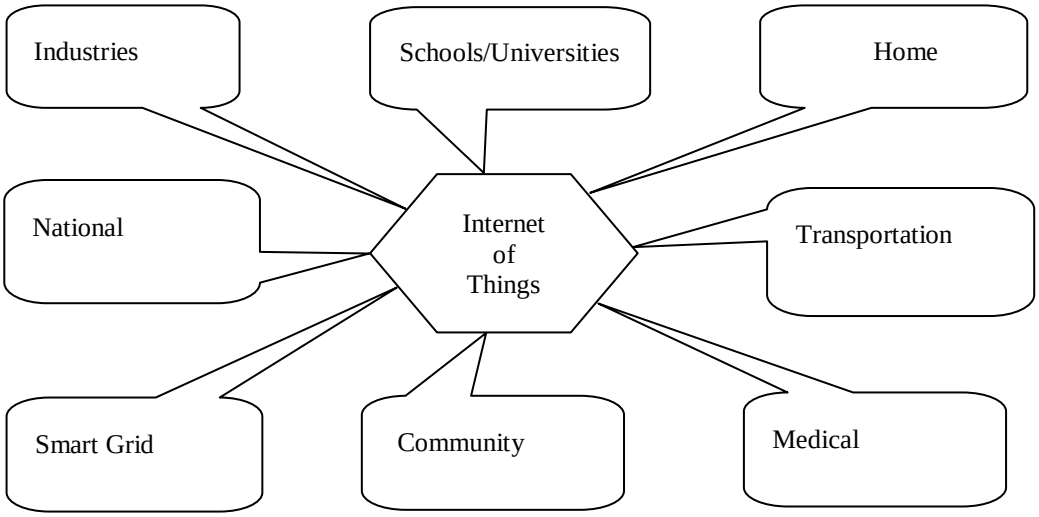

Figure 3: Components ofIOT Architecture

- Transportation
- Smart Grid
- Medical
- Home

- Community
- National
- Industries
- Schools/Universities

V. CONCLUSION

Internet of thing is a new platform for developers and software engineers and we are moving into new world. In new world all the objects will be connected to the internet like TV, Fridge, Cars, Door, Fan etcand these objects(IOT device) will behave smartly. IOT is shaping our future and make our life comfortable, easy and more efficient. Architecture which is mentioned in figure 1 can easily implementable in any of the area. From largescale to smallscale area.It is transforming everything from business to life. In every area it will work very efficiently and appropriately.Now everything will be in your fingertip. It will be the boom in the IT sector again.

REFERENCES

[1] Available at: https://en.wikipedia.org/wiki/Actuator last visit 29-APRIL-2017.
[2] Available at: https://en.wikipedia.org/wiki/Internet_of_things.
[3] Available at: http://saphanatutorial.com/internet-of-things-and-ipv6/.
[4] Available at: https://www.lifewire.com/introduction-to-the-internet-of-things-817766.
[5] Available at: https://en.wikipedia.org/wiki/Smart_objects.
[6] Availableat: http://www.studytonight.com/computer-networks/connection-oriented-and-connectionless-service.
[7] Available at: https://en.wikipedia.org/wiki/Network_layer
[8] Available at: https://en.wikipedia.org/wiki/Server_(computing)
[9] J.Gubbi, R. Buyya, S.MarusicandM.Palaniswami, "Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions",*Future Generation Computer Systems*, Vol. 29, no. 7(2013), pp.1645-1660.
[10] Y. Liu, B. Dong, B. Guo, J. Yang and W. Peng, "Combination of Cloud Computing and Internet of Things (IOT) in Medical Monitoring Systems",International Journal of Hybrid Information Technology,Vol.8, No.12 (2015), pp. 367-376.
[11] M. Kovatsch, S. Mayer and B. Ostermaier, "Moving Application Logic from the Firmware to the Cloud:Towards the Thin Server Architecture for the Internet of Things",2012 Sixth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing,Palermo, 2012, pp. 751-756.
[12] H. Ning and Z. Wang, "Future Internet of Things Architecture:Like Mankind Neural System or Social Organization Framework?",IEEE Communications Letters, vol. 15, no. 4(2011), pp. 461-463.
[13] R.Khan, S.U. Khan, R. Zaheer and S. Khan, "Future Internet: The Internet of Things Architecture,Possible Applications and Key Challenges",2012 10th International Conference on Frontiers of Information Technology, Islamabad, 2012, pp. 257-260.
[14] T. Yashiro, S. Kobayashi, N. Koshizuka and K. Sakamura, "An Internet of Things (IoT) Architecture for Embedded Appliances",2013 IEEE Region 10 Humanitarian Technology Conference, Sendai, *2013, pp. 314-319.*
[15] P. Desai, A. Sheth and P. Anantharam, "Semantic Gateway as a Service Architecture for IoT Interoperability," *2015 IEEE International Conference on Mobile Services*, New York, NY, 2015, pp. 313-319.

