Comparative Analysis of Standard Interoperable Protocols of Internet of Things

Deepu C G
4MC13CS015, Computer Science Engineering
Malnad College of Engineering Hassan,India

Dakshayani H N
4MC13CS011, Computer Science Engineering
Malnad College of Engineering Hassan,India

Sinchana D M
4MC13CS046,Computer Science Engineering
Malnad College of Engineering Hassan,India

Sushma J A
4MC13CS056,Computer Science Engineering
Malnad College of Engineering Hassan,India

Gururaj H L
Assistant Professor,Computer Science Engineering
Malnad College of Engineering Hassan,India

Ramesh B
Professor,Computer Science Engineering
Malnad College of Engineering Hassan,India

***Abstract*: Internet of Things (IoT) consists things that have unique identities that are connected to the internet. IoT is anticipated to bridge various technologies to enable new applications by connecting physical objects together in support of intelligent decision making. In this paper we compare protocols of different layers based on factors like speed, distance,frequency and cost by varying number of packets transmitted and number of nodes took part in communication.The purpose is to support wireless connectivity of large number of industrial and home applications etc.This also introduces various aspects of Contiki Operating system designed for the IoT environment along with the Cooja platform.**

Keywords: IoT, protocols , Cooja, Contiki

I. INTRODUCTION

Internet of things which is having capabilities like self configuring, coordinating etc. It is mainly based on the communication protocols which are acts as a backbone. It is dynamic global network infrastructure. It uses intelligent interfaces and is continuously integrated into the information network, often communicates data associated with users and its environment. It enables different ways to establish communication between devices and humans.[2]In the rapid growing world of Internet and communication innovation, creativeness made our lives are progressively driven to another dimension of enhanced reality and become completely automated in the upcoming years.

The scope of IoT is not just limited to just connecting things to the internet .IoT allows these things to communicate and exchange data while executing meaningful applications towards a common user or machine goal. Data itself does not have a meaning until it is contextualized processed into useful information. Applications on IoT networks extract and create information from lower level data .This information obtained is then organized and structured to infer knowledge about the system and/or its users, its environment, and its operations and progress towards its objectives.

II. HISTORY

IoT is enabled by several technologies including wireless sensor networks, cloud computing, big data analytics, embedded systems, security protocols architectures , communication protocols , web services , mobile internet and semantic search engines.

A. Cloud Computing

Cloud computing is a computing paradigm that involves delivering applications and services over the internet. It involves provisioning of computing, networking and storage resources on demand and providing these resources as metered services to the users ,in a “pay as you go” model. .It offers different forms of service like Infrastructure-as-a-Service, Platform-as-a-Service, Software-as-a-Service.[1]

B. Big Data Analytics

Big data is defined as collections of data sets whose volume , velocity or variety is so large that is difficult to store ,manage ,process and analyze the data using traditional databases and data processing tools. The underlying characteristics of big data are volume ,velocity and variety.

C. Wireless sensor Networks

A Wireless Sensor Network (WSN) comprises of distributed devices with sensors which are used to monitor the environmental and physical condition. A WSN consists of a number of end-nodes and routers and a coordinator. End nodes have several sensors attached to them. Each nodes can also act as routers, Routers are responsible for routing the data packets from end-nodes to the coordinator. The coordinator collects the data from all nodes .Coordinator also acts as a gateway that connects the WSN to the internet .for Example, weather monitoring systems use WSNs in which the nodes collects temperature, humidity and other data ,which is aggregated and analyzed.[4][2]

D. Embedded Systems

An embedded System is a computer system that has computer hardware and software embedded to perform specific tasks. In contrast to general purpose computers or personal computers (PCs) which can perform various types of tasks, embedded systems are designed to perform a specific set of tasks.[10]

III. COMMUNICATION PROTOCOLS

Communication protocols from the backbone of IoT systems and enable network connectivity and coupling to applications ,These allows devices to exchange data over the network .These protocols of IoT will define the data exchanging formats, data enciphering ,addressing schemes for things and routing of packets from source to destination. Other functions of the protocols include sequence controls , flow control and retransmission of lost packets.[3]

1. Link layer

Link layer protocols determine how the data is physically sent over the network's physical layer or medium. The scope of the link layer is the local network connection to which the host is attached. Host on the same link exchanged exchange data packets over the link layer using link layer protocols. Link layer determines how the packets are coded and signaled by the hardware device over the medium to which the host is attached. Some of the link layer protocols are as follows

a) *Ethernet*:

IEEE 802.3 is a collection of wired Ethernet standards for the link layer. These provide data rates from 10Mb/s to 40Mb/s and higher. It does not require a gateway because it can directly wired to the internet. It has different topology with zero alliance.

b) 802.11-WiFi:

IEEE 802.11 is a collection of wireless local area network communication standards, including extensive description of the link layer. These provide data rates from 1Mb/s to upto 6.75Gb/s.

c) 2G/3G/4G Mobile Communication:

These are different generations of mobile communication standards .IoT devices on these standards can communicate over the cellular networks. Data rates for these standards ranges from 9.6kb/s to up to 100Mb/s and are available from the 3GPP websites.

2. Network or Internet Layer

The network layer protocols are responsible for sending of IP datagram's from the source network to the destination network. This layer performs the host addressing and packet routing .The datagram's contain the source and destination addresses which are used to route them from the source to source to destination across multiple networks, Host identification is done using hierarchical IP addressing schemes such as IPv4 and IPv6.Example of network layer protocol is 6LoWPAN. IPv6 over Low Power Wireless Personal Area Network(6LoWPAN) brings IP protocol to the low power devices which have limited processing capability. It operates in the 2.4Ghz frequency range and provides data transfer rates to 250Kb/s.

3. Application Layer

Application layer protocols define how the application interface with the lower layer protocols to send the data over the network. The application data , typically in files ,is encoded by the application layer protocol and encapsulated in the transport layer protocol which provides connection or transaction oriented communication over the network.[9]

Some of the application layer protocols are as follows:

a). CoAP:

Constraint Application Protocol (CoAP) is an application layer protocol for machine to machine applications. CoAP uses a client-server architecture where clients communicate with servers using connectionless data grams. CoAP easily interface with HTTP. [6]

b). MQTT:

Message Queue Telemetry Transport (MQTT) is a light-weight messaging protocol based on the publisher subscriber model. MQTT uses a Client-Server architecture where the client connects to the server and server publishes messages to topics on the server.

c). DDS:

Data Distribution Service (DDS) is a data-centric middleware standard for device to device or M2M.DDS uses a publisher subscribe model where publishers create topics to which subscriber can subscribe. It provides QoS (Quality of Service) control and configurable reliability.

d).AMQP:

Advanced Message Queing Protocol (AMQP) is an open application Layer protocol for business messaging .It supports both point-to-point and publisher subscribes models.

IV. SIMULATION SETUP

To study the factors like speed, frequency, distance and cost by varying network traffic and number of nodes in the communication network, we have used Contiki operating system, to create scenario of varying nodes and traffic we used cooja simulator.

Contiki is an open source operating system for the IoT. It is used for connecting tiny low-cost, low-power microcontrollers to the Internet. It is one of the powerful toolbox for building complex wireless systems .It supports fully standard IPv6 and IPv4, along with the recent low-power wireless standards: 6lowpan, RPL, CoAP etc. With the help of Contiki's ContikiMAC and sleepy routers, even wireless routers, the battery can be operated. This operating system specifically designed for small systems, having only low kilobytes of memory available. This will provide a fully IP networking stack with standard IP protocols such as UDP, TCP along with the new low-power standards like 6LoWPAN, RPL, and CoAP.[5][8][7]

Contiki operating systems has features like memory allocation, full IP networking, power awareness, dynamic module loading. We used specifically Contiki why because it supports Internet standards and also it uses simple C language so that it provides rapid development. Since it is a open source ,the code can be used for both commercially and non commercial purpose.

Contiki devices often make up large wireless networks. Deploying and testing of software for such networks is really difficult. Cooja, the Contiki network simulator, makes this enormously easier by providing a simulation environment that allows developers to both see their applications executes in large-scale networks or in excessive detail on fully emulated hardware devices.

For the simulation of the standard interoperable protocols we use the Contiki operating system with Cooja platform. The following figure.1 represents how to simulate the protocols of IoT .

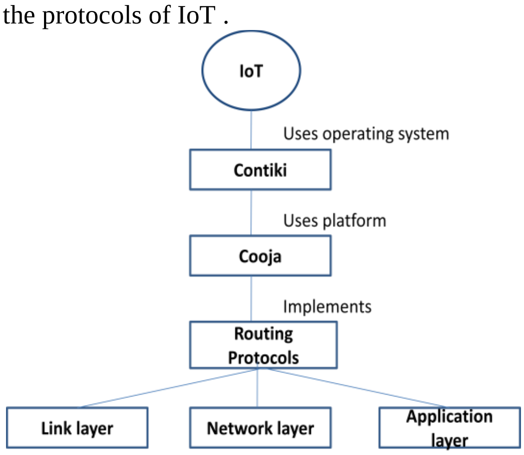
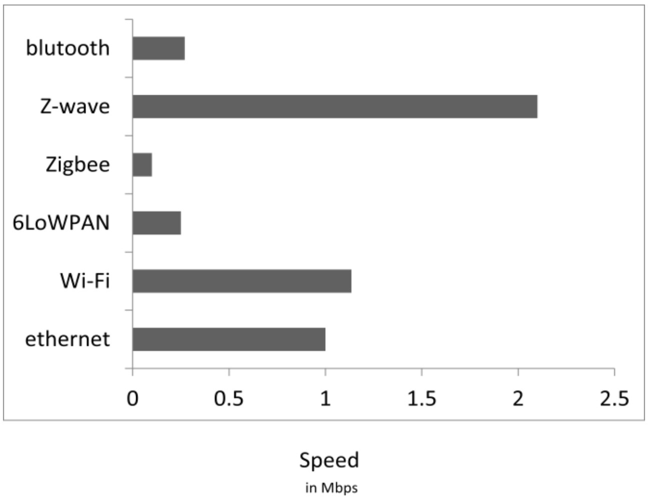


fig.1 Simulation of protocols using Contiki OS along with the cooja Simulator

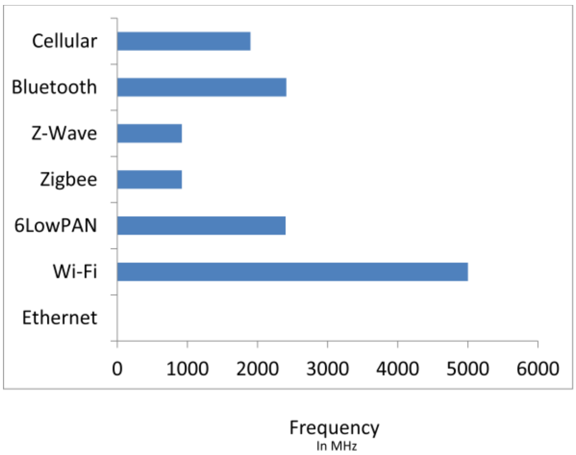
V. RESULTS

Data rate can be defined as the amount of data transferred in unit time .In the below Graph.4.1 the data rate of different protocols are represented. Z-Wave with the maximum rate of 225Mbps and ZigBee with the minimum of 0.25Mbps .The Knowledge obtained can be utilized in the application where data rate of primary concern.



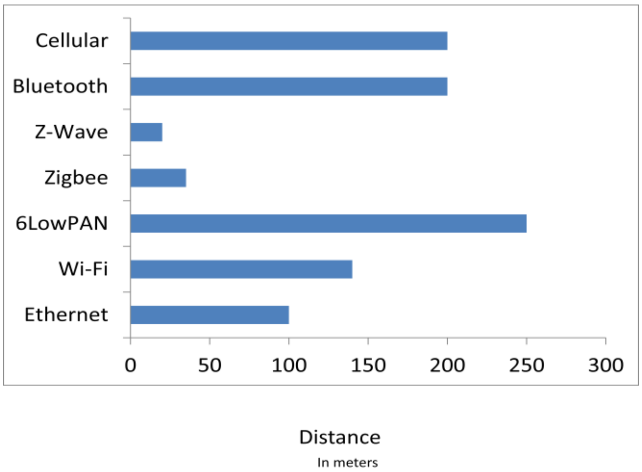
Graph.4.1 data rates of different protocols

Frequency can be defined as number of cycles per unit which is measured in Hertz. The below Graph.4.2 depicts the frequencies used by different protocols with Ethernet using maximum up to 5GHz and Z-Wave with minimum frequency range of 1GHz.This information serves as a great help to choose protocols for an application where frequency is given at most importance.



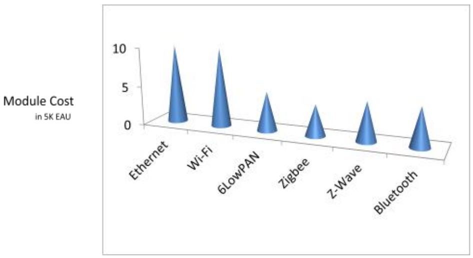
Graph.4.2 Wireless Spectrum of different protocols

Range can be defined as the distance in which the signal is strong and coverage of protocols is provided. The below Graph.4.3 representation provides information about the range of different protocols of IoT. The 6LoWPAN has maximum range where as Z-Wave has minimum range .



Graph.4.3 Maximum range of different protocols

The cost representation for different protocols is given in the below Graph.4.4.This cost factor can be considered when an application is bound with a tight budget schedule.



Graph.4.4 Module Cost of different protocols

The above comparison is done to the link layer and network layer protocols of IoT with respect to data rate ,spectrum, range and cost. The quantitative analysis is done to the application layer protocols with respect to fault tolerance, security, paradigm etc. which are crucial to analyze and differentiate them.

VI. CONCLUSION

In this paper we have compared different protocols of link layer and network layer with respect to data rate, cost, range, frequency .Also we have made Quantitative analysis of application layer protocols with respect to scope, paradigm used , fault tolerance and other factors. The Knowledge inferred by this comparison analysis can be used for various applications like cellular phones and telemetry, metro broad band connectivity, Building automation etc. and also proves to helpful for the selection of required efficient hardware component for a system in real time .

VII. REFERENCES

[1] A.Paventhan ,"Internet of Things based approach to Agriculture Monitering ",Asia-Paci Advanced Network (APAN) 36th Meeting 20th August 2013

[2] Dr.Albert Becker , Purshottam purswani ,Sudharma karekar ,"Internet of Things" , atos white paper.

[3] JP Vasseur, Cisco Fellow," RPL: The IP routing protocol designed for low power and lossy networks" ,Cisco Systems and ipso alliance.

[4] Ala Al-Fuqah," Survey paper on Internet of things.

[5] A. Dunkels, B. Gronvall, and T. Voigt, "Contiki—A lightweight and flexible operating system for tiny networked sensors," in *Proc. 29th Annu. IEEE Int. Conf. Local Computer. Network.*, 2004, pp. 455–462.

[6] J. Jin, J. Gubbi, S. Marusic, and M. Palaniswami, "An information framework for creating a smart city through Internet of Things," *IEEE Internet Things J.*, vol. 1, no. 2, pp. 112–121, Apr. 2014.

[7] Ioannis Glaropoulos ,Stefan Mangold , "Contiki80211 in Radio Link Layer" ,Florence,Italy,2006.

[8] Padmini Gour,Mohith P,Tahilani , "operating Systems for Internet of Things" ,NITK, Mangalore ,India 2010

[9] Z.Sheng et al "A Survey on Protocol suite of IoT", IEEE Wireless Communication,December 2013

[10] M.Yu , T.J Lu "Study and Application of technologies of IoT" , ICATCE 2013