International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

A Compendium on Qos Matrices in Iot

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Abstract: The Internet of Things (IoT) has turned out as an emerging technology with an aim of simplifying and easing human life by automating most of the day to day activities with wide range of applications in different domains. QoS indicates how offered service qualities are? Computing, Communication and Things are the major components of IoT. It comprises of heterogeneous elements such as RFID, sensor, Wireless Sensor Network, mobile network, cloud services. For desirable service provisioning and popularizing IoT applications, QoS parameters for IoT are very essential. This papers aims at providing a review work done by different researchers about the QoS parameters for IoT applications, transmission network and perception.

Keywords : Internet of Things (IoT), Quality of Service (QoS), LPWAN, Zigbee, RFID

I. INTRODUCTION

Internet is the worldwide network could be connected through Wi-Fi or mobile data and Things are any electronic device that has capability to sense. Devices that have sensors, that are programmed to act in a certain way and are connected together to achieve a desired result. "IoT is about embedding intelligence to the things around us so that they become smarter and do more than they were proposed to do".

IoT, a dream which can be realized due to advancement of new generation of cheaper and smaller wireless devices with a number of communication protocols along with development and awareness of key technologies including RFID, sensors, actuators, embedded computing, cloud computing. IoT has become an active medium for exchange of information actively across the globe [13]. Necessary information is collected by sensing objects or things, connected with RFID, sensors, GPS etc. and then transmitted via various access networks and Internet to exchange information. The things could be identified, managed, controlled in this way and the interaction of things to things and things to person could be achieved.

To ensure how these IoT objects access the offered services proficiently, it is essential to manage all the basic building blocks of IoT system efficiently, proper utilization of existing infrastructure and most importantly guaranteeing Quality of Service (QoS) requirement of the system. Quality of service is a notion used describe of the overall performance of an offered service [2]. QoS is expressed as a set of parameters that quantify the feature and performance of a particular data stream. Quantitatively the QoS is evaluated by means of defined set of factors which can be useful to specify the QoS level of a system.

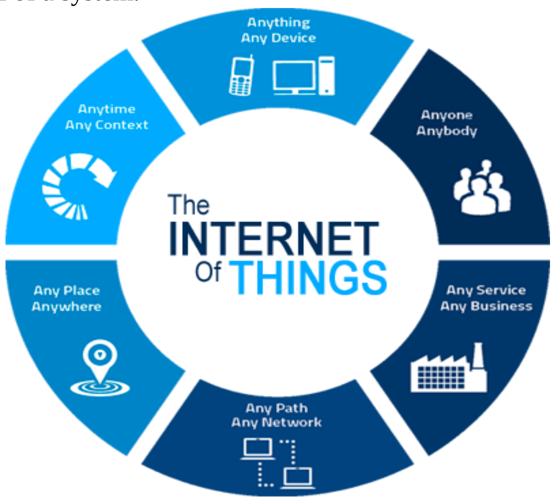

Fig. 1: IoT environment

It is not a trivial task to ensure QoS in an IoT environment due to its heterogeneity in types of users, piece of equipments, network configurations, each with diverse service requisite. Furthermore, same service is offered by different providers using diverse technologies [2]. The QoS settings begin by identifying the attributes necessitate by the applications and users, such as the throughput, security, reliability etc. These attributes agreed upon to attain an adequate level of QoS, and Service Level Agreement (SLA) is negotiated. After specifying the SLA conditions, the resources are assigned and monitored with renegotiation possibility if the system undergoes any changes.

Perception, processing, transmission, decision making and offering desirable service are the major functionalities which makes IoT a complex system [11]. It is an integrated technology consisting of sensing, communicating, intelligent data analysis etc.

Manuscript received on February 10, 2020.
Revised Manuscript received on February 20, 2020.
Manuscript published on March 30, 2020.

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Among the various IoT subsystems, some already have well-defined QoS function, such as mobile communication networks [9], Internet [3], while research is still in progress in Wireless Sensor Network [12], Zigbee [8], 6LowPAN[10]. Also some are lacking of proper QoS definition, for instance, RFID [7].

II. IOT LAYERED ARCHITECTURE

According to [17] the IoT architecture consists of three layers.

The Perception Layer: It perceives the environmental data with the help of various perception devices.

The Network layer: The upper layer receives the perceived data from network layer with the help of various supportive networks.

Application Layer: This layer is directly interacted by the users using IoT applications. Data storing, information management, data analysis, decision making are the functionalities provided the application layer by leveraging various technologies.

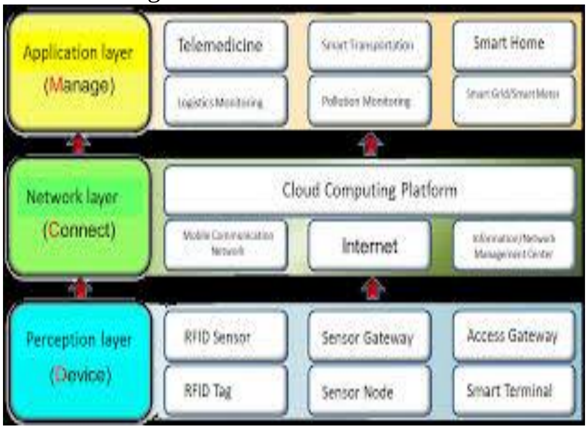

Fig2: IoT layered architecture

III. IOT COMPONENTS AND RESPECTIVE QOS PARAMETERS

Communication, Computing and Thing are the main pillars of IoT. For development and implementation all the components are equally important and hence must ensure QoS requirements for the wide acceptance of IoT applications and make it a frontier technology across the globe. Authors [1] have proposed QoS matrices for the individual components of IoT. The responsibility of communication networks is to transmit real time data perceived by the IoT devices and the information generated by IoT applications [11]. IoT consists of a huge number of smart equipments embedded with sensors and RFID. Enormous data generated by IoT applications are stored and maintained by computing system(may be cloud service, fog service or edge service).Computing also helps technologies like big data analysis, data science, deep learning to use the data for analytical purpose and facilitate decision making [14]. The QoS matrices will assist the users to evaluate service providers to choose the service.

IV. APPLICATIONS AND SERVICE MODELS IOT

Authors [3] have proposed various service models for various IoT applications. Now-a-days IoT touches every industry across economic landscape from financial market, agriculture, healthcare, energy, retail, automotive etc.

The service models are defined based on three factors: Interactive, Delay and Criticality [15]. The Open Service Model is interactive, non-real time and non-mission-critical. The Supple Service Model is sometimes interactive, sometimes not, SRT and mission critical. The Complete Service Model is non- interactive, SRT or HRT based on application and is mission critical [Table. 2].

QoS implementation can be done using three models:

- Best effort-Equal priority packets, no guaranteed delivery, no need of QoS support
- **Integrated Services (IntServ)** - It is a flow-based mechanism. Prior network path setting, applications need bandwidth and other resource reservation, every router is implemented with Intserv for successful deliverance of the packets hence guaranteed QoS provisioning.
- **Differentiated Services (DiffServ)** - It is a class-based mechanism. Network is configured with multiple classes of traffic with different priorities, supports modern IP network

Authors [17] have divided IoT applications into four types and accordingly the QoS level is assigned.

The open service model implements QoS using Best effort or DiffServ model, the supple service model is implemented by using best effort or IntServ model and the complete service model is implemented using DiffServ and IntServ model[16].

V. WIRELESS NETWORKS USED IN IOT WITH THEIR QOS REQUIREMENTS

Communication network is the major component of IoT, but since IoT is a extensively assorted and versatile domain, it is merely not possible that any one network satisfies all the service requirements and appropriates for all kind of application domains.

We provide an overview on some of current trends in wireless technologies widely used for IoT. Each network has its criteria, strengths and limitations and hence suitable for different IoT application domains accordingly need desirable QoS supports ([7-9], [10], 15]).

VI. METHODOLOGY

We have used secondary data collection method for this research work. We thoroughly studied different research papers and gone through the various data sources from the Internet.

VII. RESULTS

IoT is based on heterogeneity. Not only different networks, this technology uses various kind of computing and devices. Through this study we found assorted QoS parameters for the main components of IoT such as communication, computing and things.

VIII. CONCLUSION

This paper will provide an in-depth review of QoS matrices used in IoT in various contexts such as: layer wise QoS specification, application requirement based QoS implementation. Communication, computing and things are the main backbone of IoT. Hence QoS parameters are identified for each of the component and presented. For communication IoT makes use of various wireless networks. QoS parameters are represented thoroughly as per network type. This review work will be helpful for researcher, academia, IoT application developers to a great extent.

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APPENDIX

Table 1: Iot Layers And Qos Parameters

Layers	QoS Parameters
Application Layer - Directly accessed by users hence service requirements must meet.	Execution time, delay, accuracy, application priority, mobility, reliability, data security.
Network Layer - QoS depends upon network type.	Bandwidth, delay, packet loss rate and jitter.
Perception Layer - Perception objects and associated technologies specific.	Area of coverage, time synchronization, location information, sampling parameters.

Table 2- IoT components and respective QoS metrics

IoT Components	QoS Metrics
Communication	Bandwidth, throughput, jitter, latency, availability,security,privacy, reliability, connection time, financial cost.
Things	Response time, power consumption, mobility, interoperability, flexibility, reliability, consistency, range, security, sensitivity, precision, weight, drift rate.
Computing	Reliability, scalability, availability, cost, capability, security and privacy.

Table-3: Application type and QoS level

Application type	Controlling/ Mission critical	Querying	Real-time service access	Non Real-time service access
QoS level	Guaranteed service, Integrated service	Guaranteed service, Integrated service / Differentiated service	Differentiated service	Best effort

Table – 4: IoT Application specific service and implementation models

Application Domains	Applications	Service Models	QoS implementation Models
Healthcare	Tracking	Complete	IntServ or DiffServ
	Identification & Authentication	Supple	Best effort or IntServ
	Data collection	Supple	Best effort or IntServ
	Sensing	Complete	IntServ or DiffServ
Smart Environment	Smart homes & office	Supple	Best effort or IntServ
	Industrial plants	Supple	Best effort or IntServ
	Smart gym	Open	Best effort or DiffServ
Agriculture	Data collection	Supple	Best effort or IntServ
	Sensing	Complete	IntServ or DiffServ
	Tracking	Complete	IntServ or DiffServ
Transportation & logistics	Monitoring environmental parameters	Supple	Best effort or IntServ
	Logistics	Supple	Best effort or IntServ
	Mobile Ticketing	Supple	Best effort or IntServ
	Assisted Driving	Complete	IntServ or DiffServ
Personal and Social	Wearable	Complete	IntServ or DiffServ
	Losses and Thefts	Complete	IntServ or DiffServ
	Social Networking	Open	Best effort or DiffServ
	Historical Queries	Open	Best effort or DiffServ

Table-5: IoT supporting networks with QoS requirements

IoT Networks	Network Characteristics	IoT Applications	QoS requirements
RFID	Radio wave technology is used for small chunk of data transmission to a limited distance.	Retail sector, logistics	Usability, reliability, efficiency,maintainability, portability.
Wi-Fi	Not a viable network for IoT due to major limitations in scalability, range and power expenditure. It is opted as a backbone network for communicating data from central IoT node to cloud.	Smart home	Throughput, cost, security, latency, jitter, antenna coverage.
Bluetooth Low Energy/ Bluetooth smart	Optimized for consumer IoT applications for its low power utilization. BLE-enabled devices are generally used in association with electronic devices, mostly smart phones that provide the main center for transferring data to the cloud.	Fitness, medical wearable (smart watches, glucometer, oximeter) smart home devices.	Bandwidth, response time, security, reliability, interoperability.
Zigbee	It is short-span, low-powered, wireless standard organized in mesh topology to expand its range by transmitting sensor data over many sensor nodes. The data rate of Zigbee is higher than LPWAN but not as much power efficient than LPWAN due to mesh organization.	Home automation, security and energy management	Data rate, energy efficiency, coverage, mobility, response time.

Cellular network (5G)	Support high speed, low latency and higher reliable communication capable to support massive number of static and mobile IoT devices with diverse range of speed, bandwidth and QoS requirements.	Smart city, industrial robots, smart vehicle, predictive maintenance, wearable technology	Band width, latency, response time, reliability, transmission delay.
LPWAN	It provides long-distance coverage on miniature, low-priced batteries that sustain for a long period of time and support large-scale IoT networks. Small data blocks can only be transmitted at low rate and hence mostly not suitable for high bandwidth and real-time demanding applications.	Remote monitoring, smart metering, facility management etc.	Packet loss rate, delay, cost, battery life, reliability, range, security.