Quality of Service in the Internet of Things (IoT) – A Survey

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Abstract

Internet of Things (IoT) is an emerging technology that collects information from the physical environment. The data from the physical environment are transferred in the form of packets. During this process a lot of challenges such as loss of packet, fake packet transformation, changes in packet etc. may be encountered. By overcoming these challenges the quality of service and security can be improved. In this paper, a survey has been made to identify the Quality of Service (QoS) parameters and has presented the taxonomy of layer wise QoS parameters for IoT. The paper also focuses on QoS metrics for IoT. Each metric plays a unique role in improving the quality of services in IoT.

1. Introduction

Internet of things is a predominant concept proposed by Kevin Ashton formulated in the year 1999. Twenty-two billion of IoT devices will be connected to the internet by 2021. Internet of Things is the network of physical objects that contain embedded technology to sense and establish the communication to the external or internal environment [9][10]. IoT comprises of a wide variety of devices and applications. Based on the application, architectures are proposed. The architecture of IoT may consist of three layers, four layers or five layers. The main aim of these architectures is to achieve efficient service and quality of service, where quality of service is considered as an important factor throughout the service process.

This paper describes about the IoT and Quality of services in IoT. This paper is organized as follows: Section 1 provides a brief introduction to IoT, Section 2 presents the state of art existing works, Section 3 elaborates the Quality of Service, Section 4 presents the taxonomy of layer-wise QoS parameters of IoT and Section 5 presents the summary.

2. Review of Literature

In IoT, quality is considered as an important factor to ensure the quality in service. Requirements of QoS will vary from application to application. Quality of Service in IoT is considered as the key factor in the service process while framing the application.

Ravi *et al*. [1] have explained about the importance of the QoS in IoT. The authors have highlighted the QoS Parameters and QoS metrics that have to be considered at each layer in brief. The authors have classified the existing literature on IoT according to various research topics such as standardization, system architecture and performance, QoS etc.

Arem Colakobic *et al*. [2] presented the state-of-the-art IoT enabling and emerging technologies along with their functional domains. The aim of the paper was to thoroughly analyze the QoS requirements of IoT and focus on the performance and QoS model as well as protocols discussed by the authors. The authors have pointed out that the QoS performance namely latency, reliability, packet loss and jitter have to be taken into consideration at all layers of the IoT architecture. They have suggested that optimization of resource allocation can lead to QoS enhancement. Furthermore, it is understood that latency sensitive IoT applications must be concentrated on the network performance issues such as delay, bandwidth, congestion and reliability since the edge devices like sensors will be transferring a huge amount of data to the cloud. They have also discussed the challenges and open research issues in each of these areas. From this survey, it could be inferred that network delay, throughput and reliability are the key issues.

Manisha Singh *et al*. [3] have designed a framework for IoT and elaborated the working principle. The framework contains three parts: Things implanted with sensor, communication which includes exchanging the information through gateway from the sensor to application and computing that involves processing the information between the gateways to application. Since things, computing and communication are the three major entities of IoT, the authors have identified and listed out the various QoS metrics that must be considered at each of the entities namely: i) QoS of Communication, ii) QoS of Things, and iii) QoS of Computing. They have suggested that these metrics must be satisfied to provide efficient service.

Yash *et al*. [4] have discussed the factors such as packet delivery ratio, number of packets dropped and end to delay. The authors have analyzed these factors as a function of the sensor reporting rate per second. The analysis of these factors has helped the authors to achieve more reliable form of WSNs. Moreover, the authors have pointed out that, by monitoring fault tolerance, scalability, topology, production costs, hardware constraints, transmission media and power consumption, more reliable protocols could be designed.

Mahendra *et al*. [5] discussed about IoT architecture, cross layer design in WSNs, problem faced in IoT and solution for overcoming the problems. In this paper, the authors described the architecture of IoT in the cross-layer approach. Overview of the applications like smart home, smart transport, smart health care, smart city was discussed.

In Nivek Nallur *et al*. [6] have proposed a QoS based approach of the IoT architecture. In this paper, the authors evaluated the QoS based approach for measuring the performance and have listed the factors that were taken into account.

Animesh Roy *et al*. [7] have identified the issues that influence QoS in Disruption Tolerant Networks (DTNs). The authors have done an analysis of the effects of these issues such as delivery ratio, packet drop, etc., and based on this the authors have proposed a QoS management solution for DTNs. The authors also identified some more issues like congestion, selfishness, fairness, queuing delay and jitter for QoS management in DTNs. The authors presented a systematic classification of various QoS management schemes available in the literature for DTNs.

Kamran *et al*. [8] have proposed a QoS-aware energy and jitter-efficient downlink predictive scheduler for heterogeneous traffic on LTE networks. The authors evaluated the downlink by observing the real time heterogeneous traffic. QoS requirement for this proposed cloud radio access network(C-Ray) and ray tracing based on scheduling approach to achieve optimal solution in terms of both EE and the packet delay. Four heuristic algorithms were proposed to solve the optimization problem. The results showed that there was massive improvement in the system through the proposed work.

From these reviews, it's clear that understanding the metrics that are used for enhancing the quality of services is important. In this paper, the metrics that must be considered at the network layer for enhancing the QoS are focused.

3. Quality of Service in IoT

Quality of service refers to the effectiveness of a network to provide more suitable or appropriate service to the application. QoS is an important predominant factor to be considered in the services offered by an IoT application. Quality of service is determined from how much the user benefits from the service. By considering various aspects of QoS, the services can be constructed to offer efficient service.

3.1 Architecture of IoT

In IoT, Internet Protocol uses the Internet model with five-, four- and three-layer architecture. So far, there is no generalized architecture defined for IoT. The architecture of IoT may vary from application to application. We consider an IoT architecture that involves five layers as depicted in Figure 1 where, each layer plays individual role to achieve the same objective.

3.1.1 Control Layer

The control layer is considered as an important layer in IoT. The actual work that has to be done by this layer will be defined by the developer. The overall process from the assortment layer to application layer are controlled by this layer.

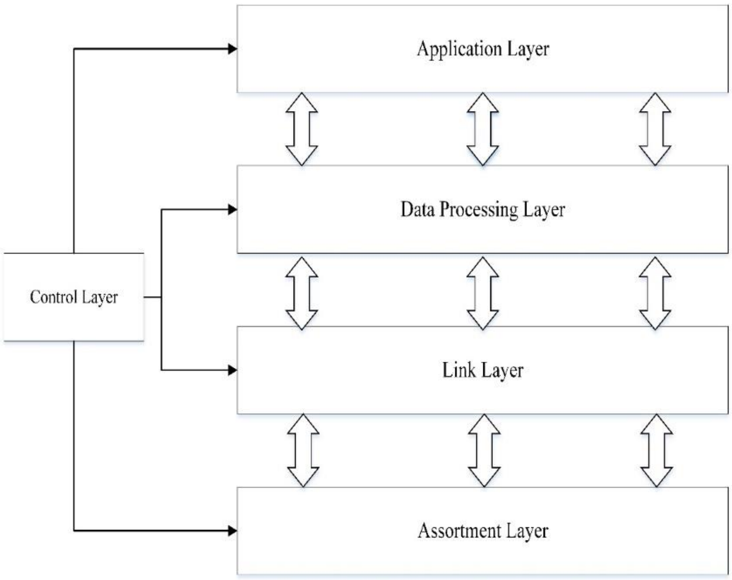

Fig. 1: Architecture of IoT

3.1.2 Assortment Layer

In the assortment layer, the data are sensed from the sensor. The sensors collect the information from the physical environment. Then the data from the assortment layer are transferred to data processing layer through the electronic devices with the help of communication technologies. Communication technologies include Bluetooth, Zigbee and so on. This layer comprises smart objects. These smart objects help users to collect real time information from the physical environment. The Smart objects establish connection to the link, application and data processing layers.

3.1.3 Link Layer

The link layer is used to establish connection between the various layers. The data from the smart objects are transferred through this layer to the application and data processing layers. It acts as an intermediate between the application layer and data processing layer.

3.1.4 Application and Data Processing Layer

In application and data processing layer, two major functionalities namely storing and analysis are carried out. The information gathered from the smart devices are transferred through the link layer to the application layer where it is processed. Data are not stored in the cloud directly. Before storing, the data are analyzed and processed for the further action. This process helps to maintain the standard of the information. After evaluation, the collected data are stored according to the users' needs.

4. QoS Parameters and Metrics

4.1 Taxonomy of layer-wise QoS parameters of IoT

There is no standard architecture for IoT. The architectures of IoT are classified into three layer, four layer and five layer architectures. Depending on the application the architecture of IoT will vary. The Quality of Services of the IoT are classified into three types. They are: (i) QoS of Application layer, (ii) QoS of Network layer, and (iii) QoS of sensing layer. Each layer has its own QoS parameters. Based on these parameters the quality of services is determined in the services process. QoS parameters of the application layer are Service Time, Service Availability, Service Delay, Service Accuracy, Service Load, Service Priority, Information Accuracy, and Cost of Network Deployment. Figure 2 depicts the taxonomy of QoS parameters in IoT.

4.2 QoS metrics for IoT:

4.2.1 Throughput and Efficiency

Throughput is defined as the number of packets that are transferred from the source to destination within specific time period. Throughput is measured in bits per second.

4.2.2 Bandwidth

Amount of packet that can be transferred from source to destination within the specific time period is known as bandwidth. The term bandwidth can be measured in megabits per second.

4.2.3 Packet Loss Ratio

Packet loss is denoted as number of packets that are not delivered at the destination during transmission. It can be denoted by the total numbers of packets sent and total numbers of packets delivered.

4.2.4 Packet Delivery Ratio

The packet delivered ratio presents the ratio of the number of received packets and the number of sent packet of nodes

4.2.5 Delay

Time taken to transfer the packet from source to destination than the actual time is known as delay.

$$D = AT - TT$$

where, D denotes delay, AT denotes Actual Time, TT denotes Time Taken to execute.

4.2.6 Network Connection Time

Time taken by the server to process the request as network connection time. If the service request is not processed in the particular time period than the connection timeout error may occur.

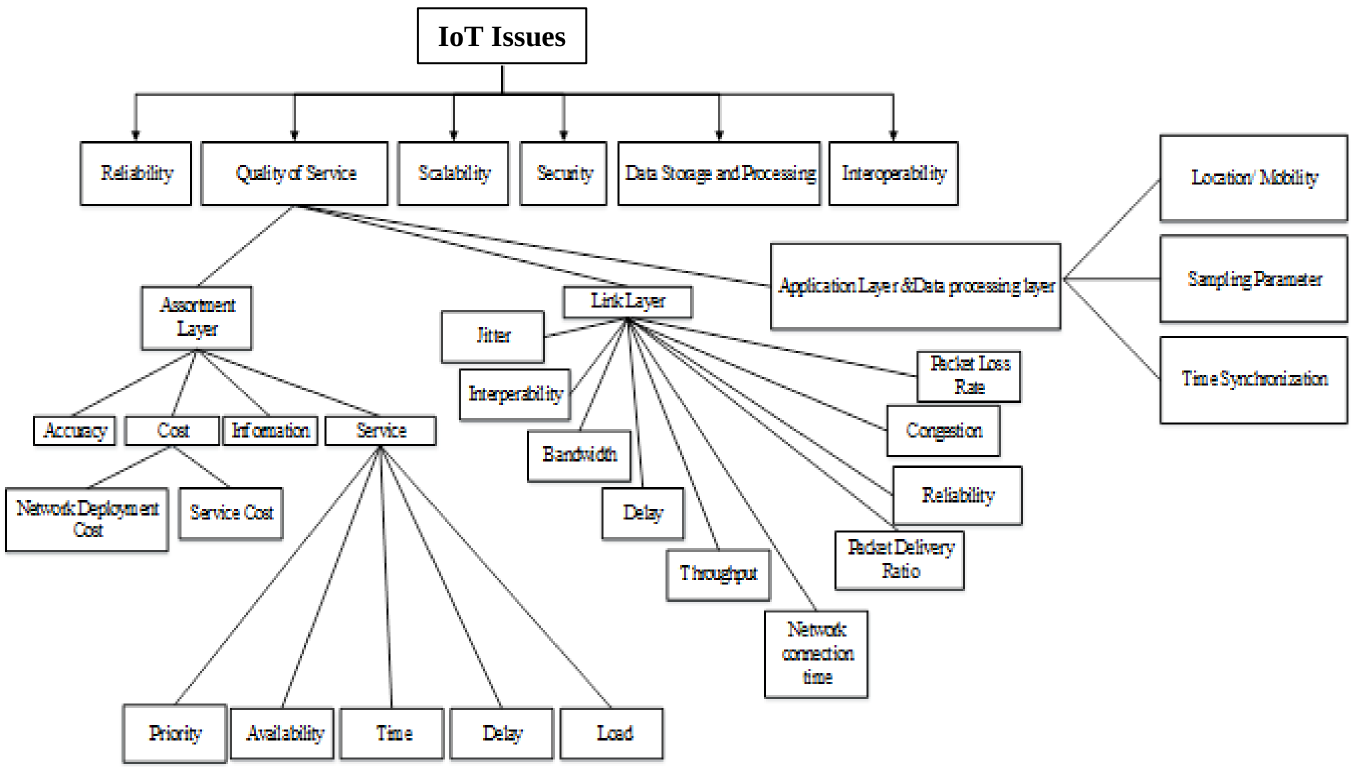

Figure 2: Quality of Service parameters in IoT

4.2.7 Jitter

Overall latency time for the execution time of the packet transformation from source to destination is known as jitter

4.2.8 Interoperability

When communication is established between two devices, which run on different platforms it is known as interoperability.

4.2.9 Reliability

When a communication begins from a source to destination with an accurate or reliable information and if A is a source node and D is the destination then, if node A transfers the packet from source without any packet loss and security rift then the service is known as reliable service.

4.2.10 Congestion

When a packet is transmitted, the packet delivery rate gets delayed in the execution process. This delay may be due to low bandwidth, too much of request that are sent in the same path. Due to this the packet will have to wait until the previous transmission has completed its execution. Thus, congestion in the path occurs.

5. Summary of IoT Layerwise QoS Parameters

Table-1, Summarizes the parameters of Quality of Service for each Layer in the Internet of things.

Table-1: Summary of IoT Layerwise QoS parameters

Layers	Parameters	
Assortment Layer/ Physical Layer	Accuracy	
	Cost	Network Deployment Cost, Service Cost
	Information	
	Service	Priority, Availability, Time, Delay, Load
Link Layer	Jitter	
	Interoperability	
	Bandwidth	
	Delay	
	Throughput	
	Network Connection Time	
	Packet Delivery Time	
	Reliability	
	Congestion	
	Packet Loss Rate	
Application Layer & Data Processing Layer	Location / Mobility	
	Sampling Parameter	
	Time Synchronization	

Conclusion

IoT is the growing technology which is experiencing vast amount of changes in order to offer better services to the society. In this survey paper, the architecture explains the functions of the layers in IoT and taxonomy shows the parameters of the quality of services. The metrics that are to be addressed to improve the quality of services were also given. In future, this can be extended by proposing new approaches, by addressing the problems like unstable link, traffic, node failure, packet loss, lifetime of node, congestion, etc. to enhance the Quality of Service in IoT. Only few metrics were discussed in this paper. Detailed description of the metrics can be given in future.

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