Methods for Monitoring and Managing Computer Networks QoS

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Abstract— **QoS (Quality of service) is very important for the normal functioning of currently used and newly developed network protocols, applications and services. However, providing for each protocol, applications and services the required level of QoS becomes a serious problem. To solve this problem, it is necessary to continuously monitoring and management QoS in real time. This article discusses existent methods for monitoring and managing QoS for the purpose of analyzing the problems associated with providing QoS.**

Keywords— ***quality of service (QoS); QoS parameters; performance metrics; QoS model; QoS monitoring methods; QoS monitoring and managemen; monitoring metries***

I. INTRODUCTION

Today, computer networks, particularly the Internet, using a variety protocols, applications, services and multimedia, which have different requirements for QoS (Quality of service). In such circumstances, providing for each protocols, applications, services and multimedia the required level of QoS becomes a serious problem. Since, QoS is complex; it is also difficult to get his measure and assurance. Therefore, conducting real-time continuous monitoring and management of QoS parameters of computer networks have become very important task.

For over ten years many researchers have studied QoS of computer networks and have developed a variety of architectures, technologies and mechanisms for monitoring and management it [1, 2, 3, 4]. A lot of research and development were made by IETF (Internet Engineering Task Force), for example, IETF RFC 1633 [5], IETF RFC 2430 [6], IETF RFC 2475 [7], etc. CAIDA (Cooperative Association for Internet Data Analysis) created environment for measuring network traffic, which is used for data collection and analysis of QoS. Also, the latest achievements in the development of protocols and technologies have been used to increase the flexibility of computer networks in the processing of network application traffic with different QoS requirements to help ensure certain guarantees QoS. Today these architectures, technologies and tools are widely used in computer networks and mainly focused on the provision of network performance.

However, QoS still remains one of the most ambiguously defined concepts of computer networks today. Depending on the type of task for ensuring network service, QoS can be defined in different ways and can include wide variety of service requirements such as performance, availability, reliability, security, etc. All these requirements are very important aspects to ensure a comprehensive QoS. Therefore, to ensure the QoS of computer networks is necessary to show the creation of the necessary QoS structures, which would include the principles, specifications, and mechanisms for monitoring and managing QoS.

QoS ensury can be provided in both determinism and random forms. The deterministic form, for example, could be expressed in a network that has a constant bandwidth. The random form, for example, could be expressed in a network where some percentage (eg 95%) of packets can be guaranteed a certain average delay, etc. However, along with the provision of network resources to provide QoS, it is necessary to closely monitor and control QoS. In this case, QoS monitoring and management is required to track the current state of QoS. From that, the state is compared with the expected level of QoS to determine any in quality. Finally, network resources are configured so as to achieve the required level of QoS [3, 4].

QoS management is very important for the normal functioning of currently used and newly developed network applications and services. However, the influence of managing the network should be minimal and the managing algorithm should respond promptly to the deterioration of the network QoS. This can be achieved by monitoring and analyzing network traffic.

This article discusses some existing methods for monitoring and managing QoS for the purpose of analyzing the problems associated with providing QoS. Taking into account the capabilities of these methods, network administrators can choose the appropriate methods for monitoring the QoS of their networks. Monitoring and managing QoS can increase the efficiency of network resources by reallocating existing resources along with network-to-network applications and services in accordance with their requirements for QoS. As well as monitoring systems are becoming increasingly important to measure and provide QoS [8].

II. COMPUTER NETWORKS QOS MONITORING MODELS

The monitoring of QoS parameters can be divided into end-to-end monitoring [9] and distributed monitoring [10]. In end-to-end monitoring, QoS traffic between two points, that is, between the sender and recipient, is observed. A distributed approach for monitoring QoS, along with the end-to-end monitoring approach, monitors various segments of the network.

Traditional modeling of network QoS [11] includes the following functional components: application monitoring, QoS monitoring, monitor, and object monitoring (Fig. 1) [12].

The monitoring of application components provides an interface to the network administrator. Its main functions are receiving network traffic information from monitors, analyzing the information, and providing analysis to the administrator. Based on the analysis results, the network administrator can make certain decisions on the management of the network.

The monitoring component provides the mechanisms for monitoring QoS, which will allow monitoring of application components in order to obtain network traffic information regarding QoS parameters.

The monitor component collects and stores information about network traffic and sends this information to the application monitoring component. In particular, the monitor component measures the flow in real-time and transmits the measured data to the application component.

QoS monitoring objects can contain information as attributes and actions. In networks where QoS monitoring is present, the monitoring objects are basically the data elements included in the flow.

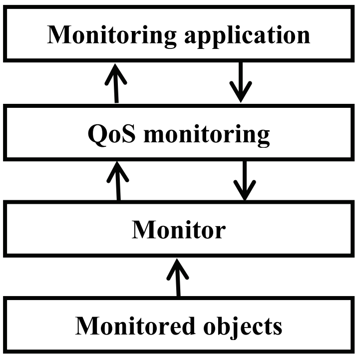

Figure 1. QoS monitoring model

The QoS monitoring model is similar to the traditional model of network monitoring, but there are some differences. First, the QoS monitoring model uses a multi-monitor component that collects and stores information about the various objects used for monitoring. Second, the QoS monitoring model uses monitoring sites in the main part of the flow, while the traditional model of network monitoring monitors objects in the main part of the overall traffic. Thus, the traditional monitoring of computer networks is usually restricted to the network layer model of the OSI, while the QoS monitoring model could work with models of application-level protocols in the OSI (eg, UDP and RTP protocols). Therefore, the third difference is that in a model for QoS monitoring, the monitoring is performed at the application level. The fourth difference is that the QoS monitoring model includes a new component, the component that allows monitoring of the application component to the appropriate information about the QoS parameters of network traffic. Finally, in contrast to the traditional model of network monitoring, the QoS monitoring model can perform analysis to identify issues in QoS and configure the system for the monitoring and reconfiguration of network systems.

III. Computer Networks Monitoring Metrics and Methods

Despite the high current level of network technologies, it is still not a common objective parameter to assess the QoS of computer networks. Today, QoS is defined by three unconnected with each other in various ways: at the level of Ethernet, on the IP-level and for ATM networks. This is one of the reasons for the lack of unified objective QoS parameters.

ITU (International Telecommunications Union) created SLA (Service Level Agreements) for use between ISPs (Internet Service Providers) and their subscribers to determine the QoS parameters of network services. However, SLA is not based on objective standards and may vary depending on the client, the ISP, and the services offered. [13] Therefore, the lack of a uniform standard QoS makes properly determining the QoS of network services an arduous task.

QoS parameters for network service and network performance metrics are indicators of the quality of network services and the efficiency of the network. In this case, QoS parameters can be different depending on the type of network services and should be objectively defined.

Generic QoS parameters that are required for network services are: availability, delivery, delay, bandwidth, MTBF (Mean Time Between Failure) and the MTRS (Mean Time to Restore Service). Each is defined as follows. Availability is the percentage ratio of the feasibility of service for each request. Delivery is the opposite of packet loss, i.e., the percentage of service delivery without packet loss. Delay is the time it takes to move a packet from the access point to the remote service goals and back, which usually includes the time of transport and delays in the queue. Bandwidth is the use of performance or the performance available MTBF is the average time between the service failures, and the MTRS is an average time necessary to restore service in case of failure.

Performance metrics of computer networks are the primary means of evaluating the effectiveness of the level of network management. Typical performance metrics of computer networks used in the definition of QoS are bandwidth, latency and packet loss. IETF IPPM also developed several standards for measuring the performance of computer networks:

• Metric for Measuring Connectivity (RFC2678) [14], which defines a series of procedures for measuring connectivity between a pair of Internet hosts;

• One-way Delay Metric (RFC2679) [15], which defines a metric for measuring the one-way delay of packets across Internet paths;

• One-way Packet Loss Metric (RFC2680) [16], which defines the means of finding one-way packet loss across Internet paths;

• Round-trip Delay Metric (RFC2681) [17], which defines a metric for finding round-trip delay of packets across Internet paths;

• One-way Loss Pattern Sample Metric (RFC3357) [18], which defines two derived metrics "loss distance" and "loss period", and the associated statistics that together capture loss patterns experienced by packet streams on the Internet;

• IP Packet Delay Variation Metric (RFC3393) [19], which defines a metric for the variation in delay of packets that flow from one host to another through an IP path.

QoS mechanisms can be performed in either offline or online modes, i.e based on the pre-processing the collected data, or analysis of data in real time. In this case, the autonomous QoS monitoring is more focused on long-term solutions for managing networks and assumes a broad analysis of the network. Line QoS monitoring is focused on short-term solutions for managing networks and is typically determined by the current state of the network. In this case, the results of monitoring can be used by rocket-propelled machinery for the management of traffic.

QoS monitoring systems may have centralized or distributed architectures [20]. The centralized approach provides an easy method for obtaining a comprehensive view of network performance, but may have problems with scalability. That is, with a significant increase in the number of nodes, the monitoring of data in the infrastructure can become difficult. In a distributed approach, the monitoring data is collected and processed at each point of measurement. Therefore, QoS monitoring can be implemented at different levels of abstraction. Monitoring can be used to obtain performance at the packet level, application level, user level, etc. Monitoring network traffic for QoS parameters occurs at the network layer of the OSI model. These parameters include performance metrics, such as one-way delay variation of packet delay, one-way packet loss, as well as parameters related to traffic, such as traffic load and bandwidth.

Typically, in QoS monitoring systems, parameters can be measured in either an active or a passive manner. The active dimension is introduced into the network to test traffic, which is a simple way to estimate the QoS parameters of the network. However, using this method can disrupt network connectivity and some network services. Despite this, the active monitoring is a subject of much research [21]. Shalunov et al. even developed a protocol which tests traffic between hosts to measure one-way delay and packet loss [22].

In passive QoS measurement approaches, QoS parameters of network traffic are monitored in real time. Despite the fact that passive methods of measurement are typically used to monitor a single host, they can also be used for measurements from node to node. An alternative to the measurement from node to node is a measure based on analysis of information on the actual flow of applications [23]. To achieve a scalable system for monitoring QoS, it is advisable to use both active and passive measurement techniques [24, 25].

IV. COMPUTER NETWORKS QOS MONITORING AND MANAGING ARCHITECTURES

In today's computer networks, providing QoS network services is possible through the differentiation of traffic and level of service. For example, in comparing e-mail applications with VoIP, knowing the volume of throughput and packet delay is crucial. However, to ensure the required level of QoS, network services are often not enough to provide the resources necessary to QoS. Therefore, appropriate mechanisms for the monitoring and management of QoS are required.

QoS management in computer networks is often associated with QoS technologies that are used for driving traffic and differentiating tiers of bandwidth in network services. In general, QoS management of computer networks is based on the results of monitoring and analyzing network traffic. QoS management is crucial for avoiding network collisions and reducing congestion in real time to determine the quality of the service.

However, due to the heterogeneity of computer networks, QoS is often difficult to determine, which complicates the task of managing it. Therefore, for effective QoS management, various indicators must be selected to help determine QoS, requiring continuous monitoring of the network. When detecting the deterioration of performance, QoS indicators based on analysis of data should be taken accordingly. The choice of QoS performance indicators can be made directly from separate data network performance metrics or the average values of overall performance. Likewise, each networks individual attributes must be taken into account.

In the past two decades, various architectures have been proposed to aid in monitoring and managing QoS in computer networks.

OSI QoS architecture: The OSI QoS architecture was one of the first architectures for QoS monitoring and management and mainly focuses on the management of OSI communications. The OSI QoS Architecture defines terms and concepts of computer networks as a model for QoS, which is then used to define open systems, or QoS objects. In this case, QoS objects and their interactions are described by a set of characteristics. The basic concepts of OSI QoS architecture are as follows:

• Demand for QoS, which is realized through QoS management and support;

• Characteristics of QoS, which are the description of the main indicators of QoS, which must be managed;

• Categories of QoS, which represent a group of QoS policy management requirements for the network environment;

• Management of QoS, which can be combined in various ways in order to meet various network requirements, use the various characteristics of QoS.

The OSI QoS architecture consists of two levels of government (special and systemic levels), which provides a means of monitoring and supporting various QoS requirement.

XRM architecture: The XRM architecture is used for both monitoring and managing QoS ATM networks and end multimedia systems. It defines concepts for characterizing ATM networks and end multimedia systems. The XRM architecture consists of the following components:

- Network management and systems;
- Communication management;
- Planning processes;
- Flow management:
- Abstraction and data management.

QoS-A architecture: On the other hand, the QoS-A architecture is a multi-layered architecture of services and mechanisms for QoS management and control for continuous media flows in multiservice networks. QoS-A architecture includes the following basic concepts:

- Flows, characterizing the processing, transmission and consumption of multimedia streams with the appropriate QoS;
- Maintenance requirements that are binding agreements between users and providers that determine QoS levels;
- Flow of control, which provides control and support for the appropriate level of QoS.

Implementation of threading requires active management of QoS and tight integration between device management, final system thread scheduling, communication protocols, and networks.

[4] gives a broad overview of these and other architectures that are mostly intended for the so-called end-to-end monitoring and management of QoS, including end-to-end architecture schemes, QoS monitoring and management, and QoS monitored only between sender and recipient. However, for the monitoring and management of modern computer networks, QoS, scalability is the key. In order to address the issue of scalability, [26, 27, 28, 29, 30] have proposed various principles and architecture of distributed monitoring and management of QoS. Many of the principals in these works are based on agent technologies.

V. CONCLUSION

QoS monitoring and management is of paramount importance in ensuring the normal operation of currently used and newly developed network applications, services, and protocols that have different QoS requirements for computer networks.

The monitoring and management of QoS can increase the efficiency of network resources by reallocating existing resources along with networks-to-network applications and services in accordance with their requirements for QoS.

This article discusses existent methods for monitoring and managing QoS for the purpose of analyzing the problems associated with providing QoS. Taking into account the capabilities of these methods, network administrators can choose the appropriate methods for monitoring and managing QoS in their own networks.

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