Interaction of models and methods of providing QoS in networks

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Abstract. The article shows how constructive blocks interact to ensure the quality of services (QoS) and how they are used to create QoS quality methods. For this, we consider three standardized methods: the method of integrated services (IntServ), the method of differentiated services (DiffServ). The article may be useful both for learning how to use the system and for choosing the technology you need to use.

1. Introduction

The article examined the existing standards for ensuring the quality of service in IP networks. An analysis is made of the main characteristics that determine QoS – reliability of the network and network elements, delay, jitter, packet loss. Based on the available data, a description of the quality of service models is provided: IntServ, DiffServ methods.

2. Integrated Services Method IntServ

The IntServ method is primarily intended to support real-time latency-sensitive applications [5]. It is built on the basis that a stream has a limited delay, and that network equipment can guarantee a delay boundary for a stream by reserving resources for each stream. To implement this method, the network application, before starting to send data, first sends the requested service request signals to the network, including parameters such as the requested traffic profile and delay requirements. Then, the network equipment determines whether it can allocate sufficient resources to ensure the required quality of service indicators. Of particular importance is the development of the IntServ method in connection with the development of the organization of the educational process using remote technologies [1], as well as in other fields of science [3, 6]. After the request is satisfied, the application can begin to transfer data.

Structural blocks related to the IntServ method include admission control, queuing, resource reservation, classification, and traffic tracking. In particular, the Resource reservation protocol (RSVP) is used for resource reservation. The network can accept or reject a reservation request using access control based on the availability of resources. A successful reservation request results in the setting of resource states in nodes with the RSVP protocol. Structural blocks interact by accessing information about the status of resources, and to other data objects provided.
3. Differentiated Services Method DiffServ
The DiffServ method is based on the principle of analyzing the IP TOS packet header (TypeofService), and the requested class of service is determined on its basis. As a rule, the provider enters into a service level agreement with each client, which determines how much traffic the client can send within any given class of service. So, the client’s outgoing traffic is analyzed in packets and sorted into one of the few aggregated flows or classes at the provider’s border. In contrast to the IntServ method, the analysis is carried out not for each stream, but exclusively for the specified class of service. The corresponding building blocks (which include buffer management, packet labelling, service level agreement, traffic measurement and recording, traffic monitoring, traffic modelling and scheduling) interact in a relatively static mode, mainly through the provided data objects.

4. MPLS switching
Designed initially for interworking between IP and ATM / Frame Relay networks, MPLS switching has excellent advantages in packet transmission speed by using short labels similar to Layer 2 labels in the OSI model.
Upon entering the MPLS network, the forwarding packet is always assigned the Forwarding equivalence class forwarding equivalence class (FEC), which is encoded in a fixed-length field called the MPLS label. When a packet is forwarded to the next transit section, this label is also transmitted along with it, which is used as a pointer in a preconfigured table to determine the next transit section and a new label. The old label is replaced with a new one, and the packet is transmitted to the next transit section. This process continues until the packet reaches its destination. Thus, packet forwarding during MPLS switching is completely label-controlled, so packets that are assigned the same FEC class are forwarded along the same path. Moreover, labels are relevant only for a pair of routers sharing a path, and in only one direction – from sender to receiver.
For providing quality of service (QoS) support, MPLS switching uses certain elements from the IntServ and DiffServ methods. For example, the label distribution protocol may rely on the RSVP resource reservation protocol. At the same time, the required network resources for the switched label path can be reserved in the phase of its establishment in order to guarantee the quality of service for packets passing through this path.
Besides, when using a label and certain bits of the EXP field in it, which is used for representing classes of differentiated services, packets of the same FEC class can be analyzed using the DiffServ method. The relevant building blocks for MPLS switching include buffer management, packet labelling, quality of service (QoS) routing, queuing, resource reservation, traffic classification and modelling. They interact through the label switched path state information available at each MPLS switched node using the label distribution protocol and the provided data objects.

5. Implementing QoS on CiscoIOS
CiscoSystems is a world leader in the field of network technologies, production of network equipment for enterprises and telecom operators.
The basic QoS architecture, as recommended by CiscoSystems, consists of three components:
• Identification and labelling methods;
• Providing QoS in a separate element of the network;
• Management features to provide end-to-end QoS on the network.

6. Identification and labelling
For priority servicing of a certain type of data, first of all, it is necessary to identify it, and then mark the selected packets in a certain way. Classification and labelling are done on a separate network element and is not passed on to the next network element.
The main methods for identifying flows in CiscoIOS are Access Control Lists (ACLs), consistent access speeds (CommitAccessRate – CARs), and in-depth traffic analysis and application recognition methods (NetworkBasedApplicationRecognition – NBAR).
7. Providing QoS in a separate network element

The quality of service in routers is ensured by controlling congestion, sequence, channel efficiency, as well as employing restricting flows and setting policies. Since the queue buffers are not infinite, they can overflow. In this case, packets are dropped, the so-called end losses (tail drop). The main problem in case of trailing losses is that the router can no longer discard an important high-priority packet because there is no place in the queue. Thus, a mechanism is needed that primarily discards packets from low priority streams.

One of the methods used by network elements to prevent overflow of the interface queue buffer is to use some sequence algorithm to sort data streams and select one of the methods for setting priorities on output channels. CiscoIOS Software allows using several queuing methods:

- The order “first-in, first-out” (Eng. FirstIn – FirstOut, FIFO);
- Priority priority (English PriorityQueuing, PQ);
- Customizable sequence (English CustomQueuing, CQ);
- Flow-based, somewhat weighted queue (WeightedFairQueing, WFQ);
- A class-based fair weighted queue (Class-BasedWeightedFairQueuing, CB-WFQ).

The flow restriction (eng. – policing) is similar to shaping, but differs in one very important point: data that could not be transmitted is not buffered but discarded.

8. Management functions to provide end-to-end QoS network

QoS management involves network auditing using testers with specialized software. This process allows determining the parameters of data transmission over the network and applications that require the use of QoS. After the data, transfer parameters are received, and the applications that require improving the quality of service are selected, the appropriate mechanisms are configured. The next step is to evaluate changes: testing application responses to determine if the desired QoS has been achieved or not.

9. Classification and labelling

Classification of packets (packet classification) is a tool that allows you to assign a packet to a particular class of traffic depending on the value of one or more fields of the packet.

10. Management and congestion avoidance methods

Routing devices operate on OSI Layer 3 (Layer 3). On most Cisco router models, queue support is provided programmatically. This process means, in most cases, the absence of hardware limitations on their number and a more flexible specification of processing mechanisms. The general principle of QoSLayer 3 includes marking and classification of packets at the input (Marking & Classification), and the distribution of queues and their processing (Scheduling) at the output. There are several queue processing algorithms:

- FIFO;
- PriorityQueuing (PQ);
- CustomQueuing (CQ);
- Weighted Fair Queuing (WFQ);
- Class Based Weighted Fair Queuing (CB-WFQ);
- LowLatencyQueuing (LLQ).

The congestion avoidance mechanism is the mechanism that the router uses when deciding whether to drop a packet when queues are full. In routers, the two most common are:

- **Random Early Detection** (RED) is used in high-speed networks to prevent TCP traffic congestion by dropping (randomly) packets from the thickest streams.
- **Weighted Random Early Detection** (WRED) works in the same way as RED – monitors the length of the queue and discards a certain percentage of packets, avoiding congestion.
- **Explicit Congestion Notification** (ECN) uses the same logic as RED but does not discard packets, and notifies the need for restrictions by labelling them (setting the ECN bit to the IP
11. DPI Technology and Equipment

Operating systems of existing network equipment can quite successfully solve QoS tasks in queue management and preventing congestion. At the same time, the tasks of classifying traffic to provide different levels of service, in the rapidly changing Internet, do not lose their relevance.

Deep Packet Inspection (DPI) is a technology for collecting statistical data, checking and filtering network packets by their contents. DPI devices are capable of detecting and blocking viruses, filtering information that meets specified criteria. The DPI database signature is a unique sequence of bytes that uniquely identifies the type of application (a signature is an integer constant used to identify a resource or data uniquely). Signature databases are constantly expanding due to the increase in the range of services and applications running on the Internet.

Products that implement DPI technology can be classified into two groups:

- Integrated – operating on the operating system network equipment that also performs the functions of routing, switching, for example, the Cisco NBAR application, operating under the control of the IOS operating system. Integrated solutions typically have a more limited set of features and lower performance. However, unlike specialized autonomous solutions, they have a lower cost, because they do not require the use of additional equipment.
- Autonomous DPI systems are independent of existing network equipment. Therefore they are universal. They can be used on networks with different topologies, routing protocols and technologies. Autonomous DPIs have a narrowly specialized operating system that provides a wide range of tools for traffic management, reporting.

The main tasks and functions of DPI include:

- Adaptation and filtering bandwidth. DPI enables the operator to implement resource management and apply policies for their equitable use to solve problems of optimizing bandwidth and guaranteeing a high level of user experience regarding the quality of service.
- Analysis of network usage and related reporting. Determination of preferences of subscribers and popular resources.
- Filtering Internet resources. Restricting access to prohibited content.
- Marketing research. Strategic planning based on marketing research is an important aspect of generating new sources of profit for operators.
- Ensuring security and protecting resources from external attacks.

12. Conclusions

The article examined the existing standards for ensuring the quality of service in IP networks. A description is made of the main characteristics that determine QoS – reliability of the network and network elements, delay, jitter, packet loss. A description of the quality of service models is provided: IntServ, Diffserv methods. Recommendations and examples of implementation of Cisco Systems Systems QoS are provided, including methods for classifying and marking traffic, queuing models, filtering methods, and traffic restrictions.

The problem of recognizing traffic, for its separation into groups and comparing with priority classes, is an important task. For its solution, it is possible to use the specialized traffic analysis complex for software complex Deep Packet Inspection (DPI).

Along with this, it is necessary to take managerial decisions of an organizational and technological nature to select the technology necessary to use [2, 4]. Comparative analysis was carried out [7].

References

[1] Dyachkova M A, Tomyuk O N, Shutaleva A V and Dudchik A Yu 2019 Inclusive organizational culture as a culture of diversity acceptance and mutual understanding Perspect. of Sci. and Ed. 41(5) 373–385 DOI: 10.32744/pse.2019.5.26

[2] Yegorova E V, Klyuev R V, Bosikov I I and Tsidaev B. S 2018 Evaluation of use of effective
technologies for increasing sustainable development of natural and technical system of oil and gas complex Sustainable Development of Mountain Territories 10(3) 392–403

[3] Shishlyannikov D I, Romanov V A, Zvonarev I E 2019 Determination of the operating time and residual life of self-propelled mine cars of potassium mines on the basis of integrated monitoring data Journal of Mining Institute 237 336-343

[4] Ivanova T S, Malarev V I, Kopteva A V, Koptev V Yu 2019 Development of a power transformer residual life diagnostic system based on fuzzy logic methods Journal of Physics: Conference Series 1353 Doi: 10.1088/1742-6596/1353/1/012099

[5] Zhukovskiy Y, Malov D 2018 Concept of Smart Cyberspace for Smart Grid Implementation IOP Conf. Series: Journal of Physics 1015(4) 042067

[6] Maksarov V V, Gabov V V, Zadkov D A, Martyushev N V, Pashkov E N 2017 Preface IOP Conference Series: Earth and Environmental Science 87 011001 doi:10.1088/1755-1315/87/1/011001

[7] Fetisov V G, Nikolaev A K, Lykov Y V 2017 Experimental Studies for Determining Gas Flow Rate Accidental Release on Linear Part of Pipeline. IOP Conference Series: Earth and Environmental Science 87(6) 062003