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METHODS FOR PROPOSAL OF QOS PARAMETERS IN DATA NETWORKS

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1. Introduction

Recent and also most of today's data networks are based on packet switching general principle which was proposed basically for data transmission between computers. At present IP or Ethernet backbones are starting often be used as a multiservice environment (for instance for voice over IP, business critical data, multicast, video interactive streams, etc.) and it is difficult and very complex to satisfy application's needs regarding random delay, not controlled jitter and packet loss and also guarantees of the minimal throughput and availability. That is why the quality aspect has to be considered very carefully. The network provider should also to know what is typically required on the market (class of service) and how to fulfil these needs for quality. At least he has to know, which customer's needs can be fulfilled by his existing IP infrastructure.

New technologies such as IP MPLS (Multi-Protocol Label Switching) or Carrier MEN allows not only providing new and more flexible way how to satisfy Virtual Private Networks for customers, but is mainly designed for simplifying of decision making process for packet/frame switching. Today's data network devices can perform very efficient hardware switching of different traffic flows running through the device and it avoids unpredictable delay caused mainly due to processing decision.

For Service Provider's IP service, the SLA commitments are based usually on network performance parameters like delay, jitter, packet loss rate, throughput and availability. The following pages will give basic ideas of quality of service approach, explains basic tools that are available for quality guaranties, explains the basic structure of a Service Level Agreement, gives some examples of network performance parameters that can be used for SLAs, and shows some open problems for further investigation.

2. Quality of Service

General Considerations

There is no common or formal definition of QoS. However, there are several of definitions at the communication level where the notion originated to describe technical characteristics of mainly non-time-dependent data transmission. According to ITU Recommendation E.800 24 Quality of Service is "The collective effect of service performances which determine the degree of satisfaction of a user of the service". This satisfaction does not exist without customer experiences and depends not only on the customer himself, but also on his environment.

The IEEE paper, Distributed Multimedia and Quality of Service: A survey, provides a more general definition of QoS for applications that must communicate in real-time: "The set of those quantitative and qualitative characteristics of a distributed multimedia system, which are necessary in order to achieve the required functionality of an application."

From simplifying point of view QoS criteria is splitted to two parts: human part (sales, service management – provisioning, technical support, repairing, etc.) and technical oriented one. Most of technical aspects are related to the network. Further on we will consider just technical part of QoS criteria. Technical QoS features are usually serviced by supporting dedicated bandwidth, improving loss characteristics, avoiding and managing network congestions, shaping/policing network traffic and setting traffic priorities across the network.

3. Network QoS parameters

One-way Delay

This characterizes the time it takes between the entering of the packet in an ingress PoP or customer's CPE device and its exit out of an egress PoP or remote CPE device.

Delay is made up of four components.

- *Propagation delay*

It is around 5 ms per 1000 km (ITU document G.144, table A.1). This is constrained by speed of light in a medium. The only tool to manage this type of delay is Traffic Engineering. This rule does not apply if there is a satellite in the route. If a satellite is present in any portion of the route, that portion is allocated a fixed 320 msec. The value of 320 msec takes into account factors such as low earth station viewing angles, and forward error correcting encoding.

- *Processing and Switching Delay*

It is a time taken from packet received on incoming interface to enqueued in class based queue.

- *Serialization Delay*

This is the time it takes to clock the port's transmit queue on the link. This is dependent on the size of the port's transmit queue, the size of the packets in that transmit queue and the port speed. This is normally not significant delay at line rates above 1Mbps. For lower speed lines, link fragmentation mechanisms such as FRF.12 or LFI should to be configured.

- *Scheduling Delay*

It stands for delta time between the enqueue of a packet in its class queue and its enqueue in the port's transmit queue.

One-Way Jitter

This characterizes the variation of the delay. It is computed as the variation of the delay for two consecutive packets. The components of network jitter are:

- *Propagation delay*

If a link fails and another route is selected there will be a change of progagation delay which will cause a sudden peak of jitter.

- *Processing and Switching Delay*

Some packets can require more processing than others, some platforms can be interrupted by some other tasks than packet forwarding.

Network Loss

This characterizes the drops that occur between the ingress link of the ingress PoP or CPE and the egress link of the egress PoP or CPE.

Network Availability

The network between a measurement agent and a test point is considered available at a given time t, if during a specified time interval around t, the measured packet loss rate and the relevant statistics on the round trip delay (such as average or maximum) are below predefined thresholds. Network service availability is defined as the fraction of time the network is available from a specified group (one or more) of measurement agents to a specified group of test points.

4. Service Level Agreement

SLA Concept

A Service Level Agreement is the formalisation of the “Quality of the Service” in a contract between the customer and the service provider.

Critical success factors for SLAs are used to define key elements for successfully building obtainable service levels and for maintaining SLAs. The high−level process flow for service level management contains two major groups:

- Defining network service levels
- Creating and maintaining SLAs

It is recommended to follow following steps for building SLAs after service level definitions have been created:

- meet the prerequisites for SLAs
- determine the parties involved in the SLA
- determine service elements
- understand customer business needs and goals
- define the SLA required for each group
- choose the format of the SLA
- develop SLA workgroups
- hold workgroup meetings and draft the SLA
- negotiate the SLA
- measure and monitor SLA conformance

The main SLA components are:

- metrics
- processes
- remedies/reparations

Very important is also that SLAs has to be:

- simple to understand
- standardised
- simple to measure and report
- should be the same for all customers, not to customise SLA per customer

Usually end-customer is not educated in communication technologies, than SLA between end-customer and service provider has a specific position. This SLA should allow to customer understand, on which quality will be service delivered to him.

Other SLAs on lower layers are negotiated between service provider and network provider or between other entities where understanding of communication technologies is necessary. Then SLA should be based on network performance parameters (NPP). The main gap in this SLAs structure is insufficient knowledge how individual network performance parameters influence to the end-to-end quality in different services. This is why recent SLAs are based mostly on NPP negotiation, and why SLA based on end-to-end quality is more-or-less an exception.

SLA Structure

Formal statement of these values and procedures is called Service Level Agreement (SLA). As it was briefly mentioned before, a general structure of SLA could be structured in this way:

- interface specification
- traffic parameters and values
- QoS/NP parameters and values
- measuring procedures
- reaction to SLA violence

Interface Specification

Interface specification includes general specification of the interface, customer details, service provider details, service description, service access point description (e.g. location of the interface, electrical, logical and mechanical description of the interface etc.), and other legal or business aspects.

Traffic Parameters and Values

Traffic parameters describe limits for the traffic generated by the customer. They can be described directly by parameter values of the policing mechanism, which looks after customer traffic. This part can include also signalling that may be used by customer to control the service.

QoS/NP Parameters

QoS/NP parameters describe quality of service or network performance. They have to be clear to customer, and the customer should know which end-to-end quality would obtain by agreed NPPs. They may be expressed in various forms, e.g.:

- targeting operating value,
- min/max values,
- acceptable values.

Measuring Procedures

Description of the measuring procedures have to state, how the agreed QoS/NP parameters will be measured and evaluated under all situations that can occurred on the interface. It should include who (which of partners) will measure, what, when and where. Usually the main problem for negotiation is, what should me measured and how to evaluate the measurements.

Reactions to SLA Violence

Reaction to SLA violence describes behaviour of the partner who finds that the SLA is not met. Typical reactions are no action, monitoring and recording measured values for later evidence, reservation or reallocation network resources, starting of control mechanisms that will keep parameters within agreed values (e.g. traffic shaping, admission policy control), warning, error massages, interruption or cancellation of the service.

5. Proposal for SLA in data networks

This part of the paper contains generalized framework of proposal for SLAs. It is based on today's SLA concepts and structures and also is depending on the existing network QoS mechanisms which are available in data networks.

It is almost impossible to provide SLAs via dial access lines. In case of DSL service the ability to provide QoS support depends on the design of access network. Usually there are to types of access networks – ATM based and Ethernet one. It is necessary to consider the specifics which designate the manner how to provide the quality of services. The common way today is to provide SLAs on leased lines - fixed, permanent, point to point data communications links, which are is leased from a telco or similar organization.

Proposal of types of profiles and its relation to access rates

In order to provide SLAs it is necessary to prepare proposal for types of profiles which will be offered to the customers according to their needs and requirements and also to define the partitioning to the classes. It is also necessary to define ranges for individual classes according to the used technology.

The profile definition is based on the best practice class definition in IP networks – Best effort, Business class, Streaming class and Voice class. It is also possible to partition business class to several sub-classes which are optimized for different groups of application according to their different requirements related to network performance and QoS parameters.

TAB 1	CoS			
Profile	BE	Bus	Str	Vo
P1	√			
P2	√	√		
P3	√		√	
P4	√	√	√	
P5	√			√
P6	√	√		√
P7	√		√	√
P8	√	√	√	√

TAB 5	Detail part of CoS (%) within access line		
BE	Bus	Str	Vo
100			
40-80	40-60		
40-80		30-50	
20-40	20-30	20-30	
40-90			10-50
40-60	20-30		10-50
30-50		20-30	10-20
20-40	20-30	20-30	10-20

Table 1 *Profile proposal, recommended partitioning of access line*

TAB 2	Definition of CoS (%) at access line			
Profile	BE	Bus	Str	Vo
P1	100			

P2	60	40		
P3	70		30	
P4	40	30	30	
P5	50			50
P6	30	30		40
P7	50		30	20
P8	20	30	30	20

Table 2 *Proposal for definition of Class of Services CoS (%) per access line*

TAB 3	Profile							
access rate	P1	P2	P3	P4	P5	P6	P7	P8
64 k	√							
128 k	√	√						
256 k	√	√			√			
512 k		√			√	√		
1M			√	√	√	√	√	√
2M			√	√	√	√	√	√
4M				√		√	√	√
8M						√	√	√
34M						√	√	√
155M						√	√	√

Table 3 *Describes relation between profiles and access rate*

The defined profiles means just recommended ones, but customer can also use others which have to be discussed with his service provider and will satisfy his requirement more tightly. But it was already mentioned before that the SLAs provided by service provider should be as standard as possible, to minimize customization in order to simplify operation, provisioning and troubleshooting.

For instance it is possible to recognize from the tables that the voice class is not supported on 128 kbps access speed links and bellow. Streaming class is not supported up to 1 Mbps access speed links. This is due to physical and theoretical limitation which does not allow to provide such kind of services with a sufficient quality and reliability.

Also there are limitations to provide voice class on any type of link up to 100 % of utilization. Over-utilization brings excessive drops, jitter and also delay which leads to the service quality degradation.

SLA parameters

Following tables defines standard SLA parameters which could be offered to the customer. It is based on assumption that the worst case is for the low speed access lines, (i.e. 128kbps) and the higher speeds will provide the same or better quality of service in terms of network performance and quality parameters. Therefore there is not a definition for different speeds, just simple the worst case value for each of the parameters per individual class of service.

The parameters are estimated according to the measurements which were already performed in a lab environment.

TAB 4	SLA parameters		
CoS	Delay (RTD and OWD)	Max Jitter	Packet loss
Best effort	-	-	-
Bussiness	-	-	√
Streaming	√	-	√
Voice	√	√	√

Table 4 *Guaranteed SLA parameters based on CoS*

Following values of parameters could be recommended:

TAB 5	SLA parameters		
CoS	Average delay (OWD/RTD)	Max Jitter 95th percentile	Packet loss [%]
Best effort	-	-	-
Business	-	-	1(1)
Streaming	150/300	-	0,5
Voice	80/150	40	1(2)

Table 5 *Proposed SLA parameters*

(1) – this value could be guaranteed only if customer's traffic conforms to CAR traffic descriptors related to the average length of the packets

(2) - this value is guaranteed only if customer does not generate malicious repeating calls when all voice channels are busy

Best effort class

No values are needed to be guaranteed.

Business class

According to the recommendations this class should be optimized for transport of human or machine interaction with remote equipment, such as Web, FTP, telnet, SSH, specialized applications, etc. The source characteristics are almost unpredictable but probably bursty. It is difficult or impossible to specify delay, bit rate, packet loss. Traffic handling priority is used (e.g. CBWFQ) to show better quality than in BE class. Until service provider is not sure, that customers will not use this class for UDP traffic also, it is recommended to optimize and guarantee the packet loss at minimal values. If the customer would use this class only for TCP like traffic, RED parameters may be decreased. This leads to the significant delay reduction, but possible better traffic goodput. Increased packet loss will be handled by TCP.

The minimum average length packet 1 kB is based on the measurements that shows majority of packets with extreme lengths: below 64 B and 1500 B. Importance of a downstream with composition of 70 % long packets and 30 % short packets leads to average length packet approximately 1 kB.

Streaming class

Although the bit rate of a streaming source codec may vary, streaming traffic is assumed to be relatively non-bursty. MPEG-4 video payload needs 150 - 400 ms end-to-end delay and less than 10-3 BER. Taken into account measurements in lab network for video application, values in table 9 are guaranteed for streaming class. Because Streaming class is defined only in profiles offered on faster link than 1 Mbit/s, no LFI is assumed.

The strong condition to the customer's LAN has to be applied. All streaming sources have to be located on a separated LAN segment that is connected directly to CE.

Voice class

100ms is given as a maximum transfer delay. Maximum one way delay 80 ms in the service provider's network was obtained by following calculation: 25ms coding delay for G.729A codec + 2x80 ms RTD + 30 ms jitter buffer. Using E-model with default settings and 1 % packet loss for receiver using zero stuffing, G.729A coding and P.342 handsfree set, customer quality is MOS = 3.36. To cross the lower limit for medium quality, OWD 60ms should be reached. 95th percentile of a maximum jitter was set to 40 ms, jitter buffers are usually able to accommodate jitter 30 ms without adaptation. It is assumed, that adaptive jitter buffer will be able to accommodate 40 ms jitter with probability 0.99.

The strong condition to customer's LAN has to be applied. All IP phones have to be located on a separated LAN segment that is connected directly to CE equipment. If not possible then the LAN infrastructure and its influence to the quality of service has to be analyzed or should be QoS enabled.

Table 6 gives recommended capacity dedicated to the voice channels in accordance with call hours per month. We assume that the main purpose for VoIP integration into VPN is migration from PSTN service towards VPN. Then PSTN bills can indicate a voice volume that should served by VPN voice channels. This volume is expressed by call hours per month. Similarly, as ITU-T Recommendation E.500 recommends it, the calculation is based on an observed Yearly Representative Value. If the traffic intensity tends to be fairly homogeneous from month-to-month, it is recommended that the second highest value be chosen, since this would help avoid outliers. However, if there is not much homogeneity (e.g. one or two months tend to generate the peak loads), then using the peak value is recommended.

TAB 6	Voice traffic characteristics	
Capacity dedicated to voice class	Voice channels	Call hours per month
64 kbps	2	19
128 kbps	5	135
256 kbps	10	363
512 kbps	21	933
1 Mbps	42	2236
2 Mbps	85	5089

Table 6 *Voice traffic characteristic*

Using specific CODEC and standard network performance and QoS tools it is not necessary to report to the customer tight SLAs related to the voice class but only to satisfy minimal value of these parameters in order to satisfy good MOS or E-model values.

6. Conclusion

SLA is a quit new phenomena in packet-based networks. Therefore the previous text can be assumed just as a starting point for further discussion. New and deep experience, more precise measurements and even research is needed.

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Resumé

METODY PRO NÁVRH PARAMETRŮ KVALITY V DATOVÝCH SÍTÍCH

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Článek popisuje technologie které umožňují poskytovateli síťových služeb navrhnout přesnější dohodu o kvalitě služby (SLA) v datových sítích a tím dosáhnout kompetitivní výhody a lépe vyhovět požadavkům zákazníka. Jsou určeny SLA parametry které by měli být brány do úvahy a rovněž jsou popsány rozhodovací kriteria podle nichž se volí vhodné technologie zabezpečení kvality. Závěrečná rozhodnutí jsou podepřena současnými znalostmi a zkušenostmi a taktéž výsledky z laboratorních měření a praktického provozu.

Summary

METHODS FOR PROPOSAL OF QOS PARAMETERS IN DATA NETWORKS

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This document describes technologies that enable Network Service Providers to offer tighter Service Level Agreements for data networks, in order to create competitive advantage and better serve their customers. The SLA parameters that need to be tightened will be defined and then the tools that should be considered are described, together with the decision criteria on where each technology should be used. The final work will be based upon current best practise and will include results from both lab testing and deployment experience later on.

Zusammenfassung

DIE METHODEN FÜR DEM VORSCHLAG DES QOS PARAMETERS IN DATENNETZWERK

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Dieser Artikel beschreibt die Technologien welche ermöglichen den Netzwerkdienstleitern näher Vorschlag für Dienstqualität (SLA) zu vorschlagen und damit kompetitiver Vorgaben zu erreichen und besserer Kundewunsche zu erfüllen. Hier sind hergestellt SLA Parametern welche sollten in Betracht ziehen und gleichartig sind hier beschrieben die Entscheidungskriterien wonach ist gewählten die geeignete Technologie für Qualitätssicherung. Die Endbescheide sind unterstutzt durch derzeitigen Wissen und Erfahrungen und auch durch die Ergebnissen aus den Laboratorienmessungen und den praktischen Verkehr.