New Principle in Admission Control Realisation

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Abstract: Our paper deals with the simulations of selected admission control methods: Simple sum, Measured sum, Predicted sum and Hoeffding bound. We focused on finding a new way to improve the properties of the analysed admission control methods. Primarily, we focused on the parameter of link capacity. Then the results of the original and proposed admission control methods were compared.

Key–Words: Admission Control, IMS, Quality of Service

1 Introduction

Products offered by telecommunication companies changed considerably in the last decades. The traditional voice services were extended by data and voice. Growing demand for these new services resulted in merging formerly separate networks into one in the process of convergence. ITU-T introduced the concept of NGN in 2001. NGN is a packed switched network able to provide telecommunication services with a guaranteed Quality of Service (QoS) [1]. One of the key aspects of NGN is the division of services and transport, which allows their separate development [2]–[6].

The definition of NGN was introduced later by 3GPP forum in document Release 5. Their IP Multimedia Subsystem (IMS) platform was accepted as a standard for use in mobile networks. The task of IMS was to provide multimedia services via IP protocol. Therefore, IMS is the realisation of NGN principals in practice. It defines the complete architecture, that provides the convergence of voice, video, data and mobile networks over the common IP infrastructure. SIP protocol was defined by 3GPP as the standard protocol to be used in this architecture [7].

ETSI established a cooperation with 3GPP and extended the use of IMS also to fixed access networks [8]. The standardisation part of ETSI called TISPAN used IMS as the core of their definition of NGN. The TISPAN architecture is subsystem oriented, which allows for incorporating additional components and by that covering the requirements of new services. This means, that it can also use subsystems developed by other standardisation organisations [9].

In TISPAN architecture is the process of decision making regarding the incoming data flows done in block Resource Admission Control Subsystem (RACS), where one of various admission control (AC) methods is applied. The admission request is processed by the AC method, which evaluates whether the network is capable to guarantee requested QoS [11]–[15] for the new data flow and also whether its acceptance would not compromise the existing connections.

Since the recommendations do not explicitly define any specific method as a standard, more approaches exist as to how to deal with the problem of admission control. This allows us to analyse and compare admission control methods in this paper.

The rest of this paper is organized as follows. Section 2 describes the TISPAN Architecture and block Resource Admission Control Subsystem (RACS). Section 3 is devoted to the Admission Control (AC) methods. In this section we describe two categories of AC methods: Parameter-Based and Measurement-Based Admission Control methods. Section 4 describes the simulation process. In section 5 is the analyse of AC methods and section 6 brings information about proposal of new admission control principle. Section 7 is the conclusion.

2 TISPAN Architecture and RACS

The structure of TISPAN architecture (Fig. 1) is in accordance with ITU-T definition of NGN, meaning that the transport layer and service layer are separated. The service layer is composed of a set of subsystems, that allow the service control. It consists of [9]:

- Core IMS,
- PSTN/ISDN Emulation Subsystem,
- other multimedia subsystems, used for streaming or broadcast, and applications,
- components, allowing for access to applications, security management or routing.

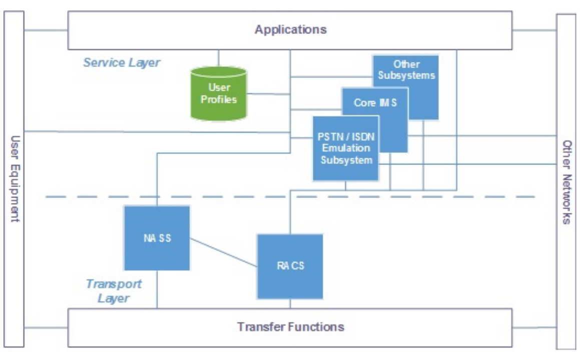

Figure 1: TISPAN architecture scheme.

The transport layer provides IP connectivity to the user, and it is controlled by subsystems Network Attachment Subsystem (NASS) and RACS [8].

Requests for service provision from authorised users are handled by RACS. This part of the architecture deals with the admission control process. Upon receiving a request, RACS confirms the availability of network resources. RACS must have the access to the information about configuration and current usage of the network. The provider is able to define certain policy, which limits the admission according to a of set parameters. RACS oversees the compliance with the set rules. Should there be enough resources available and should the application request meet the policy requirements, RACS reserves the requested resources for the given application [8], [9], [10].

RACS can be divided into two functional blocks: Service-based Policy Decision Function (SPDF) and Access-Resource and Admission Control Function (A-RACF).

2.1 Service-based Policy Decision Function

This block applies the decision policy defined by the provider onto the incoming requests. It evaluates if the services requesting resource allocation are in compliance with this policy. The result of this decision is the base for the next step, which is either sending the data flow to A-RACF or to Boarder Gateway Function (BGF). The result is also sent back to the Application Function (AF).

The functions of SPDF are:

- Incoming data flow evaluation according to the decision policy,
- authorisation of the requested resources for creating the session,
- locating the BGF and A-RACF,
- requesting the resources from A-RACF,
- requesting one or more services from BGF,
- hiding the information about the transport layer from the AF.

2.2 Access-Resource and Admission Control Function

This component gets the requests for resource allocation e.g. bandwidth, which is the means of ensuring QoS. The information about requested resources is provided by SPDF. A-RACF then checks if the requested QoS resources are available and if they can be allocated to the requesting application, then the SPDF is informed about the result of the decision making.

2.2.1 Application Function

Application Function (AF) is located in between the application and RACS and is responsible for sending out the resource allocation requests. The functions of AF are:

- Provides SPDF with the information for identifying flows, which is necessary for specifying the required bandwidth. It also adds other information, such as characteristics of the expected QoS,
- sets, whether the data transfer should start right after the resource is allocated to the flow, or what delay should be applied,
- it is capable of transmitting requests for modifying or termination of resource reservation,

- provides means for overload control, which allows the AF to lower the number of requests in case of overload of RACS. It can also request RACS to lower the number of notifications headed towards AF when overloaded,
- authorised to use IP address or user ID for identification inside RACS.

2.2.2 Resource Control and Enforcement Function

Resource Control and Enforcement Function (RCEF) is controlled by A-RACF and its task is enforcement of the policies defined by the access provider. It opens or closes the gates in order to allow only authorised traffic and marks the incoming packets according to the criteria received by the A-RACF. Other function RCEF performs is policing the upstream and downstream to ensure the traffic remains within the authorised limits.

2.2.3 Boarder Gateway Function

Boarder Gateway Function (BGF) has the function of Network Address Translation (NAT) and also the policy enforcement function. It functions under the control of SPDF. BGF can block individual media flows or admit the authorised ones. In case of the admitted flows, SPDF instructs BGF to open the gate. The resources managed by BGF are IP addresses or ports, which are assigned to the specific applications and also the bit rate on BGP interfaces.

2.2.4 Network Attachment Subsystem

Network Attachment Subsystem (NASS) is a module, that covers the registration of users in the network. After the registration the users can use the services of service layer. From the network point of view this subsystem provides the identification and authentication of users and is also responsible for management of addresses in the access network domain. NASS provides:

- Dynamic allocation of IP addresses and other parameters,
- user authentication,
- authorisation for accessing the network,
- configuration of the access network based on the user profiles.

2.2.5 Session Description

The basic requirement for starting the relation is ensuring IP connectivity. The user contacts the network through NASS in order to get IP access to the network. This subsystem authenticates the user and decides, if it has proper authorisation for accessing the network. Subsequently, NASS allocates IP address to the user and also connects it with a line identifier, identifying access type. After connecting with the access network, NASS uploads a set of static policy parameters to the A-RACF block. This information is based on the user network profile, which is accessible through the access network profile database. It can contain information like maximum bandwidth that the access line is able to support. The user must register at AF to be able to use the network services. At this point of the session, the AF contacts RACS and specifies required resources. Through NASS the AF discovers which SPDF is to be contacted. This information might also be predefined. The SPDF then applies policies and notifies BGF to enforce them. Based on evaluation of the request, the BGF accepts or denies the incoming data flow. The SPDF may also request reservation of resources in the access network from A-RACF. The decision is then send from A-RACF to the IP edge router, which applies it to the particular data flow. All components taking part in this process inform each other about the decisions made, while SPDF is the one to announce the final decision to the AF.

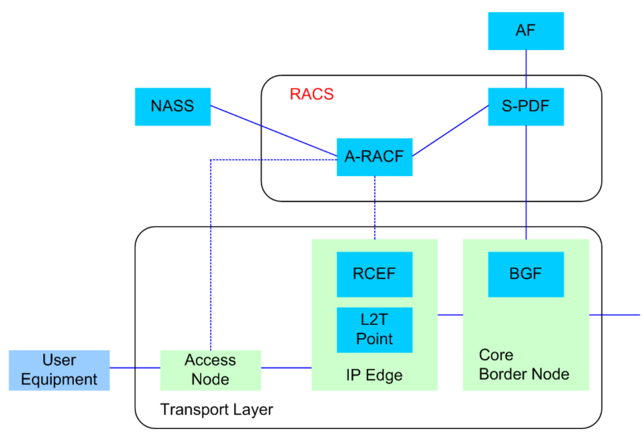

Figure 2: RACS architecture.

3 Admission Control Methods

One of the basic functions of NGN is ensuring the QoS that is needed by the customer. Because of the fact that the key element of this type of network is IP, certain acceptable limits of packed delay, jitter or packet loss must be set. These parameters are crucial for reaching the desired QoS in real-time applications.

AC methods are the means of meeting this goal. They accept data flows, with QoS requirements that can be reached and decline those which could cause the network to overload. Therefore, the process AC methods use to ensure the QoS is blocking incoming data flows during a critical period [16].

There are several types of AC methods. The main difference between them lies in the type of data they use and implementation of the admission control. Some rely on mathematical calculations and statistics and others use traffic measurements. The AC methods can be divided into two categories [16], [17]:

- Parameter-Based Admission Control (PBAC),
- Measurement-Based Admission Control (MBAC).

3.1 PBAC Methods

This approach relies solely on the information about traffic provided by the application. In some cases, the methods belonging to this category are preferred because of the easy implementation. If the admission request is granted, the bandwidth needed by the application is reserved merely for the specific data flow. This attribute of PBAC methods causes inefficient use of network resources. It is common practice for the application to request more resources then they actually need in order to avoid the loss and delay of packets. This can cause the network to decline some data flows even though they would not affect the QoS of existing traffic if accepted. Restriction based on the available bandwidth is present while using AC methods belonging to this category [16]–[18].

3.2 MBAC Methods

This method is used when services with less strict QoS requirements are expected. Most of the MBAC methods are focused on the state of the link. However, there are also approaches which target individual data flows or look at the network as a whole. With every incoming admission request a measurement is done, based on which the admission control decision is made. In case of MBAC this is not related to the application in any way, it depends only on the current state of the network. Methods belonging to this group can function using measurement of end-to-end connection. When using this approach, there are two categories: active and passive MBAC. Passive method uses real traffic, while active creates the so-called testing traffic. The advantage of using end-to-end measurements is that real-time data are taken into account. This means that the new data streams are accepted, if the current situation in the network allows it, which allows for bigger flexibility in admission controls and can lead to better resource optimisation. Dependency on measurement accuracy and possibility of errors can be mentioned as the disadvantages. They can be abused in so-called QoS attacks, when the data flows have small bandwidth requirements while requesting the admission which rises drastically after the access is granted, causing a network overload [16], [19].

Many different MBAC algorithms exist. In our paper, we study the methods:

- Simple sum,
- Measured sum,
- Predicted sum,
- Hoeffding Bound.

a) Simple Sum

Using simple sum of both, the existing and incoming connections, this algorithm determines if the acceptance of the new flow would not cause the link capacity to be exceeded. The new data flow is accepted if the following condition is met:

$$R + r < C \tag{1}$$

where *R* [kbit/s] is the sum of bandwidth used by the existing data flows, *r* [kbit/s] is the bandwidth required by the new data flow and *C* [kbit/s] is the link capacity.

b) Measured Sum

This algorithm ensures that the sum of peak transmission rates of new data flows and the existing traffic is less than the goal link capacity utilization. This is described by:

$$R + p \leq \theta.C \tag{2}$$

where *R* [kbit/s] is the sum of the existing data flows, *p* [kbit/s] is the peak transmission rate of the new data flow, θ is the parameter used to set the link utilization from interval (0,1) and *C* [kbit/s] is the link capacity.

The measured traffic data are valid only for a certain period of time for the given data flow. When applying the AC method to other data flows, the measurements must be repeated as the conditions in the network are different. Every time window consists of more time intervals. In the end of every interval, the measurements are repeated and the highest value of traffic from the entire window is then set as the reference value. Parameter θ is set to a value less than 1, so the QoS is guaranteed for all the connections [18], [21].

c) Predicted Sum

Data is sampled in predefined intervals. The obtained samples are used to predict the value of future incoming data flows. This prediction is then used as a reference for AC. This process is based on the following assumption:

$$x(n+1) + p \leq \theta.C \tag{3}$$

where *x(n+1)* [kbit/s] is the predicted total traffic in the network for the next sampling interval, *p* [kbit/s] is the peak transmission rate of the new data flow, θ is the parameter used to set the link utilization from interval (0,1) and *C* [kbit/s] is the link capacity [18], [20].

d) Hoeffding Bound

For bandwidth allocation, this method uses the so-called Hoeffding Bound C_H. This parameter is defined by:

$$C_H = R + \sqrt{\frac{ln(\frac{1}{\varepsilon})\sum_{i=1}^{x}(p_i)^2}{2}} \tag{4}$$

where *R* [kbit/s] is the sum of the existing data flows, ε is the probability that the incoming transmission will exceed the link capacity, p_i [kbit/s] is the peak transmission rate of data flow *i* and *x* is the number of existing connections.

The condition, upon which the decision is made is:

$$C_H + p \leq \theta.C \tag{5}$$

where *p* [kbit/s] is the peak transmission rate of the new data flow, θ is the parameter used to set the link utilization from interval (0,1) and *C* [kbit/s] is the link capacity. If the sum of the Hoeffding Bound of all existing connections and the transmission rate of the new data flow is lower than the available bandwidth, AC method accepts the new connection. In case that this sum exceeds current capabilities, the data flow is rejected [18], [22].

4 Simulation Process

Using MATLAB environment, we were able to simulate selected AC methods, which allowed us to compare them based on selected criteria. The monitored parameters were the number of accepted data flow, the number of times the overall link capacity has been exceeded, the incoming data flow decision time and the link utilization. The monitored time is assumed to be dependent on the device where the simulations were completed. This means that the time data presented are relevant only in the extent of this paper. The simulations were done on a PC with Intel Core i3-4000M processor and 4 GB of RAM.

The first step in simulating the AC methods was the creation of data flows. It was done using a matrix with 100 rows and 500 columns. One row represents one data flow with values that change in time (data flows with variable bit rate). This variation is observed in the matrix columns, where one column represents one time unit. The values are created using the exprand(m) function, which is a random number generator with exponential distribution. Parameter m in this function represents the mean value which was set to 2 Mbit/s according to available recommendation for video streaming. This value corresponds to video with resolution of 1280x720 pixels with H.264/MPEG4 AVC encoding. This protocol is currently one of the most widely used standard for video compression [23], [24]. The Fig. 2 shows a general scheme of the used network. The link capacity used in all of the simulations was set to 100 Mbit/s and the link utilization parameter was set to 85% based on our previous experiences with AC methods simulations. The Fig. 3 shows the value variation in time for the first accepted data flow. During the first 100 time units new admission requests were received by the network, while the admission decision was made by the used AC method. The result was that after this time, the so-called upper triangular matrix was created. After the first user was rejected by the network, no other connections were established. Some of the original AC methods mention that the peak transmission rate of the incoming data flow should be used while making the AC decision. In our paper, we used the current transmission rate of the new data stream as the reference value, because according to [22], using the peak rate would cause an inefficient use of network resources.

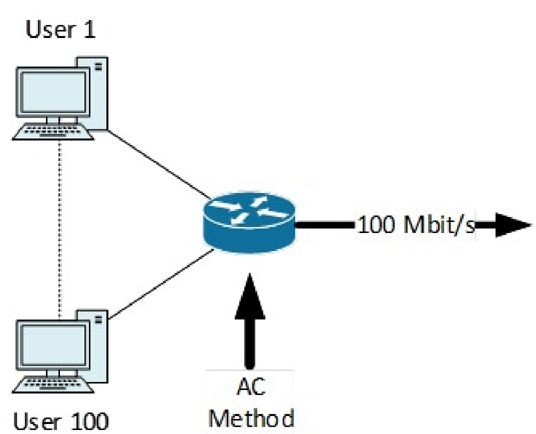

Figure 3: Scheme of the used network.

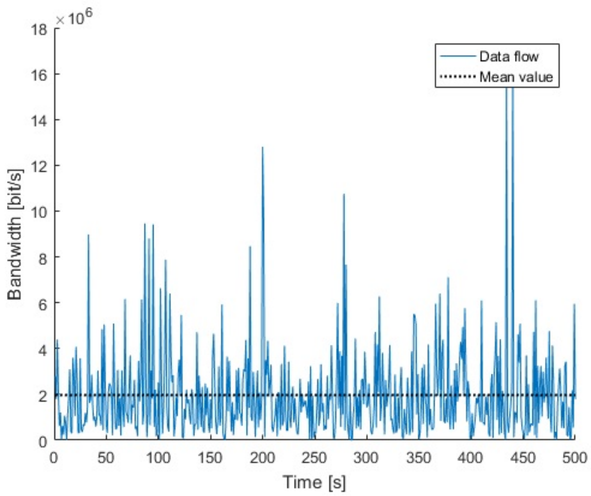

Figure 4: Example of the first accepted data flow time variation.

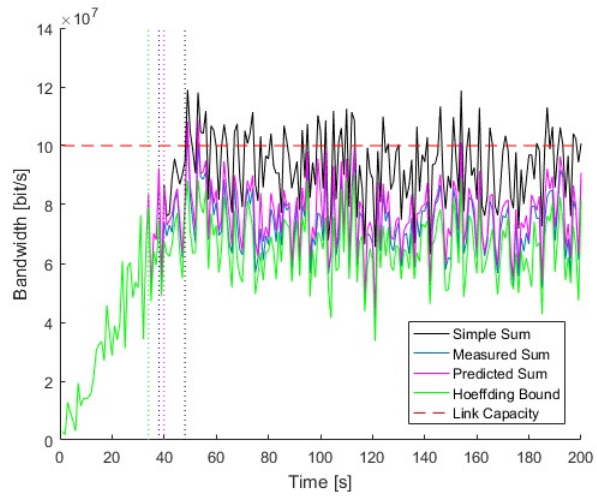

Figure 5: Comparison of the analysed AC methods.

5 Analyse of Admission Control Methods

The measurements were repeated 50 times and the arithmetic mean was then calculated to ensure more precise and reliable output. The graph presenting the situation in the network after the admission control process shows the first 200 time units. This part of the data is the most interesting one, because the link capacity is reached quickly and the results of AC methods are visible here.

In the Fig. 4 the comparison of all simulated AC methods for one measurement is shown. Tab. 1 contains the mean results for 50 measurements. The assumption that the Simple Sum method will accept the highest number of data flow was confirmed (43 were accepted). The link utilization has reached the highest level using this method (81,82%). Such a high percentage caused that the number of times that the link capacity has been exceeded rose to 84. On the other hand, the lowest number of connections was observed by using the Measured Sum and Hoeffding Bound methods. Both algorithms accepted 36 data flows and their link utilization was very similar as well. When considering the parameter of link capacity excess number, the best result (only 15) was achieved by using the Hoeffding Bound method. From the perspective of time consumption, the quickest decision making was observed in the simulation of Simple Sum. On average it took 0.46 s for it to decide whether the request will be granted or not. From all the compared algorithms the Predicted Sum method was found to be the most time consuming.

6 Proposal of New Admission Control Principle

In our paper, we also focused on finding a way to improve the properties of the analysed AC methods, primarily on the parameter of link capacity excess number. The aim of the proposed change in the algorithms is lowering this number. When the link capacity is exceeded, it may lead to increased data loss, or delay, which means, that this parameter is directly linked to the provided QoS. A new criterion was therefore added to all the analysed AC methods. From the previous simulations we gained information used in the proposed change. From all the 50 measurements done before we took the smallest number of data flows present in the network at the moment of the first rejection. In the proposed AC methods, the first k data flows are accepted using the general AC method. From the flow *k+1* the modified method is applied. First, the current value of transmission speed of the new incoming data flow is compared with the maximum value from the previous time instant, according to (5). If the value of the new data flow *k+1* is greater than the maximum found, the data stream is rejected. If it fulfils the condition, the AC method takes over the control. The Fig. 5 shows, where the proposed change is implemented.

Table 1: Monitored parameters.

Method	Number of Accepted Data Flows	Number of times the link capacity has been exceeded	Decision Time [μs]	Link Utilization [%]
Simple Sum	43	84	0.46	81.82
Measured Sum	36	18	0.52	69.95
Predicted Sum	41	53	2.28	77.68
Hoeffding Bound	36	15	1.68	68.60

Table 2: Monitored parameters with proposed change applied.

Method	Number of Accepted Data Flows	Number of times the link capacity has been exceeded	Decision Time [μs]	Link Utilization [%]
Simple Sum	39	5	0.86	66.37
Measured Sum	33	1	1.09	57.73
Predicted Sum	35	1	3.19	60.00
Hoeffding Bound	34	1	2.60	59.16

Table 3: Percentage difference of original and proposed method parameters.

Method	Number of Accepted Data Flows [%]	Number of times the link capacity has been exceeded [%]	Decision Time [%]	Link Utilization [%]
Simple Sum	-9	-94	88	-19
Measured Sum	-8	-94	111	-17
Predicted Sum	-15	-98	40	-23
Hoeffding Bound	-8	-94	55	-14

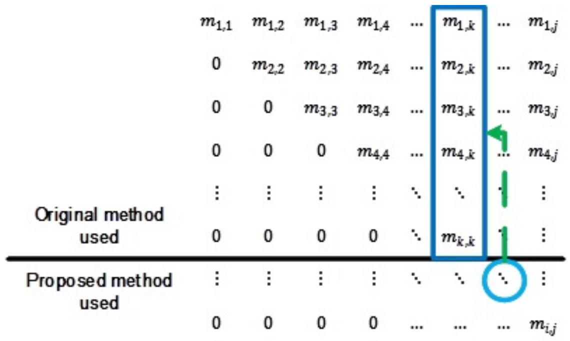

Figure 6: Matrix showing the place of implementation of proposed change.

Functional process of the proposed algorithm:

- First *k* incoming requests are reviewed by the original AC method, while the number k is based on the previous simulations,
- the flow *k+1* is the first one where the new criterion is applied,
- current value of transmission rate of the connection $m_{k+1,k+1}$ is compared with the maximum value from the previous time instant *k* using (6),
- in case, that the data flow meets the condition, the AC method takes over the control,
- the data flow is accepted to the network only, if it fits both decision-making parts, condition (6) and also the used AC method.

$$max\{m_{1...k,k}\} > m_{k+1,k+1} \quad (6)$$

From the Table 2 we can see that after applying the proposed AC methods change, the number of times the link capacity has been exceeded decreased greatly. This means that the change was able to positively influence this parameter. We observed a decrease of over 90% of this parameter in all analysed AC methods. Our change also affected the other monitored parameters (number of accepted data flows, decision time and link utilization), but this effect was negative. The smallest impact was registered in the Hoeffding bound method, where the number of accepted data flows dropped only by 8% and 14% negative difference in the link utilization was observed. An interesting result was achieved in case of Predicted sum algorithm, where the positive and also negative changes were most recognisable. From the perspective of decision time, this method was the one that suffered the least consequences, the parameter rose by 40%. The percentage difference of the original and proposed AC methods measurements is summarised in the Table 3.

7 Conclusion

This paper deals with the simulations of selected admission control methods. Algorithms Simple sum, Measured sum, Predicted sum and Hoeffding bound were analysed. Four parameters were monitored while measuring all used methods: number of accepted data flows, number of times the link capacity has been exceeded, decision time and link utilization. Based on the simulations other measurements were done with a new criterion applied in the decision process. The proposed change of the admission control methods was aimed at lowering the number of times the link capacity has been exceeded, which has negative impact on Quality of Service.

The results of the original and proposed AC methods were then compared. This analysis has shown that the proposed approach was a cause of notable improvement in the parameter it was focused on. However, negative aspect of this change has been observed as well. The network has accepted less data streams and the decision time which can have a significant role in practice has been increased.

Further work related to this topic should replace the simulated data streams with real traffic. The results obtained from reliable data sources can ease help when deciding which specific method to use in practice. Simulations done with this kind of data could also provide the possibility to observe the AC process in networks with mixed traffic as well as in those dedicated to IPTV or VoIP. Further improvements should be done in randomising the admission requests and connection terminations. It is also necessary to look for such ways of influencing the number of times the link capacity has been exceeded that would not have such a great impact on other parameters. From the user point of view, it is important to achieve a certain level of QoS. However, for the provider it is equally important to efficiently utilise the bandwidth and to be able to handle the requests at certain rate.

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