Admission Control Methods in IMS Networks

Michal CUBA, Ivan BARONAK

Institute of Telecommunications, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology, Ilkovicova 3, 812 19 Bratislava, Slovak Republic

michal.cuba@gmail.com, ivan.baronak@stuba.sk

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Abstract. *The article deals with solving the problem of ensuring Quality of Service (QoS) in IP Multimedia Subsystem (IMS) networks. Admission Control methods (AC) are used to prevent network congestion and the decrease of QoS. The main function of AC is to maximize utilization of network resources and to ensure the level of QoS. Four methods were chosen for comparison. These methods are described in the main part of the article. The last part deals with simulations of these methods in the software MATLAB.*

Keywords

Admission control, IMS, QoS.

1. Introduction

Nowadays, besides of using basic services like Telephony, SMS, and MMS, is a trend to link voice and data communication. IMS allows combining various multimedia services and access from mobile and fixed devices. Because of that, it seems to be the key element to achieve network convergence. The main advantage of IMS network is a guaranty of QoS. Admission control methods are used for that purpose.

2. Admission Control

Admission control is a significant process from the point of view of ensuring of QoS. The main function of AC is to estimate capacity for the incoming traffic. Additionally, it has to decide, if it is possible to ensure this capacity without any negative impact on QoS of the existing traffic. It is a decision-making algorithm. It decides if a new connection is supposed to be allowed or denied within available network resources and guaranteed QoS.

The way how it works shows Fig. 1 [1].

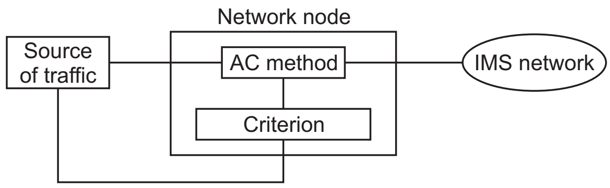

Fig. 1: Management of incoming traffic by AC method.

If the new connection with a request of transmitting enters the node, AC method determines a decisive criterion. The new connection is allowed or denied according to this criterion. AC methods and specific algorithms are described in the next Section.

3. Admission Control Methods

Many methods are known nowadays. These methods can be divided into two categories. Parameter Based Admission Control (PBAC) and Measurement Based Admission Control (MBAC). All of these methods are based on this condition, which has to be respected:

$$P\left[\sum_{i=1}^{N} r_i(t) \geq C\right] < \epsilon. \quad (1)$$

The probability that the sum of the immediate bit rate $r_i(t)$ of all N existing connections exceeds the total capacity C, has to be lower than the defined bound ϵ. Parameter ϵ, which determines the upper bound of the overload probability is 0.001 (0.1 %) [2], [5] and [6].

Good AC methods should keep these conditions:

- keep QoS of the incoming connection without influencing other connections,
- to react and to decide within a short time to minimize the delay,

- effectively allocate bandwidth to maximize utilization of the available capacity.

All of these methods should be simply implementable with the possibility of change and maintenance [2], [8] and [9].

3.1. PBAC

PBAC methods are based on parameters in the network. For their function, it is necessary to know the source characteristics. The method determines a decisive criterion based on the source information. According to this criterion, the method decides whether the new connection will be accepted or denied. To estimate the required capacity with the new connection, the following Eq. (2) is used:

$$C_{est} = m + a'\sqrt{\sigma^2}, \tag{2}$$

where m is the average bit rate and σ^2 is a variance of bit rates of the accepted traffic. Parameter a' represents non-linear change of the variance σ and it is expressed by the equation:

$$a' = \sqrt{-2\ln(\epsilon) - \ln(2\pi)}, \tag{3}$$

where parameter ϵ is described in Eq. (1).

The new connection is allowed according to the following condition:

$$C_{ef\ estimation} < \mu C, \tag{4}$$

where C is the total capacity of multiplex and parameter μ expresses utilization of the line capacity from interval $\langle 0, 1\rangle$. These parameters are used in all following methods [1] and [2].

3.2. MBAC

Unlike the PBAC methods, MBAC methods are based on the measurement. Necessary parameters are acquired by on-line measurement. Thanks to that, the new connection does not have to specify model parameters of traffic [2], [3], [4] and [6].

1) Measured Sum Algorithm

This algorithm belongs among simple measurement based methods. The load of the existing traffic is estimated by measurement. New connection is accepted according to the following condition:

$$C_m + r_{N+1} < \mu C, \tag{5}$$

where C_m is a measured load of the existing traffic, r_{N+1} is the bit rate of the new connection, and parameters μ and C are the same as in Eq. (4) [1], [2], [3] and [4].

2) Hoeffding Bound

As it is mentioned in [5], the main parameter used by this method is the parameter of Hoeffding bound C_H, which is described by this equation:

$$C_H = v + \sqrt{\frac{\ln\left(\frac{1}{\epsilon}\right)\sum_{i=1}^{N}(p_i)^2}{2}}, \tag{6}$$

where v is a measured average capacity, which is utilized by the existing connections, p_i is peak bit rate of i^{th} connection and N is a number of existing connections. According to this parameter, the method decides whether the new connection will be accepted or rejected. The new connection will be accepted according to the following condition:

$$C_H + p_{N+1} \leq \mu C. \tag{7}$$

3.3. Peak Rate Allocation

The Peak Rate Allocation (PRA) method belongs to the group of non-statistical methods. It is quite simple because it allocates the needed capacity at the level of peak bit rate of every connection. It does not depend on the fact that the source transmits at the level of the peak bit rate or not.

The decision is made according to this condition:

$$\sum_{i=1}^{N} p_i + p_{N+1} < \mu C. \tag{8}$$

The new connection is accepted, if the sum of peak bit rates p_i of existing connections along with the peak bit rate of the new connection p_{N+1} is lower than the total capacity of the output line C.

The advantage of this method is that the packet loss is very rare. The disadvantage of this method is that if sources do not transmit at the level of peak bit rate, the allocated capacity is not used effectively [1].

4. Simulations

The MATLAB software was used for AC methods simulations. The scheme of the network node with AC is shown in the following Fig. 2.

Every source represents users, who create stochastic requirements in time, using Variable Bit Rate traffic (VBR). Requirements from users represent various data services. Sources are characterized by $M \times N$ matrix, where M is a number of sources and N are bit rates of these sources. Bit rates of sources are randomly generated in the interval from 0 to 512 kbit·s^{-1}.

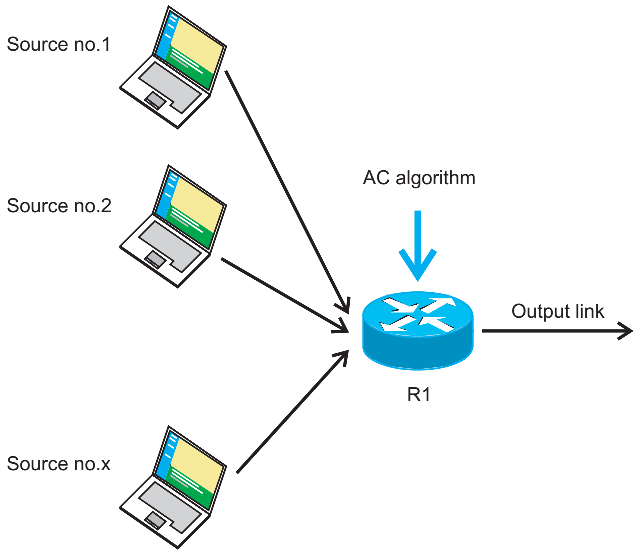

Fig. 2: Network topology.

The number of sources is 120 and they are connected to the node (router). There is one common line on its output with the capacity of 25 Mbit·s^{-1}. We consider the model that one user is connected every second.

Figure 3 shows utilization of the line when all of the sources are connected. As we can see in Fig. 3, if all sources are accepted, the capacity will be overloaded. That would cause the packet loss, or packet sequencing to the queue and the delay would be increased. QoS of all connections would be negatively affected. We are trying to prevent situations like that using AC methods. If the connection of the new source causes a line overload, the connection request will be rejected.

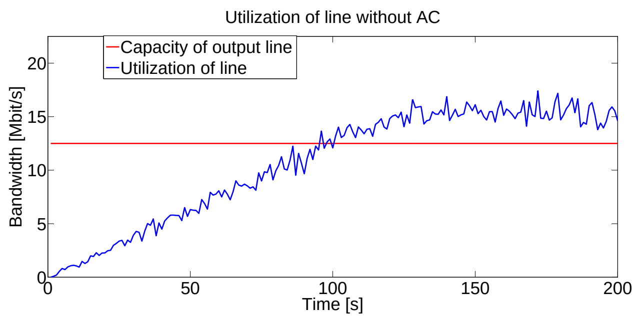

Fig. 3: Utilization of line, when all sources are connected.

4.1. Measured Sum

This methods measures and sums bit rates of connected sources. The new connection is accepted or rejected due to the Eq. (5). Figure 4 shows the accepted utilization of the line by the Measured Sum method.

It is obvious from the Fig. 4 that when the method is applied, utilization of the line (green line) reaches the bound of the output capacity. The number of accepted connections is 94, which is the most of the compared simulated methods. The method maximizes utilization of the line capacity. The Fig. 4 shows that the output capacity is overloaded in some points. The decision of the method depends on the immediate bit rates of the existing connections.

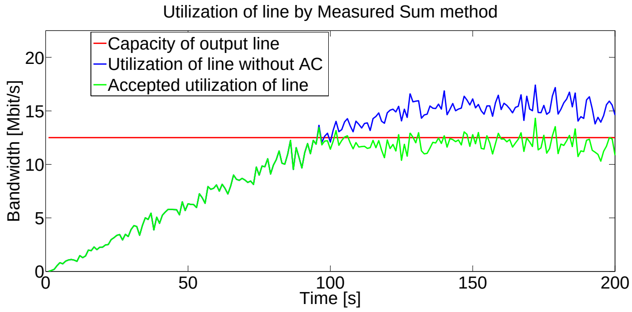

Fig. 4: Accepted utilization of line by the Measured Sum method.

4.2. Peak Rate Allocation

The new connection is accepted or rejected according to the Eq. (8). The accepted line utilization shows the following Fig. 5.

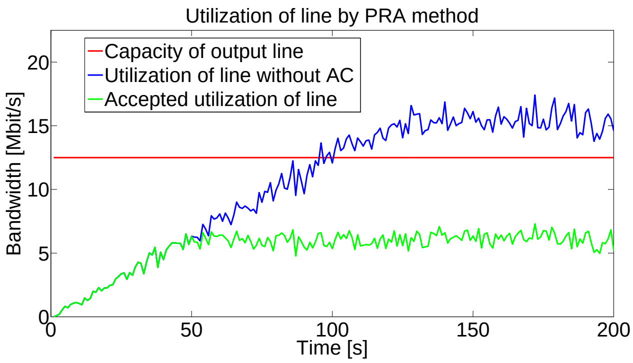

Fig. 5: Accepted utilization of line by PRA method.

In comparison with the method Measured Sum, the number of accepted connections is 47, which is half of the accepted connections by the Measured Sum method. PRA method is basically the opposite of the Measured Sum method. It is caused by the fact that the PRA method allocates the capacity at the level of peak bit rate for every source. Since we used VBR sources with randomly generated bit rates in the interval from 0 to 512 kbit·s^{-1}, the average bit rate is at the level of half of the peak bit rate. Due to this, the capacity of the output line is not utilized effectively. The method is more appropriate for the CBR traffic, or for the traffic where the bit rates are close to the peak bit rates. On the other hand, QoS of the existing connections would rarely be decreased.

4.3. PBAC

This method makes the estimation according to the Eq. (2). The decision about accepting or rejecting of a new connection is made according to the Eq. (4). The accepted utilization of the line by this method shows Fig. 6.

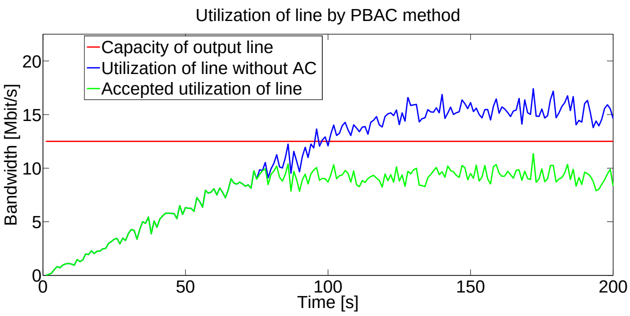

Fig. 6: Accepted utilization of line by PBAC method.

The number of accepted connections is 73, more than PRA and less than the Measured Sum. Even though this method is based on parameters defined beforehand, the computational complexity is low. Thanks to that, the decision making is fast. On the other hand, the online measurements are not made, and this method is not as flexible as MBAC methods. Another important fact is that the effectiveness of the method increases along with the number of sources.

4.4. Hoeffding Bound

The Hoeffding bound is computed according to the Eq. (6). The decision-making about accepting or rejecting of the new connection is made according to the condition Eq. (7). The accepted utilization of the line shows Fig. 7.

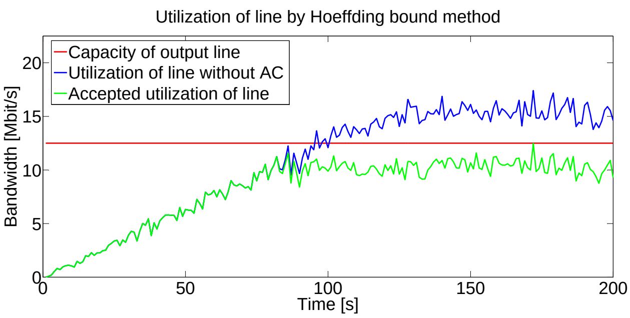

Fig. 7: Accepted utilization of line by Hoeffding bound method.

The specification of the decision-making criterion depends on an appropriate width of the measured interval. An interval, which is too small can cause a non-objective decision making. If we include all samples, the computational complexity would be very high. Dynamical sliding of the measured interval solved this problem. The number of accepted connections is 81, which is more than PBAC and PRA methods, but less than the Measured Sum method. The Fig. 7 shows that overload of the capacity was minimized. This method seems to be the most appropriate one from all of the simulated methods. It is kind of a compromise between the number of accepted connections and the capacity overload of the output line.

5. Methods Comparison

The accepted utilization of line by every simulated method shows Fig. 8.

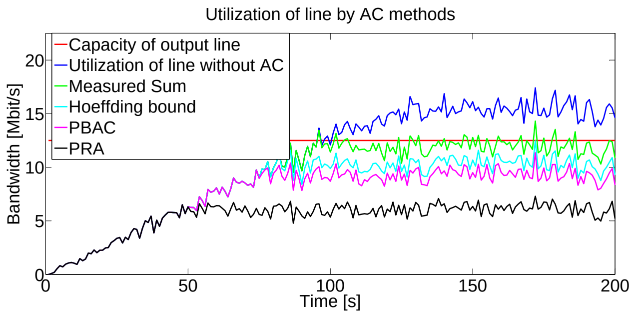

Fig. 8: Accepted utilization of line by AC methods.

The following Tab. 1 shows the number of accepted connections by each method.

Tab. 1: Number of accepted connections by each method.

Method	Number of accepted connection
Measured Sum	94
Hoeffding bound	81
PBAC	73
PRA	48

From the Fig. 8 and the Tab. 1 it is obvious that the most accepted connections were achieved by the Measured Sum method. On the other hand, this method has the most overloads of output line capacity. It would cause a decreasing QoS. Second highest number of the accepted connections has Hoeffding bound method. The overload capacity is minimal. Thanks to that this method seems to be the most appropriate one. The other method with lower number of accepted connections is PBAC method. It does not have any capacity overload, but the capacity can be utilized effectively. The least accepted connections achieved the PRA method. It seems to be the least appropriate one for this kind of traffic.

6. Conclusion

Based on these results, we can claim that the AC methods are appropriate mechanisms for ensuring QoS in IMS networks. All known methods have the same function - to prevent overload and congestion. They have to decide, whether the new connection will be accepted or rejected. From the simulations it is obvious that every method has advantages and disadvantages. The right choice of the method is very important for various specific kinds of traffic.

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About Authors

Michal CUBA was born in Stara Lubovna, Slovakia, on June 1995. Nowadays he is a student at the Institute of Telecommunications, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava. He is interested in solving the problems of traffic management, admission control methods, QoS and IMS networks.

Ivan BARONAK was born in Zilina, Slovakia, on July 1955. He received M.Sc. degree from Slovak Technical University Bratislava in 1980. Since 1981 he has been a lecturer at Department of Telecommunications, Slovak University of Technology in Bratislava. Nowadays he works as a professor at Institute of Telecommunications of Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava.

Scientifically, professionally and pedagogically he focuses on problems of digital switching systems, Telecommunication Networks, Telecommunication Management (TMN), IMS, VoIP, QoS, problem of optimal modeling of private telecommunication networks and services.