Admission Control in IMS Networks

Erik CHROMY, Marcel JADRON, Matej KAVACKY, Stanislav KLUCIK

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

chromy@ut.fei.stuba.sk, marcel.jadron@gmail.com, kavacky@ut.fei.stuba.sk, klucik@ut.fei.stuba.sk

Abstract. *In our paper there is an emphasis on simulations of admission control methods in MATLAB environment. The main task of admission control method is to make a decision if the connection requiring network access should be accepted to the network or the access should be rejected. If the connection is accepted to the network, the admission control has to ensure that Quality of Service of this connection will be satisfied, as well as Quality of Service of all other existing connections. We have observed several Measurement based admission control algorithms and the result is the identification of the suitable algorithm which can estimate the required bandwidth.*

Keywords

Admission control, IMS, MBAC algorithms, Quality of Service.

1. Introduction

Trends in telecommunication networks and services tend to IP Multimedia Subsystem networks (IMS). IMS network guarantees Quality of Service (QoS) and Admission control methods are one of applied QoS mechanisms [1].

Within the scope of the project "Support of Center of Excellence for SMART Technologies, Systems and Services II" funded by structural funds of European union we have built the most modern IMS lab at the Institute of Telecommunications. In this lab we can also conduct research aimed to admission control methods, which are necessary for Quality of Service providing for real-time services. The IMS architecture also contains the Resource Admission Control Subsystem (RACS) in which the admission control methods can be applied.

2. IP Multimedia Subsystem

IP Multimedia Subsystem architecture was developed by 3GPP group. This architecture allows to providers to offer multimedia services such as IPTV, VoIP and many others. IMS is not dedicated only to new services, but it must also support legacy services and should be ready for development of new services. Telecommunication providers can deliver their services to customers irrespective of their location, access to technology or terminals. IMS defines architecture which allows convergence of voice, video, data through IP based infrastructure [2], [3], [4], [5], [6], [7], [8].

RACS is one of the important IMS components for interaction between control layer and transmission functions for control of resources including resource reservations, admission control and QoS support. Therefore RACS component ensures QoS in IMS networks. Admission control block receives requests for QoS resources via reference point, e.g. bandwidth requirement. AC uses information from QoS for admission control, i.e. AC checks if the required QoS resources are available and sends decision if the request is fulfilled or not via reference point [9], [10].

3. Admission Control Methods

QoS in the network must be guaranteed in order to support real-time requests and real-time applications. Three QoS classes are defined for Integrated services. The first is Best-effort class. In the network with this class all connections are permitted. Network sends data of these connections with its maximal transmission rate. Each connection needs some network resources therefore there is not QoS assurance. Due to this fact admission control for this class of service is needed. The second class is Guaranteed services. This class ensures that packet in the network will be not lost and guarantees bounded end-to-end delay. This guaranty needs particular bandwidth reservation. The last class is represented by services with controlled traffic. Guaranteed services with controlled traffic require some grade of QoS, therefore they need admission control for estimation of a number of connection for which they can ensure QoS. Admission control makes a decision if the incoming connection will be accepted or rejected. The measure is provision of QoS of incoming connection and preservation of QoS of existing connections.

The field of admission control is divided into Parameter based admission control (PBAC) and Measurement based admission control (MBAC). PBAC methods regard traffic characteristics of all connections, such as peak transmission rate. This method determines required network resources for all connections based on such parameter. MBAC methods are aimed to measurement of actual traffic in the network. This method accepts incoming connections upon realized measurements.

Admission control is necessary for admission of new connection. It is possible to design the model of admission control which ensures QoS by use of admission control methods. Created models can be used separately or in combination for achievement of better QoS. The main task of admission control methods is to estimate required bandwidth for incoming data flow and to decide if this bandwidth can be allocated. Admission control methods are used mainly for services sensitive for the delay and jitter or for real-time services. There are various admission control methods and they differ mainly in different traffic types and method of realization. Some of the AC methods are based on mathematical calculations and statistical markers while others are based on traffic measurements [1].

3.1. Conditions for AC Methods

For QoS provision admission control methods must fullfill following conditions:

- provide QoS for incoming connection while existing connections are not affected,
- fast decision (in order to prevent delays),
- efficient capacity utilization and effective bandwidth allocation for particular flows,
- simple applicability into the system,
- adaptation for new service [1].

Admission control is important mainly in access network whereas nodes in backbone networks have high transmission rates and information about bandwidth calculations they send to edge nodes. The network is utilized mostly at the edge what is also a reason for centralization of admission control to edge nodes. RACS is one of the IMS components that ensures required QoS [9].

3.2. PBAC Methods

PBAC can be preferred due to their simple implementation. They work with parameters such as peak or effective bandwidth of incoming flow instead of values measured in the network. Through PBAC methods we can limit constraints caused by measurements and network monitoring [11].

3.3. MBAC Methods

MBAC methods use measurement of actual traffic in the network for decision about admission of new data flow. MBAC methods make the decision process based on measurements and QoS parameters. In the case of measurement and network monitoring the more efficient network resources utilization for aggregate data flows or for lower transmission rate than the peak rate is possible compared to PBAC methods. In this scenario remaining bandwidth can be used for other data flows [12].

3.4. MBAC Algorithms

Various measurement based algorithms are known. In the paper we deal with following algorithms:

- Simple Sum [13],
- Measured Sum [14],
- Predicted Sum [15],
- Hoeffding Bound [16] and
- Acceptance Region [17].

1) Simple Sum Algorithm

The algorithm through the sum of existing flows simple ensures itself against not exceeding of available bandwidth. It accepts new data flow only if the following condition is fulfilled:

$$v + r_\alpha < C, \qquad (1)$$

where v is a sum of reserved transmission rates [kbit·s^{-1}], C is link capacity [kbit·s^{-1}], α is index for incoming flow and r_α is transmission rate of new data flow [kbit·s^{-1}].

Measured sum algorithm is the simplest admission control algorithm. Therefore it is the most implemented algorithm in routers and switches. It is often used in combination with WFQ method [18] in order to ensure low enqueue delay. WFQ allocates individual service queue for each data flow, so data bursts are separated from each other.

2) Measured Sum Algorithm

This algorithm ensures that sum of peak transmission rates of new flows and actual traffic is lower than targeted link capacity utilization. It is expressed through the condition:

$$v + p \leq u \cdot C, \quad (2)$$

where v is measured actual traffic of existing connections [kbit·s^{-1}], p is peak rate of incoming data flow [kbit·s^{-1}], C is link capacity [kbit·s^{-1}] and u is link utilization parameter.

Actual measured traffic will not be usable for future connection admissions, because new connection will occur in the network and traffic vary. Link utilization parameter is set to a value lower than 1 in order to guarantee the QoS for all connections. Measuring mechanism makes measurements required for measured sum and it is based on window size of this algorithm.

This mechanism sets the fixed time interval for sample period and a longer time interval for window period which is multiple of sample period. Link utilization is measured at the end of each sample period and the highest value of traffic in one window period is defined as the end of the window period. End of the previous window period is regarded as measured traffic. At the end of each window the window closing period is reset to initial value.

3) Predicted Sum

Proposed algorithm samples data during defined intervals. Such acquired samples represent input data for prediction. After each sampling the prediction of the next data traffic is done. Such prediction will be then used for future admission control for admission or rejection of connection. Algorithm of predicted sum makes a decision based on the condition:

$$\hat{x}(n+1) + p_\alpha \leq uC, \quad (3)$$

where α is index for incoming data flow, $x(n+1)$ is predicted aggregated traffic used in next sampling $n+1$ [kbit·s^{-1}], p_α is peak transmission rate of new flow [kbit·s^{-1}], C is link capacity [kbit·s^{-1}] and u is source utilization.

4) Hoeffding Bound

This method uses Hoeffding bound for estimation of link traffic. Hoeffding bound sets the higher bound of traffic for connections in the networks according to equation:

$$C_H(v, \{p_i\} 1 \leq i \leq n, \varepsilon) = avg + \sqrt{\frac{\ln(\frac{1}{\varepsilon}) \sum_{i=1}^{n} p_i^2}{2}}, \quad (4)$$

where avg is total traffic of all connections [kbit·s^{-1}], p_i is peak rate of i-th connection [kbit·s^{-1}] and ε is prediction that traffic will exceed link capacity (probability of packet losses).

Hoeffding bound algorithm makes admission decision based on the equation:

$$C_H + p \leq C, \quad (5)$$

where p is peak transmission rate of new connection [kbit·s^{-1}] and C is link capacity [kbit·s^{-1}].

If the sum of Hoeffding bound of all existing connections and peak rate of new connection is lower than available link capacity the admission control accepts new connection into network. On the contrary, if this sum is higher than available link capacity, connection will be rejected. Compared to Measured sum algorithm, the Hoeffding bound algorithm will not reserve the above capacity for a short-term raised traffic, because Hoeffding bound is adapted for this case. Mechanism of measurement used in this algorithm uses exponential averaging. Firstly, average rate is measured, then the exponential average is calculated and finally Hoeffding bound C_H is estimated.

5) Acceptance Region

This algorithm estimates region in which the link utilization is maximized at the expense of packet losses. Acceptance region can be estimated on the basis of following parameters: given bandwidth, memory space of switches, parameters of buffer stack filter, data bursts of data flow and probability that actual traffic will exceed the acceptance bound. We suppose the Poisson distribution of incoming independent requests in acceptance region calculation. In the case of parameter values variation the algorithm behavior is not precise. Version of the measurement process of this algorithm ensures that sum of measured traffic and transmission rate of new data flow will not exceed the acceptance region.

$$C(s) = \frac{1}{s} \log \left[1 + \frac{v}{p} (e^{sp} - 1) \right], \quad (6)$$

where $C(s)$ is estimated bandwidth for aggregated traffic [kbit·s^{-1}], v is average transmission rate of traffic [kbit·s^{-1}], p is peak transmission rate [kbit·s^{-1}] and s

is space parameter which value is from interval from 0 to 1.

4. Simulations

This chapter deals with simulations of AC methods. Network topology used in simulations is shown in the Fig. 1.

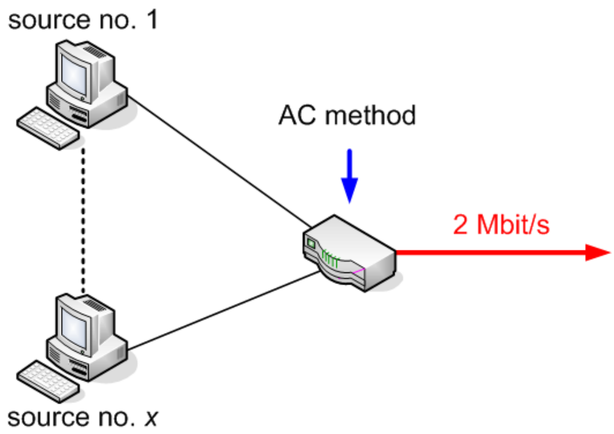

Fig. 1: Network topology.

Admission control method is applied in router. An assumption of this topology is that there is the number of users generating stochastic requests in time. These requests represent stochastic transmission rates from variable bit rate sources. Each source requires different demands on transmission rate in different time samples. Transmission rates vary from 0 to 128 kbit·s^{-1}. It is appropriate to use Gaussian distribution for simulation with a high number of users [19].

4.1. Simple Sum Simulations

The Simple sum simulations are shown in the Fig. 2.

Simple sum algorithm is the simplest admission control algorithm. The main goal of this algorithm is to admit or reject incoming flow on the basis of available bandwidth which can not be exceeded. The simulation results are shown in the Fig. 2. The black curve represents defined link capacity - 2 Mbit·s^{-1}. The red curve represents actual traffic of all users in the network before decision process. Based on the incoming admission request comparison with available bandwidth is done and connection is then accepted (green curve). This two courses show situation when the network is not loaded for maximum.

Comparison with opposed scenario (traffic load near to the link capacity 2 Mbit·s^{-1}) are made through blue and violet curves. Blue curve represents traffic on the border of bandwidth (i.e. 2 Mbit·s^{-1}, or 21 users). Any

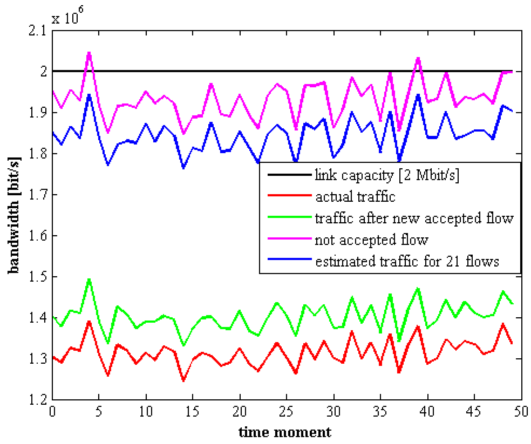

Fig. 2: Simple sum traffic simulation.

new connection can not be admitted due to lack of the bandwidth. Acceptance of new connection in such a situation will lead to QoS degradation (violet curve).

4.2. Measured Sum Simulations

Measured sum algorithm does not regard the total link capacity, but only its part (Fig. 3) compared to simple sum algorithm. The result of the decision process

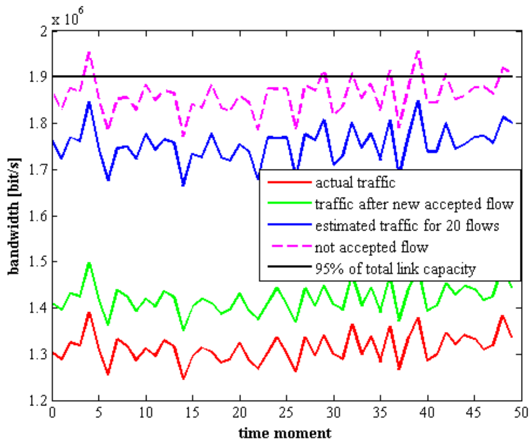

Fig. 3: Measured sum traffic simulation.

is shown in the Fig. 3. Red curve and green curve represent total traffic before and after connection admission. Blue and violet curves represent bound cases. Black curve represents 95 % of total link capacity (i.e. 1,9 Mbit·s^{-1}). Blue curve represents 20 accepted connections. Violet curve represents overrun of defined link capacity, therefore Measured sum algorithm will reject this connection.

Here we can see the difference between Simple sum and Measured sum algorithm. Another connection would be accepted by Simple sum algorithm because it not uses the transmission medium utilization parameter. Measured sum algorithm leaves reserve for the case of unexpected bandwidth increase of connections.

4.3. Hoeffding Bound and Acceptance Region Simulations

In the case of unchanged network topology and higher load the proper selection of AC algorithm is the key element in order to save some bandwidth. In the Fig. 4 the bound scenario with Hoeffding bound (violet curve) and Acceptance region (blue curve) algorithms are shown. Red curve represents actual traffic in the network.

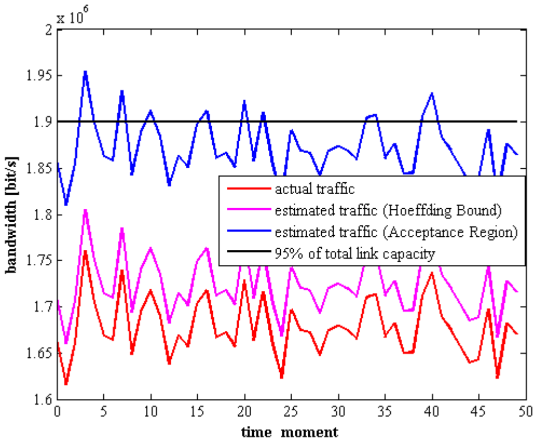

Fig. 4: Acceptance of connections in network with higher load.

We can see that Hoeffding bound algorithm is more suitable. At the moment 19 connections were in the network (actual traffic) and new connection is accepted only by Hoeffding bound algorithm. Acceptance region algorithm has rejected new connection despite of sufficient bandwidth available, therefore from effective bandwidth utilization, the Hoeffding bound algorithm is more preferable.

5. Conclusion

Realized simulations have shown the different allocation of bandwidth while each of simulated algorithms works on different measurement principles. In the case of wrong AC algorithm selection the waste of the bandwidth can occur, what is inefficient and economic unprofitable. Based on the simulations we have shown that in the case of higher traffic load the selection of Admission Control algorithm is very important. From the effective bandwidth utilization point of view the Hoeffding bound algorithm is suitable.

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About Authors

Erik CHROMY was born in Velky Krtis, Slovakia, in 1981. He received the M.Sc. degree in telecommunications in 2005 from Faculty of Electrical Engineering and Information Technology of Slovak University of Technology (FEEIT STU) in Bratislava. In 2007 he submitted Ph.D. work from the field of Observation of statistical properties of input flow of traffic sources on virtual paths dimensioning. Nowadays he works as assistant professor at the Institute of Telecommunications of FEEIT STU Bratislava.

Marcel JADRON was born in Levice, Slovakia, in 1990. He is a student at the Institute of Telecommunications, FEEIT STU in Bratislava.

Matej KAVACKY was born in Nitra, Slovakia, in 1979. He received the M.Sc. degree in telecommunications in 2004 from FEEIT STU in Bratislava. In 2006 he submitted Ph.D. work “Quality of Service in Broadband Networks”. Nowadays he works as assistant professor at the Institute of Telecommunications of FEEIT STU Bratislava.

Stanislav KLUCIK was born in Bratislava, Slovakia, in 1984. He received the M.Sc. degree in telecommunications in 2009 from FEEIT STU in Bratislava. In 2012 he submitted Ph.D. work from the field of Source and QoS traffic parameters modeling in NGN networks. Nowadays he works as researech at the Institute of Telecommunications of FEEIT STU Bratislava.