Chapter 3

Study of Admission Control Methods for IPTV Services

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Abstract

The paper deals with admission control methods used in Internet Protocol (IP) Multimedia Subsystem. The purpose of implementing AC methods in IP Multimedia Subsystem (IMS) is to control the access of incoming connections to network resources. At the Institute of Telecommunications, we have built an experimental laboratory, which is used to test these methods. In this paper, we focus on Internet Protocol Television (IPTV) services; therefore, we have created a variable bit-rate IPTV traffic generator that is used as the input to the network, so we can test the behavior of selected AC methods. They are implemented in a simulated IPTV service provider access network, so we can examine the effects of variable bit-rate IPTV streams on the decisions made by those methods. To calculate the required bandwidth of an input stream, two simulation scenarios with different number of input packets were performed. One of these AC methods was modified where the peak input rate parameter of an IPTV stream was replaced by the average bit-rate of this stream. At the end of this paper, we discuss the achieved results.

Keywords: admission control, IP Multimedia Subsystem, IPTV

1. Introduction

The usage of admission control (AC) methods in connection-oriented network is well known (e.g. CAC methods in ATM networks). But there is also a need to study AC methods in connectionless networks. The Resource and Admission Control Sub-system (RACS) block in an IMS network [1, 2] is responsible for admission and resource control. The functional architecture of RACS block is described in the standard document ETSI ES 282 003 v1.1.1. It is one of the most important blocks of the IMS architecture, and it decides whether a service or connection will be accepted or rejected. The document itself or the available scientific literature does not mention which admission control method or algorithm should be implemented in the RACS block.

The main task of AC methods is to provide sufficient bandwidth for each user service so that required Quality of Service (QoS) [3, 4] will be ensured. AC methods are defined within an IMS network node through the users who are accessing services.

A decision rule is the important part of an AC method. Whether a new request to the network will be accepted depends on the ability of the AC method to retain the QoS for both, existing services [5–7] and the new service that requests additional network resources.

Various methods for Quality of Service rating are used, e.g. subjective or objective. Subjective methods are based on feelings of users during the service provision. For admission control methods, we need to define objective parameters. The main goal of telecommunication operators is to ensure QoS parameters [8, 9] on required levels together with effective bandwidth utilization. The admission control takes a key role in service provisioning (VoIP, IPTV). A wrong AC decision can inflict degradation of QoS parameters for existing [10–12] and for newly accepted data flows.

The key feature of every AC method is the ability to precisely estimate the required bandwidth of an incoming data flow. This estimation is usually based on a theoretical analysis of the network traffic and its accuracy is limited by various simplifications that are used. For example, such a simplification is the use of constant packet lengths or constant times between consecutive packets within a stream [13]. There are many admission control methods and they can be classified into two groups:

- Parameter-based admission control (PBAC) methods and
- Measurement-based admission control (MBAC) methods.

In these papers [14, 15], various methods and algorithms for admission control have been proposed.

2. Simulation model

The purpose of our simulations is to verify the proposed IPTV traffic generator and to identify suitable AC method for IPTV services. Simulations were realized in the MATLAB environment. Input data flows were generated using the IPTV generator defined in [16]. The principle of simulations is depicted in **Figure 1**.

The users generate requests for IPTV streams that are received in the network node (router) which uses a defined AC method. Only one request from one user can originate at a time. At the beginning of the simulation, there were no users connected into the test network. If any connection request is rejected by admission control method, then every new connection request is also rejected.

2.1. Simulation principles

For simulation purpose, we need to convert packet departure times into transmission rate of IPTV flows. For this conversion, we need to know the packet size and number of packets sent per defined time interval. The ratio of these two values gives transmission rate. For conversion,

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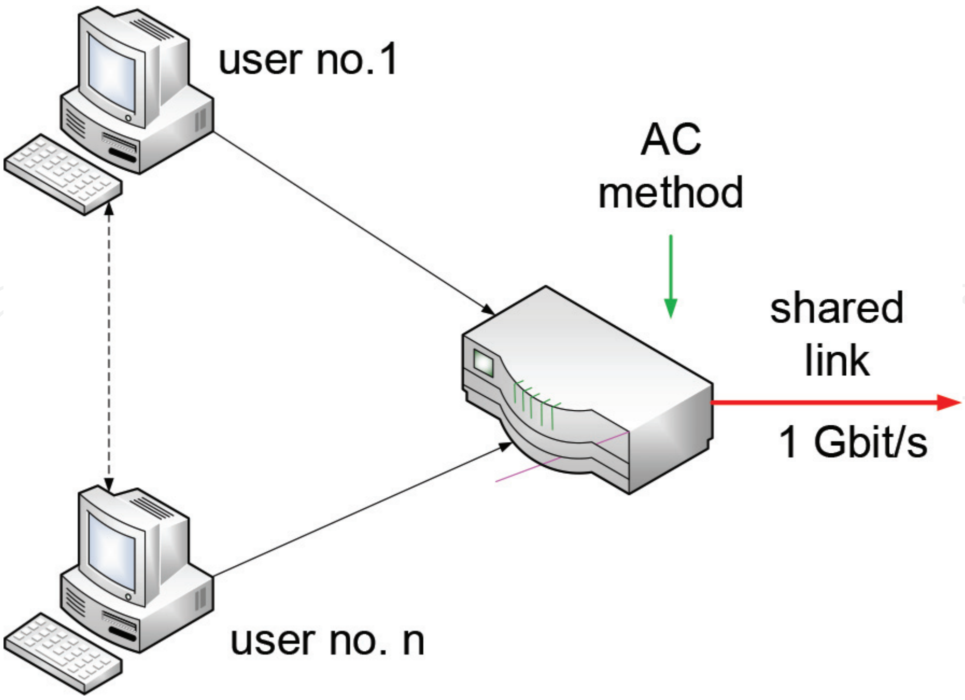

Figure 1. Network topology used for simulations.

it is important to know how frequently the router calculates the parameters of data flows. In our simulations, we used two versions of conversion—conversion for every 1000 packets (*version A*) and for every 100 packets (*version B*). It means conversion of transmission rate around every 2 ms for *version A* and 10 times more frequently for *version B*. Such frequent conversion helps to catch amplitudes (i.e. minimum and maximum) characteristic for variable bit rate traffic. The transmission rates were calculated for IPTV flows for both versions (*A* and *B*) from output of above described generator. Two matrices were created. The rows in the matrix represent IPTV flows and their transmission rates in particular time moments. Parameters of IPTV flow are the minimal transmission rate: 3.51 Mbps, the maximal transmission rate: 14.59 Mbps, and the average transmission rate: 6.14 Mbps.

Four simulations of AC methods were performed—*Measured Sum*, *Hoeffding Bound*, and two versions of *Acceptance Region* method. These methods were implemented in the router depicted in **Figure 1**. IPTV flows share common link with transmission capacity of 1 Gbps (it is the value of parameter B for all implemented methods in simulations). For parameter u, i.e. percentage utilization of bandwidth, the value 0.98 (i.e. 98%) was used.

3. Simulations

The following simulation parameters were observed and evaluated:

- Number of accepted connections
- Average link utilization (%)
- Loss (%).

Each method was evaluated for both versions of transmission rate conversion of input data flows—transmission rate conversion for every 1000 packets (*version A*) and for every 100 packets (*version B*).

If any connection request is rejected by admission control method, then every new connection request is also rejected. From that moment (in the graphs depicted by vertical black line), the observed parameters are evaluated.

3.1. Simulation of *Measured Sum* method

Acceptance of a new requesting connection into the network is based on Eq. (1):

$$v + r \leq uB \tag{1}$$

where v represents used bandwidth for existing connections, r is required bandwidth for new connection, B is overall link capacity, and u is percentage utilization of bandwidth (**Table 1**).

The resulting data flows for version A are depicted in **Figure 2**.

Version	Accepted connections	Link utilization (%)	Loss (%)
A	155	95.42	0.25634
B	141	91.83	0.704579

Table 1. Simulation results of *Measured Sum method*.

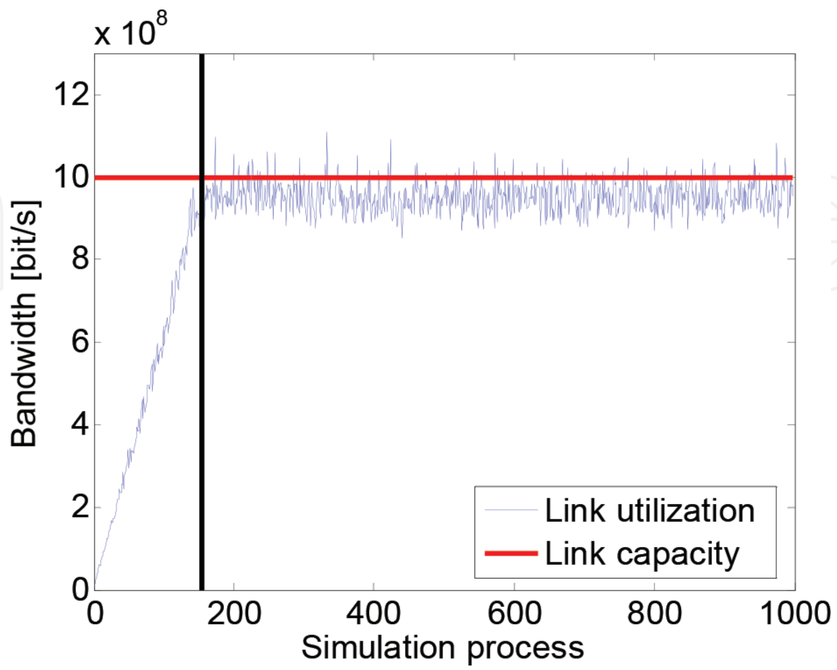

Figure 2. Simulation of *Measured Sum method*—version A.

3.2. Simulation of *Hoeffding Bound* method

Acceptance of the new requesting connection into the network is based on Eq. (2):

$$C_H + p \leq uB \tag{2}$$

For parameter p, the current bandwidth of the requesting connection is used, for parameter p_i in Eq. (3):

$$C_H = v + \sqrt{\frac{ln\left(\frac{1}{\varepsilon}\right)\sum_{i=1}^{n}\left(p_i\right)^2}{2}} \tag{3}$$

are current bandwidths of already accepted connections in the given time moment. Parameter ε (probability that requesting connection will exceed link capacity) was set to 0.05 (i.e. 5%). Resulting data flows for version A are depicted in **Figure 3** (**Table 2**).

3.3. Simulation of *Acceptance Region* method—variant 1

Acceptance of the new requesting connection into the network is based on Eq. (4):

$$np\left(1 - e^{-sp}\right) + e^{-sp}v \leq uB \tag{4}$$

Parameter s was set to the value 10^{-8}. Parameter p denotes the peak bandwidth of the requesting connection. This value is obtained as a maximum value of first 100 values of the transmission rate of the IPTV flow. This value respects two aspects—sufficient number of patterns for representation of data flow and acceptable contribution to delay (and related preservation of computation simplicity). Parameter n represents the number of accepted flows. Therefore, the implementation of buffer for the first 100 values of transmission rate of

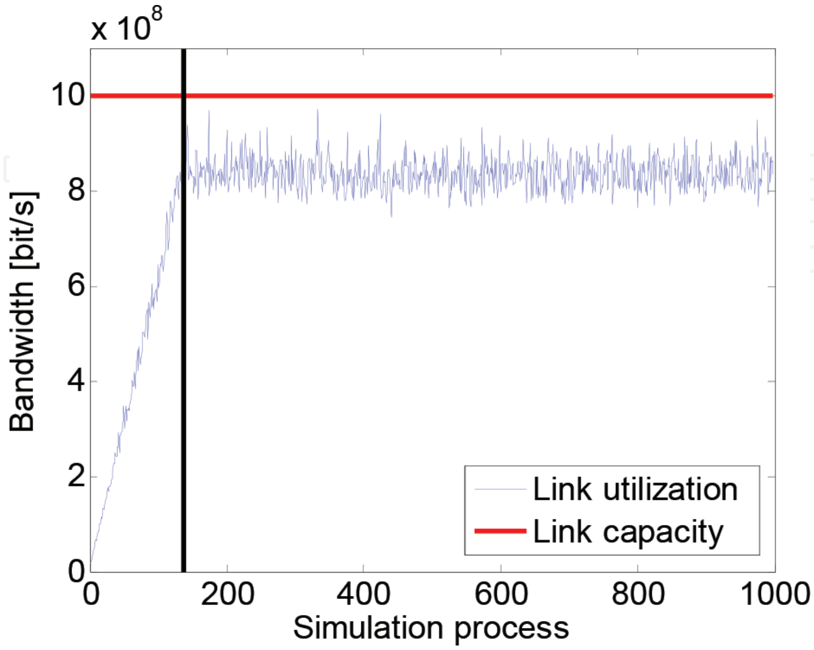

Figure 3. Simulation of *Hoeffding Bound* method—version A.

requesting connection is needed for this method. The value of parameter p is then equal to maximum value of this array of values. Resulting data flows for version A are depicted in **Figure 4** (**Table 3**).

Version	Accepted connections	Link utilization (%)	Loss (%)
A	137	83.83	0
B	125	80.78	0.0238593

Table 2. Simulation results of *Hoeffding Bound method*.

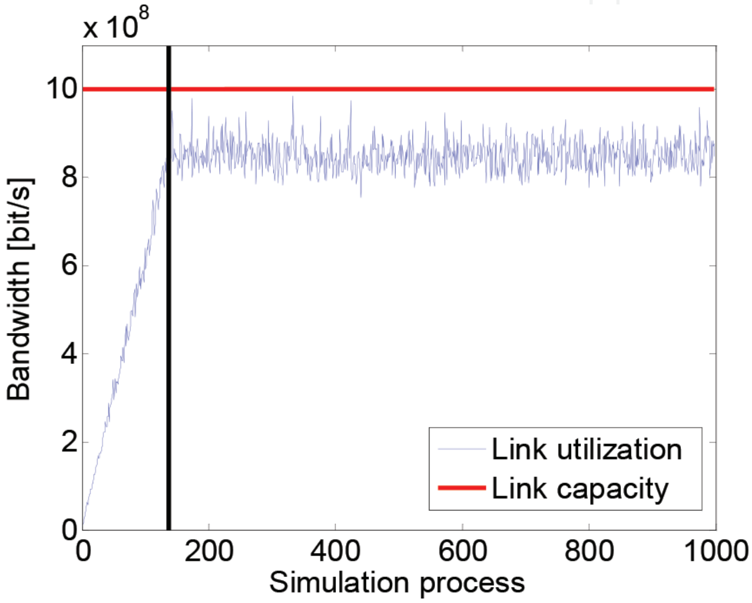

Figure 4. Simulation of *Acceptance Region method*—variant 1 (version A).

Version	Accepted connections	Link utilization (%)	Loss (%)
A	138	85.02	0
B	126	82.81	0.03564

Table 3. Simulation results of *Acceptance Region method*—variant 1.

3.4. Simulation of *Acceptance Region* method—variant 2

Acceptance of a new requesting connection into the network is based on Eq. (5):

$$e^{sp} v \leq uB \tag{5}$$

For this method, two simulations were performed. For the first simulation, the theoretically described parameters were used. For the second simulation, the calculation of parameter p was changed. The same buffer is used as in previous case, but the value of parameter p is the mean value of the first 100 values of transmission rate of the requesting connection (**Table 4**).

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Version	Accepted connections	Link utilization (%)	Loss (%)
A	137	83.83	0
A *modified*	138	85.02	0
B	124	80.78	0.023832
B *modified*	135	87.91	0.247054

Table 4. Simulation results of original and modified *Acceptance Region method*—variant 2.

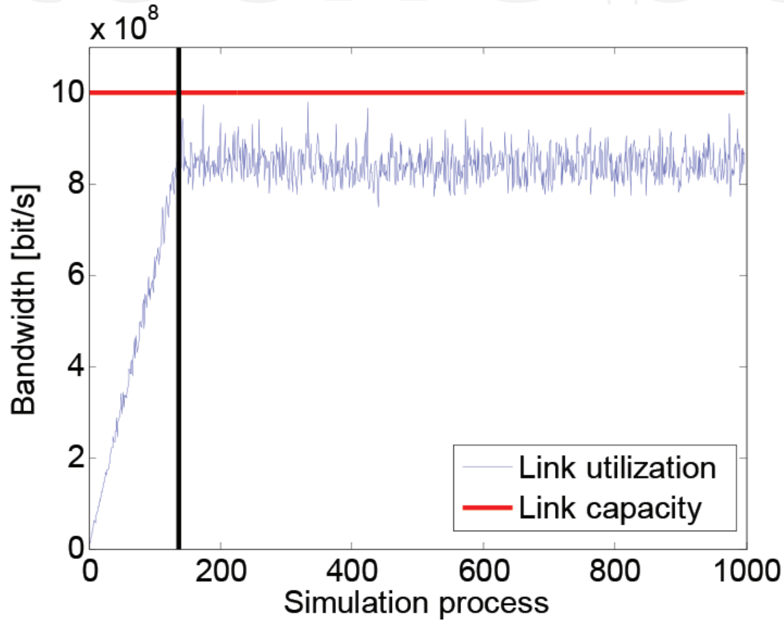

Figure 5. Simulation of *Acceptance Region method*—variant 2 (version A).

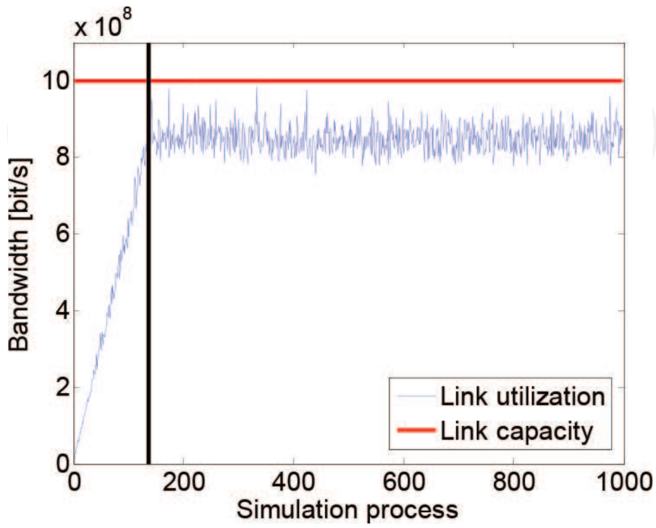

Figure 6. Simulation of modified *Acceptance Region method*—variant 2 (version A).

At first glance, it is a small change, but the simulation results are different. The version *A* of this method accepted one more connection after this change (while zero losses were preserved). The version *B* of the modified method accepted about 11 connections more. But it has a great impact on loss, which is too high, and recommended value for IPTV QoS is not fulfilled. Resulting data flows for version *A* of original method are depicted in **Figure 5** and for modified method in **Figure 6**.

4. Evaluation and comparison of simulation results

Simulation results are stated in **Table 5**. It is proven that the number of accepted connections into the network together with evaluation of link parameters depends on the conversion interval of parameters of input data flows. Obtained results of parameters for *version A* (conversion of transmission rate for every 1000 packets) and *version B* (conversion of transmission rate for every 100 packets) of the same method considerably differ.

Based on the simulation results, we can suggest *Acceptance Region* method—variant 1 as the most suitable AC method for IPTV services. This method is the most suitable regardless of conversion of transmission rates in routers for every 100 or 1000 received packets. By using this method, we can maximize the bandwidth utilization together with guarantee of the requested quality of service.

AC method	Version	Accepted connections	Link utilization (%)	Loss (%)
Measured Sum	A	155	95.42	0.25634
Measured Sum	B	141	91.83	0.704579
Hoeffding Bound	A	137	83.83	0
Hoeffding Bound	B	125	80.78	0.0238593
Acceptance Region—variant 1	A	138	85.02	0
Acceptance Region—variant 1	B	126	82.81	0.03564
Acceptance Region—variant 2	A	137	83.83	0
Acceptance Region modified—variant 2	A	138	85.02	0
Acceptance Region—variant 2	B	124	80.78	0.023832
Acceptance Region modified—variant 2	B	135	87.91	0.247054

Table 5. Simulation results of AC methods and their comparison.

5. Conclusion

The paper deals with admission control methods in IMS networks. We have simulated four admission control methods—*Measured Sum, Hoeffding Bound,* and *Acceptance Region* (two variants). In addition, the modification of *Acceptance Region* method for variant 2 was performed. The modification replaces the peak bandwidth value with the average bandwidth value. Based on performed simulations, we identified the Acceptance bound method—variant 1 as the most suitable AC method for IPTV services.

In the future work on our experimental IMS laboratory, we intend to implement selected admission control methods into the access part of the IMS network architecture. Then, we will evaluate implemented method in real time for IPTV services.

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