An Adaptive Connection Admission Control Algorithm for UMTS Based Satellite System with Variable Capacity Supporting Multimedia Services

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Abstract. This paper is focused on the design of an adaptive Connection Admission Control (CAC) algorithm for a Universal Mobile Telecommunication System (UMTS) based satellite system with variable link capacity. The main feature of the proposed algorithm is to maximize the resource utilization by adapting to the link conditions and the antenna gain of the users. The link quality of the user may vary depending on the weather condition, user mobility and any other propagation factors. The algorithm is compared against a non-adaptive admission control algorithm under different test cases. The proposed CAC algorithm is simulated using MATLAB and the performance results are obtained for a mix of multimedia traffic classes such as video streaming, web browsing, netted voice and email. The simulation results indicate a higher system performance in terms of the blocking ratio and the number of admitted connections.

Keywords: Connection Admission Control, MATLAB, UMTS, multimedia traffic.

1 Introduction

The Connection Admission Control (CAC) is an integral resource management scheme for providing Quality of Service (QoS) in a network. Satellite networks have been growing in popularity owing to their large geographic coverage, and fast deployment when compared to terrestrial networks. Although a satellite system can provide added advantages to the telecommunication infrastructure, the transmission capacity of a satellite is very limited as compared to that of terrestrial networks. Hence, the radio resources have to be managed efficiently such that an acceptable quality of service is delivered. The design of an efficient CAC scheme for satellite networks has been extensively dealt in the literature. A Double Movable Boundary Strategy (DMBS) resource allocation scheme is proposed in [1]. It dynamically controls the boundary policy of the resource sharing amongst the different traffic class according to the variable network load conditions. CAC and the bandwidth allocation decisions are taken at the beginning of each control period. The impact of the queue threshold value on the performance of the DBMS allocation policy is evaluated.

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A predictive CAC algorithm is proposed in [2] for onboard packet switching satellite systems. The algorithm performs the online measurements for the established connections. Based on the estimated parameters, the individual cell loss ratio (ICLR) is predicted ahead of the current time which is used in the CAC decision process. A measurement based admission control (MBAC) for onboard processing satellite is also proposed by the authors of [3]. Unlike, [2] where CAC is implemented onboard the satellite, this paper proposes a scalable CAC implemented on ground in Network Control Centre (NCC). The on-board measurements are performed on aggregate traffic rather than on single traffic for each downlink to reduce the computation complexities on the satellite, which are transmitted to the NCC. The CAC is based on the computation of the downlink effective bandwidth which is an estimation of the actual downlink bit rates used by the in-progress connections. Unfortunately, these approaches are only suitable for a system where the link capacity remains fixed. However, for the system in consideration, the link capacity varies with the antenna gain and the changing link condition of the user which in turn may vary depending on the weather conditions, user mobility and any other propagation factors. This paper proposes an adaptive CAC algorithm for a UMTS based satellite system which adapts to the varying link capacity in order to maximize the resource utilization. The adaptive CAC algorithm is compared against a non-adaptive CAC algorithm which does not consider these factors into account while making the CAC decision.

The paper first describes the network architecture of the system followed by the presentation of the CAC functional model for the admission control algorithm. Section 4 describes the proposed adaptive CAC algorithm and the non-adaptive CAC algorithm used for comparison. The simulation results, generated in MATLAB, are then presented and analyzed. Finally, conclusions and further work are discussed.

2 Network Architecture

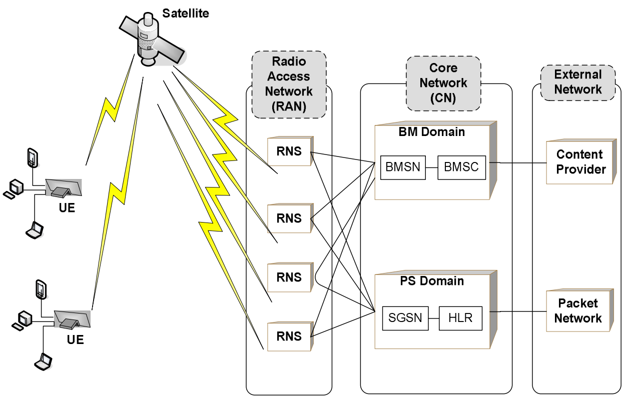

Fig. 1. UMTS based satellite network architecture

The network architecture of a UMTS based satellite system is shown in Fig. 1. It is divided into three segments: a) The User Equipment (UE) segment consists of a portable satellite modem, the Mobile Terminal (MT), connecting to a Terminal Equipment (TE) such as a personal computer or a PDA, allowing users access to UMTS services. Multiple TE can be connected to one MT such that multiple data connections can belong to one MT; b) The ground segment consists of the Radio Access Network (RAN) and the Core Network (CN). The CAC controller is located in the Radio Network Controller (RNC) of the RAN; c) The satellite segment consists of a multi-beam geostationary satellite system that provides a transparent link between the UE and the RNC. MF-TDM and MF-TDMA are adopted in the forward (satellite-to-user link) and the reverse (user-to-satellite link) links respectively. In the forward direction, each satellite channel has a bandwidth of 200 kHz, which is termed as forward sub-bands.

The proposed adaptive CAC algorithm focuses on the resource availability in the forward direction using a fixed number of forward sub-bands to admit the data connections. Each MT is tuned to a particular forward sub-band and therefore, all the data connections belonging to a MT are also tuned to the same forward sub-band. The system supports different MT Classes pertaining to the size of their antennas and operating scenario of the MT such as portable, land-vehicular, maritime or aeronautical.

3 CAC Functional Block Model

Fig. 2. shows the functional model of the proposed adaptive CAC algorithm represented by the CAC Processor. The CAC Processor is an event driven functional entity which encompasses the admission control algorithms. The algorithm is executed at the arrival of a new connection request and decides whether the connection request can be admitted. The difference between the two algorithm lies in the way the resource consumed by a connection is calculated.

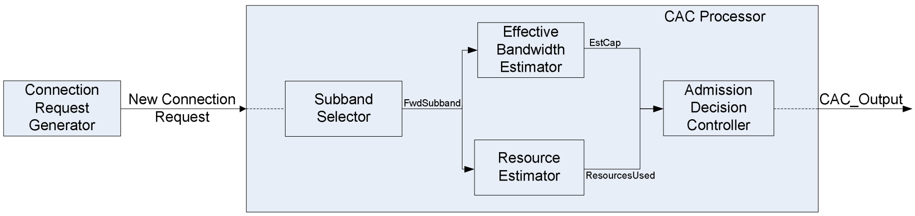

Fig. 2. Functional block model of the CAC algorithms

The Connection Request Generator generates different types of connection requests and sends the request to the CAC Processor. The model consists of four functional blocks: a Subband Selector, an Effective Bandwidth Estimator, a Resource Estimator and an Admission Decision Controller. The Subband Selector selects the forward sub-band for a new MT from the list of available sub-bands. Two methods have been proposed: a) *MinConnSubSel* selects the forward sub-band with the minimum number of connections running from the list of available sub-bands. This method allows a basic form of load balancing, b) Random method randomly selects a forward sub-band. The Effective Bandwidth Estimator estimates the bandwidth required by the connection, *EstCap*, based on the traffic class, priority, source utilization and QoS value of the connection. The Resource Estimator calculates the total resources consumed, *ResourcesUsed*, by the active connections on the given forward subband. The admission decision controller produces an output, *CAC_Output*, which may indicate an admission or a rejection of a connection request.

4 Admission Control Algorithms

The difference between the two admission control algorithms; the adaptive and the non-adaptive, lies in the calculation of the resources consumed by a connection as explained below.

4.1 Adaptive

The total resource consumption on a given forward subband is calculated using the FEC code rate applied in the physical frame for a given MT. The FEC code rate varies with the changing link condition and the class of the MT. Each MT class supports a range of FEC code rates. The adaptive CAC checks the code rate against the class of the MT for the given link condition. The resource used on a forward sub-band is calculated as follows:

$$ResourcesUsed_{givenfwdsubband} = \sum_{allconnections} EstCap \;/\; coderate \tag{1}$$

where, the '*coderate*' value varies constantly in adaptive CAC algorithm.

4.2 Non-adaptive

For this algorithm, the change in the FEC code rate either due to a change in the link condition or due to the presence of different MT classes in the system is not considered. The resource used on a forward sub-band is calculated similar to Equation 1; however, the value of the '*coderate*' remains static in the non-adaptive CAC algorithm for a given forward sub-band.

5 Simulation Results and Analysis

The performance of the adaptive and the non-adaptive admission control algorithms are analyzed and compared using a mixed class of multimedia traffic. The performances are measured under different test cases and the results are compared. Table 1 summarizes the MATLAB scenario configuration set for the simulation.

Table 1. Simulation parameters for scenarios

Common Simulation Parameters		Values
Video Streaming	Number of connections	25
	QoS (kbps)	32
	Source Utilization	0.8
	Mean Burst Period	0.1
	Avg. Holding time (sec)	300
Netted Voice	Number of connections	25
	QoS (kbps)	60
	Source Utilization	0.6
	Mean Burst Period	0.01
	Avg. Holding time (sec)	240
Web Browsing	Number of connections	25
	QoS (kbps)	32
	Source Utilization	0.4
	Mean Burst Period	0.01
	Avg. Holding time (sec)	200
Email	Number of connections	25
	QoS (kbps)	120
	Source Utilization	0.2
	Mean Burst Period	0.01
	Avg. Holding time (sec)	150

5.1 Test Case 1: Effect of Link Condition

Fig. 3 and Fig. 4, show the effect of link quality on the blocking ratio and the number of admitted connections respectively. For the adaptive algorithm, the blocking ratio reduces under high link quality condition as compared to low link quality condition. The code rates supported in the high link condition are higher than in the low link condition and since the higher code rates allow more data to be sent in the physical frame, more number of connections can be admitted in turn reducing the blocking ratio. For the non-adaptive algorithm, a fixed code rate pertaining to the lowest code rate supported, by the given type of forward subband, is considered. This results in a reduced amount of data that can be sent in a frame in the physical layer and hence reduces the number of connections that can be admitted, which in turn increases the blocking ratio.

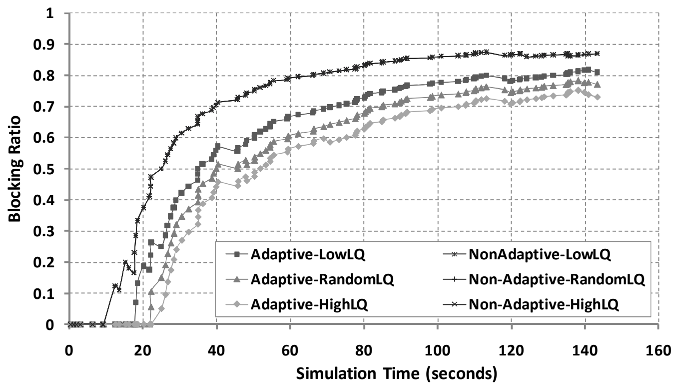

Fig. 3. Effect of link condition on the blocking ratio

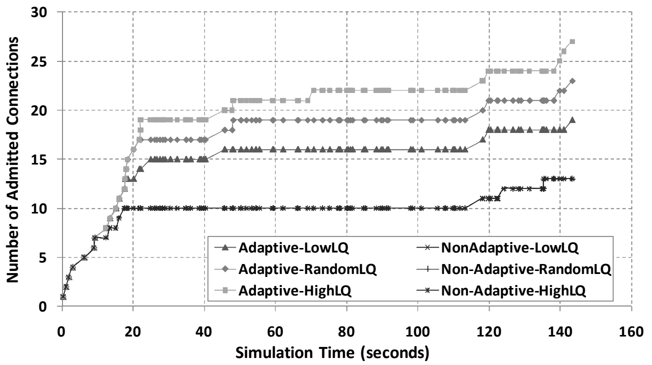

Fig. 4. Effect of link condition on the number of admitted connections

5.2 Test Case2: Effect of Antenna Gain

Fig. 5 and Fig. 6, show the effect of the antenna gain on the blocking ratio and the number of admitted connections respectively. For the adaptive algorithm, the blocking ratio varies with the different MT classes. For this test case, all the MTs are assumed to be in the low link condition. Each MT class supports a range of code rates. The MTs belonging to class 1 supports a higher code rate than class 2 followed by class 3, for the given low link condition. A higher code rate allows more data to be sent in the physical frame leading to an increase in the number of connections admitted and in turn reducing the blocking ratio. For the non-adaptive algorithm, the blocking ratio and the number of admitted connections remains same irrespective of the type of MT classes used as the algorithm considers a fixed code rate for a given forward subband.

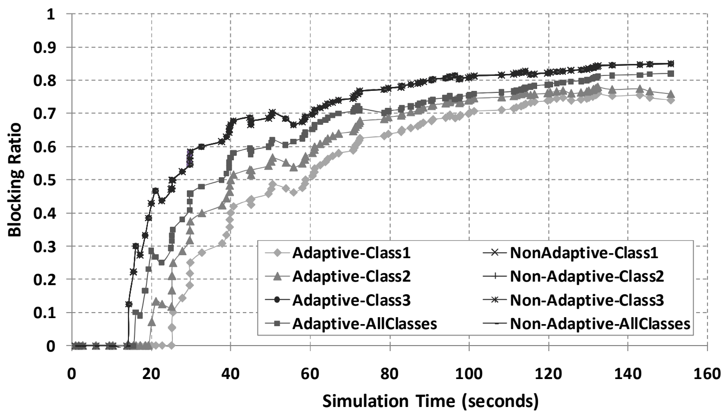

Fig. 5. Effect of antenna gain on the blocking ratio

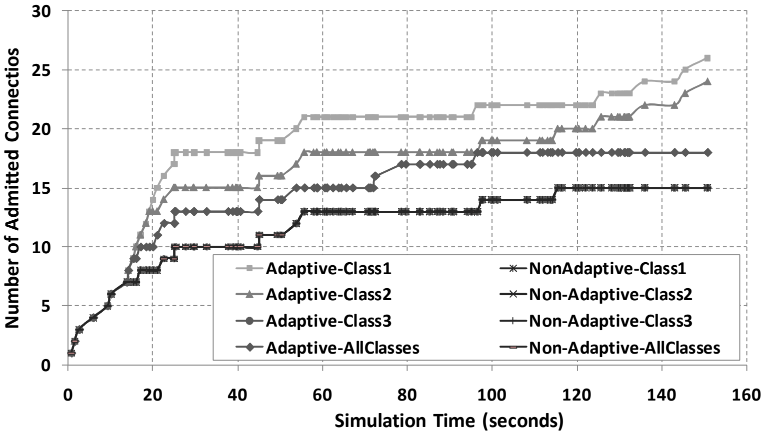

Fig. 6. Effect of antenna gain on the number of admitted connections

5.3 Test Case 3: Effect of Traffic Intensity

Fig. 7 and Fig. 8, show the effect of the traffic intensity on the blocking ratio and the number of admitted connections respectively. For this test case, all the MTs are assumed to be in the low link condition. The traffic intensity or the offered traffic load *(ρ)* is defined as the ratio of the average arrival rate (‘λ’) to the average service rate (‘μ’). Therefore, $\rho=\lambda/\mu$. The system runs with different traffic load by changing the average inter arrival times for the video streaming traffic. As can be seen, the blocking ratio for the adaptive algorithm remains lower than the non-adaptive algorithm as the traffic load increases. The amount of resources needed to accommodate the same amount of traffic for the non-adaptive algorithm is much higher than that for the adaptive algorithm with the increase in the traffic load and thus leads to a higher blocking ratio.

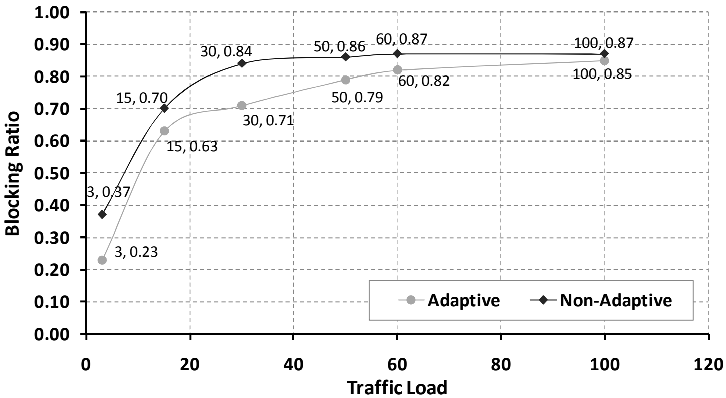

Fig. 7. Effect of traffic intensity on the blocking ratio

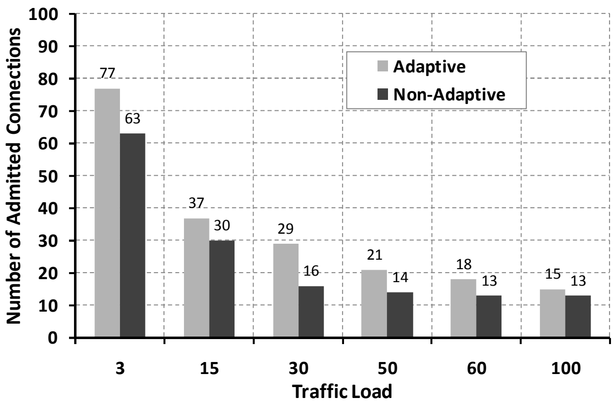

Fig. 8. Effect of traffic intensity on the number of admitted connections

6 Conclusion and Future Work

In this paper, an adaptive admission control algorithm has been presented for a UMTS compatible satellite system. The proposed algorithm allows the system to maximize the resource utilization by adapting to the variable link capacity of the system caused by the changing link condition of the users and the different antenna gains supported by the system. The algorithm is compared against a non-adaptive admission control algorithm under different test cases. The simulation results indicate a higher system performance in terms of the blocking ratio and the number of admitted connections. This work will be extended in the future to support the multicast traffic. It will involve defining an admission decision process for the multicast traffic and utilizing the adaptive admission control algorithm and the functional model defined in this paper to include the support of the multicast traffic and thereby testing the system under different test cases.

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