Hybrid Admission Control Architecture of Fault Tolerant Video on Demand Services over IP Network

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Abstract

This paper presents a research program in the design of admission controls for systems and networks which provide absolute guarantees of QoS and also optimize revenue or some other utility function for the operator, which is a key requirement for multimedia traffic. In this paper, we analyze the distributed architecture of a Video on Demand (VoD) system to design global request handling and admission control strategies. We describe a highly available distributed VoD service using IP network, which is inherently scalable and fault tolerant. We present the design and simulation results for a new hybrid admission control and QoS adaptation controller architecture for a set of media server farm.

1. Introduction

The growing availability of high-end broadband is making it possible to deliver high quality, broadcast grade video over IP. True real time VoD is considered by service providers to be one of the most lucrative value-added services, which can generate new revenue streams. The convenience of choosing and immediately viewing the desired video content out of large content repositories, without risking late-return fees, promises high attractiveness and acceptance by customers and resulting new revenues and competitiveness for service providers. In today's competitive world, high quality VoD services are quickly becoming natural, and soon mandatory elements of service packages over broadband ETTx networks.

There have been lots of interesting works in recent years on transmission of video streams and other multimedia information [1,2]. Akbar [3] presented centralized admission control architecture, which utilizes centralized computing performed by a broker. This architecture faces load-balancing problem with the increase of users. The problems of centralized admission control and prospects lead us to develop a distributed admission control and QoS adaptation scheme for multimedia servers and networks [5]. In this approach all controllers can receive request from clients and all controllers run collectively to maximize the revenue in the distributed system. This architecture suffers message-passing complexity for large number of customers. Bashar [6] proposed semi-distributed admission control architecture. In this approach, each Media Server Farm (MSF) is connected with a Local Controller (LC) and all the LCs are interconnected through a Central Controller (CC) for negotiation among them. But this approach does not provide fault tolerance.

The issue addressed in this paper is the development of fault tolerant admission control techniques, request handling strategies and QoS adaptation methodology in a Distributed Multimedia Server System (DMSS). To analyze the performance of a distributed VoD architecture, we present a simulation of admission controllers for a set of media server farms. The objective of the hybrid admission control architecture is to determine the efficient ways of using all resources in the VoD architecture within the constraints of providing guaranteed high quality services to each request.

2. Video on demand service

A Video on Demand (VoD) system consists of a video server with a video archive and a number of clients machines connected via a local area network. Figure 1 demonstrates a hybrid VoD architecture with admission controllers. The service from the servers to carry multimedia video streams for all customers is provided over a local distribution network, such as, ATM LAN, HFC, or xDSL

3. Distributed admission control architecture

To reject some of the applicant sessions when insufficient resources are available to serve all of them, some form of admission controller is mandatory. Maximization of revenue by admitting profitable sessions is an important objective of the admission controller.

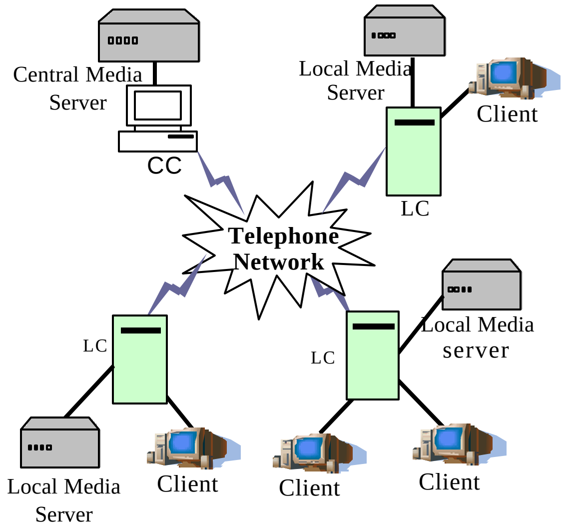

Fig.1: Hybrid Admission control architecture of VoD service

3.1. Proposed novel hybrid admission control architecture

The hybrid admission control architecture is the combination of centralized broker and fully distributed architecture. Service provider draws on the advantages of both architectures by using hybrid architecture. Some of the servers are located at the center and some at the edge according to specific requirements and optimal use of network resources. Users are connected directly with one of the LC. All the LCs are joined with CC which negotiates among the LCs shown in fig. 2. To make the architecture highly fault tolerant all the LCs are interconnected with each other so that if the CC fails then, the LC can communicate directly with other LCs.

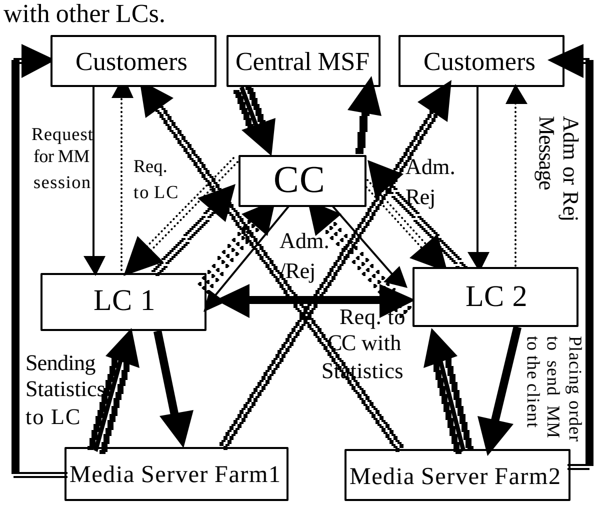

Fig.2: Message flow diagram of hybrid admission control architecture

Another way of employing the Hybrid topology is to allocate the central and distributed servers to different content types. The "Edge" servers can contain the most popular content and provide most of the streams, while the central servers contain the less popular content. Because the usage of such content is relatively low, they do not overload the network. The most popular videos are replicated and stored on different servers in the local MSF. A video replication algorithm that distributes the video collection between local and central servers based on video popularity. In some cases low usage content assets consists of several thousands of video archive hours, making the hybrid architecture the most cost-effective solution.

4. Admission control and QoS adaptation methodology

Users are required to communicate with (one of) the local admission controllers of the DMSS to submit their requests and to receive admission or rejection decisions made by the controllers. New sessions are collected into a batch over a time interval. A single batch of session sends to LC or CC's Admission Control algorithm. This algorithm accepts or rejects each session in the batch using QoS adaptation methodology. A session consists of user address, movie no, sender LC no., time stamp, etc. When the algorithm selects a session to be accepted or rejected, it starts checking whether this session's requested movie resides in this Media Server Farm's allocated servers, controlled by current LC. If satisfies, the algorithm tries to offer from highest QoS level to a lower one, for the session request according to the allocated servers resource statistics, which later maximizes the total earned revenue.

4.1. Failure handling

The main objective of the hybrid admission control architecture is to make the VoD system fault tolerant. If the communication bandwidth decreases due to the failure of any communication link or a server goes down, then QoS adaptation is done as soon as the fault is detected. It is done in three steps:

Step 1: All the admitted sessions are transferred to the lowest QoS level. If the algorithm supports lowest QoS to all the admitted sessions then adaptation is complete. Otherwise execute step 2.

Step 2: All the admitted sessions are transferred to the null QoS level. Now algorithm will admit some sessions and some may be rejected. If any session is rejected then execute step 3.

Step 3: All the sessions admitted in step 2 are transferred to the lowest level of QoS. Now some resource will be released and algorithm is applied to the rejected sessions from step 2. This will allow some sessions to be admitted and the rest will be rejected. These rejected sessions will not be considered further.

5. Simulation setup

The primary objective of simulation is to analyze the end-to-end performance of different admission control architecture of VoD system using Greedy approach. The table 1 presents the simulation parameters of the set of Media Server Farms. The overall average request arrival rate at the VoD system is λ, determined from the equation, $N = \frac{l(1+L_{avg})}{mL_{avg}}$, where 1/μ = MOVIE_LENGTH/2, L_{avg} = Number of users waiting in the queue and N is the allowable number of users enjoying the lowest QoS from a server at full load. The inter-failure arrival of a server follows exponential random distribution, with mean ($1/T_{fail}$). We assume that server will go operation after repairing it in SERVER_REPAIR_TIME.

Table1: Different simulation parameters

Parameter	Meaning	Value(s) for the experiment
MOVIE_ LENGTH	Maximum length of movie.	3 hours
NO_OF_ MOVIE	Number of movies	10
M	Number of video servers	5, 10, 15, 20, 25, 30, 35,40, 45, 50
NO_OF_ REP	Number of replications	3, 3, 3, 4, 5, 6, 7, 8, 9, 10
COPIES_ PER_SRV	Number of movie copies per server	6, 3, 2, 2, 2, 2, 2, 2, 2, 2
NO_OF_ DATA_SE TS	Repetitions of the simulation experiment	5
T_{fail}	Average interval between two server failure	20000 sec
CPU	CPU cycles required to support lowest QoS	0.25%
BW	BW required to support lowest QoS	1.5 Mbps
RAM	Memory required to support lowest QoS	0.3Mbps
L_{avg}	Users waiting in the queue	5%

6. Simulation results and discussion

Fig.3 shows prominent acceptation time difference among semi–distributed, hybrid, fully distributed and broker control architecture. Our new hybrid admission control architecture requires much less time than semi-distributed. This is because in the semi-distributed architecture all the temporally rejected sessions are forwarded to CC for further admission by other LCs and therefore communication cost increases. Normally the time requirement for CC acceptation or rejection is four times higher than local acceptation in case of semi-distributed architecture. But in hybrid architecture not all the temporary rejected sessions are admissioned by other LC. Some sessions are accepted

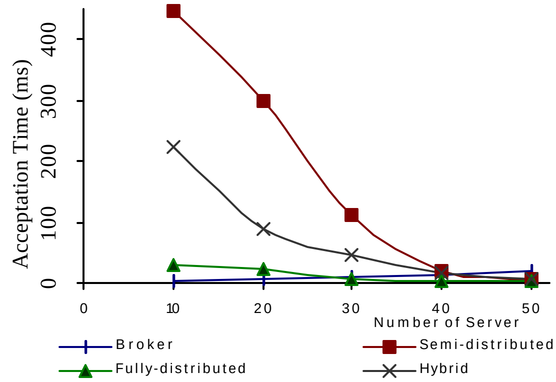

Fig.3: Average acceptation time for different number of servers

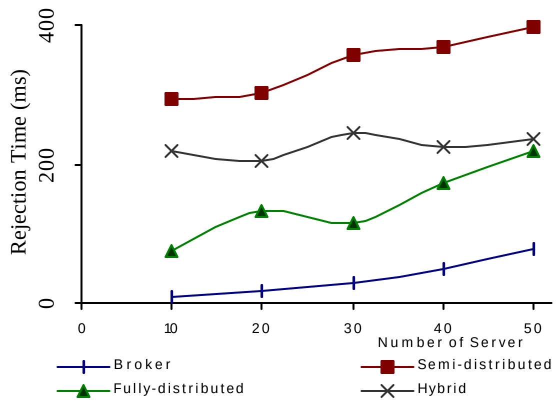

Fig.4: Average rejection time for different number of servers

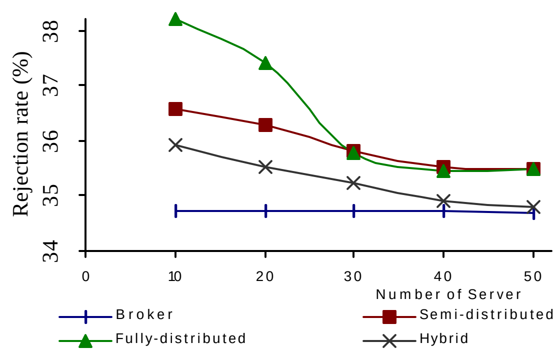

Fig.5: Rejection rate of different admission controllers for different number of servers

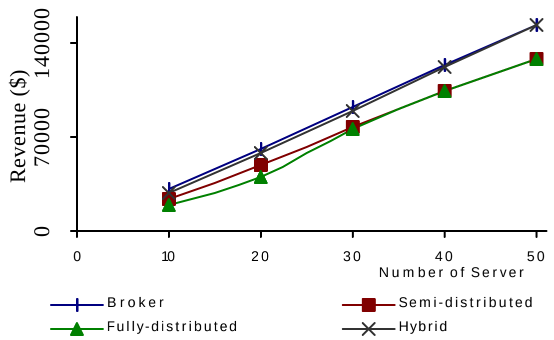

Fig.6: Revenue earned for different number of server

by CC itself and provide video stream from the central server and also the number of accepted session increased in hybrid architecture. Fig.3 also depicts that acceptation time increases as the number of server increases in broker architecture. On the other hand, in hybrid and semi-distributed architecture, the acceptation time decreases rapidly as the number of server increases. This phenomenon can be stated, as the number of the server increases, acceptation via CC reduces. For the same reason the hybrid architecture requires higher rejection time shown in fig.4 than broker and fully distributed architectures but less than semi-distributed. We also observe from fig.4 that as the number of server increases the rejection time varies slightly in hybrid and increases in all other control architecture. This feature makes the hybrid architecture more stable with the increased system load.

Due to the increased self-acceptation of CC, the rejection rate of hybrid architecture is less than semi-distributed and fully distributed and decreases as the number of server increases in fig.5. So for a large VoD system hybrid architecture is better and efficient. Hybrid architecture has same revenue earned as broker architecture represented in fig.6. This feature makes the hybrid architecture more attractive to the VoD service provider. In each architecture, earned revenue increases as the number of server increases, because large number of server has greater amount of resources. So, from the above observations and discussion we can conclude that for the large system with increased load the hybrid architecture is definitely better as it is highly fault tolerant with more revenue return than all other admission control architectures.

7. Conclusion

We have presented a new hybrid model for admission control and QoS adaptation architecture which addresses the issues of optimal admission of user requested sessions, server failures and scalability. These are the key features of video on demand service. The complete hybrid admission control is necessary as the load and hence the computational time requirement increases with the increase of number of users and number of servers. The hybrid admission control and QoS adaptation gives more fault tolerance, as the system can run even if one of the LC or CC fails. This model gives optimal strategy of admission control for selecting servers and QoS level for a set of multimedia session request. This architecture offers a giant leap for satellite video service providers, enabling true VoD by using IP as the edge of the satellite broadcast infrastructure and earned significant amount revenue by providing VoD service.

8. References

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