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Performance Studies of Multimedia-Based Networks

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ABSTRACT

Multimedia applications are fundamentally different from other non-multimedia applications due to their real time delivery and large volume of data storage requirements. The multimedia applications like Video-on- Demand demonstrate the diverse characteristics and express the requirements of designing common platform for supporting such applications. With the emerging trend of multimedia-based services over the network, there is a need for investigations into its operations, performance and implementation aspects. The design of networks suitable for multimedia traffic requires the consideration of performance requirements, scalability of networks and cost effectiveness. The present research was devoted to study the design issues for the multimedia-based network architecture, and subsequently, propose schemes for performance evaluation of proposed architectures.

INSPEC Classification : B6250F; C0230; C3370Z

1) INTRODUCTION

Recent advances in computing and communication technologies coupled with storage technologies, enabled the provisioning of multimediabased services over the networks (S.H.Gray, 1990). The term multimedia refers to integrating diverse classes of media to represent information. The media is classified into four categories: i) text ii) audio iii) image and iv) video. Several multimedia -based services, which integrate two or more of such media, are video telephony (speech and video), multimedia mail (text, image and video), e- Commerce (text, image, audio and video), Web TV (text, audio and video) and Multimedia -On-Demand (text, image, audio and video) services like, Video-On- Demand (VoD) (S.H.Gray, 1990). Among these the Video-On-demand may become one of the technically and economically feasible potential services in near future (Hongliang, 2006).

Among different media types, text and images are generated and represented in digital form, while speech, audio and video however are generated as analog signals. Thus, to integrate all these media, it is necessary to convert the analog signals into digital form. The integrated digital stream can then be stored within a computer and transmitted over the network in a unified way (Fred, 2002). The digital text and images are in the form of a singleblock of digital information, but speech, audio and video signals, when digitized,

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producelarge volume of information. Multimedia network systems are fundamentally different from conventional data networks systems because of i) a larger storage space requirement of audio and video data and ii) real time transmission of such data for their continuous storage, retrieval and playback (Dan, 1998). For this reason, most of the multimedia applications need to reduce the volume of information using some algorithm, and should have arich resourceful communication network.

One of the challenging aspects of designing network architecture is to provide required quality of service (QoS) for multimedia applications. QoS for a multimedia service can be defined by several parameters such as, I/O bandwidth, memory requirements, jitter and transmission delay, and are critical issues in designing the system architecture (E.W.M Wang,2001, Jack Y.B, 2002, Mourad,1995). The envisaged system should guarantee the real time constraints for continuous delivery of video streams D.P.Anderson, 1996).

The design of multimed ia-based networks requires understanding of the different characteristics of multimedia services (S.H. Chen, 1998). These include following features:

i) Multimedia traffic generation,
ii) File related characteristics,
iii) User interactions, and
iv) Performance Requirements.

The feature of multimedia traffic generation has three attributes: i) the request arrival process, ii) number of requests in each arrival and iii) total time required for either viewing video or interacting with data. The file related characteristic features of multimedia applications include streaming bandwidth, size of the files, number of video movies and their popularity. The attribute, user interactions, considers the issues related to modifiability of video files, types, frequency and locality of interactions. The performance requirement feature vary from application to application and are like, start-up-delay, user interactions, streaming capacity, low loss of user requests (blocking probability) and utilization of resources etc. The focus of the research is to study the performance issues for the multimedia-based networks such as VoD systems, and consequently propose an effective video server design.

1) MODEL ANALYSIS

The design of distributed VoD systems to provide multimedia service put forward some challenges. These challenges could be in terms of having scalable storage and streaming capacities. This can be achieved by means of deploying a hierarchical storage system, and by applying request batching and multicasting techniques. Video servers based on hierarchical storage systems provide a cost effective solution for achieving storage scalability in video servers. The objectives of this research are:

1. Design cost effective and scalable VoD systems, which meets the application performance requirements. Such requirements include low call blocking probability, utilization of network resources, low start up delay, maximizing the number of users served per stream channel, having an estimate for the time after which the system should yield profit and the cost incurred so far etc.

2. Develop suitable models for analyzing and validating the proposed designs for performance related issues.

3. Analyze the effect of user's reneging behavior in VoD environment, by developing a model for different request patterns. A simulation system will be developed to validate the proposed model for QoS issues .

With the increase in the complexity of such systems, it is necessary to develop suitable analytical and simulation models that will facilitate the design process. These models will approximate the behavior of the systems, incorporating the system performance parameters. In this research, the developments of Continuous Time Markov Chain (CTMC) models and simulation system were proposed to investigate the behavior of multimedia -based network system considering multiple video categories, user reneging and multi-class workloads.

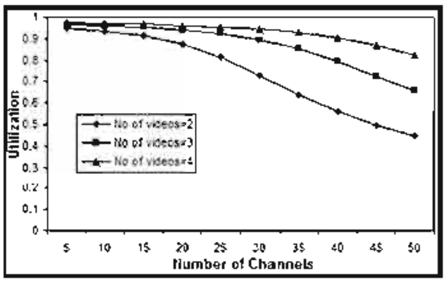
In multimedia-based systems with multiple categories, request-batching scheme was employed to use the system resources more efficiently. In this scheme all the user requests for a video arriving within short time interval are batched together and a single channel is allocated, thus saving on network resources.

While batching scheme uses the network resources efficiently, it leads into increase in the time of service (waiting time). The requesting users will leave the system if time of service is too long. It is a challenge for system designers to maintain waiting time within the user's reneging tolerance for the system with limited server and network resources. Therefore the proposed batching scheme was studied in view of different user's reneging behaviors and gives out the optimum-batching interval. These models provide designers with quantitative measures of the multimedia based network (VoD) system performance, in terms of its input parameters.

2) RESULTS AND DISCUSSIONS

The model developments were based upon the operation assumptions that characterize the VoD system behavior as a stochastic process. The models describe the behavior of each access node by means of CTMC. The model's complexity and state space increased significantly with multiple video categories and multi class workloads. But the models solution remained tractable. The results produced by models were close to the simulation results. Some of the important results are given as:

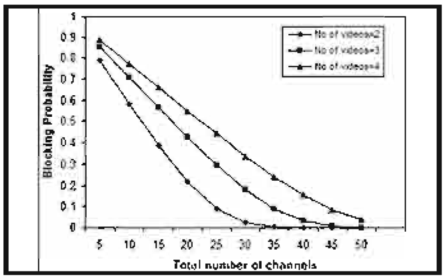
Fig. 1
Utilization against Number Of channels for batching time W = 10 min., service time = 120 min., request rate = 2 req./min & video category = 2 – 4.



The plot for channel utilization is shown in Fig..1. The parameter channel utilization decreases rapidly for small number of video categories. Similarly, for a video category it remains stable at lower values of number of channels and decreases as the number of channels increase. This plot can be used to find the optimum value for number of channels for different video categories. The curve also indicates that the system should accommodate more number of video categories for better utilization of resources.

The parameter blocking probability decreases with increase in number of channels. The plots shown in Fig 1 and Fig 2 can be used to find the optimum value of number of channels for acceptable channel utilization and blocking probability values.

Fig. 2
Blocking Probability against Number of channels for batching time W = 10 min., service time = 120 min. and request rate = 2 req./min



In order to run the system in profit, it is necessary that total earning (yield) must be more than investment. The investment includes cost of establishing the infrastructure which is defined as per channel cost. The channel running and maintenance cost which is dependent upon number of channels used. Obviously for some time the yield will be always less than the investments. Thus for the given design parameter values, it is required to know that after how much time, the system will start giving profit. This point of time is called the break even point.

Fig. 3
Cost at break even point against Number of channels for batching time W = 10 min., service time = 120 min. and request rate = 2 req./min

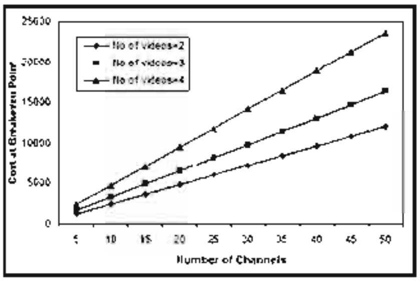


Fig.3 and Fig.4 present the variation in cost incurred and time required in achieving the breakeven point with number of channels. Both performance measures increase as the number of channels increase. These plots indicate that the system having larger number of videos will require more time in achieving the breakeven point. Applying other methods should do the reduction in cost and duration.

Fig. 4
Duration of breakeven point against Number of channels for batching time W = 10 min., service time = 120 min. and request rate =2 req./min

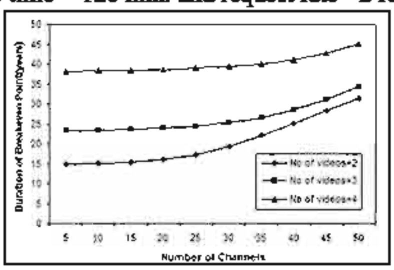
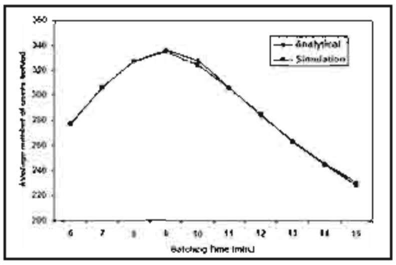


Fig.5
present the analytical and simulation results for the variation in average number of users served with batching time. The simulation was carried out for 10000 rounds. The simulation results compare the predicted value of average number of users served by analytical method and confirmed the accuracy within 1-2%.

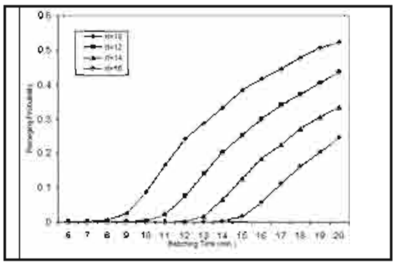
Fig. 5
Analytical and simulation results for Average number of users served against batching time for Number of channels N = 30 service time = 120 min., request rate = 2 req./min, & reneging time (rt) = 10 min.



At times it is also important to know the fraction of users not served. The parameter reneging probability gives the measure for fraction of users not served in one batch due to reneging.

Fig.6 presents the variation in parameter reneging probability against batching time. The curve shows threshold effect on reneging probability. When batching time is below the threshold value, the reneging probability remains close to zero. For batching time greater than threshold value, the reneging probability increases rapidly. This is because as batching time reaches closer to reneging time, more number of users renege there by increase in fraction of users not served.

Fig. 6
Reneging probability against batching time for Number of channels N = 30, service time = 120 min., request rate = 2 req./min, s = 1 and reneging time (rt) = 10-18 min.



The main contributions of the study carried are given as follows:

1. Different system architecture cases for hierarchical multimedia based networks involving multiple video categories, request batching, user reneging were studied by developing suitable CTMC models and simulation system. The results obtained from these models produced within acceptable ranges. The models resulted in several performance parameters including blocking probability, average number of users served, channel utilization, reneging probability. Generalizing Erlang B loss formula to handle video requests of different characteristics in VoD systems developed the multidimensional CTMC. In practical situations the multiple class of applications share the network resources. The models were evaluated for various system design parameters like, number of channels, request rate,

batching time and service time.

2. The investigations of VoD system with multiple video categories and incorporating request batching has led to a conclusion that it is not advantageous to increase the network channels beyond a certain number as there will not be any improvement in the system performance and will lead in increasing the cost. The results show the tradeoff between blocking probability and channel utilization. The results are also obtained for economics related parameters like, the time to achieve the breakeven point and the cost incurred so far.

3. The request batching scheme uses the network resources efficiently, it increases the time of service thereby increasing the user reneging. Using the model results, the design choices on proper selection of batching time and number of network channels can be successfully facilitated.

4) CONCLUSION

The investigations for different system architecture cases for hierarchical multimedia based networks involving multiple video categories, request batching, user reneging were made to benefit the planning of capacity of network resources like, network channels for optimized performance.

The current explosive growth of the World Wide Web still does not do full justice to the potential of the Internet; It is inevitable that Internet will support distributed application and services of greater complexity. Future, multimedia services will be beneficial to the alliance of different enterprises: content and service providers, entertainment houses, and educational and medical services. It is expected that this research will help multimedia-based system designers to adopt new schemes for better services.

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