Load Balancing with Network Information for Multimedia Service

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Abstract

The number of users and applications of the Internet is increasing and network traffic is increased in proportion to that enormously. Application and services, which are provided from a relatively long distance away, running on wide area network are not independent of the current network state. As a multimedia service is provided to a lot of users over the Internet, network status is one of factors to be considered in providing high quality of multimedia service. In this paper, one of methods to get network information is discussed and it is applied to a multimedia service.

1. Introduction

As the Internet has been used widely, multimedia services over the Internet gain more popularity than before. One of the important requirements for a multimedia server is *scalability*. A straightforward approach to enhance scalability is to have a number of replicated servers in proportion to the number of clients, where replication of multimedia contents can be determined statically or dynamically.

Several multimedia service systems support *dynamic replication mechanism*, which replicates a desired content to a nearby server according to users' location [1][2]. In those systems, a user's request is directed to a chosen server after replication. *Akamai service system* [2] and the *Berkeley Video on Demand (VOD) system* [1] fall in this category. However, their inherent advantage can be overshadowed by the overhead due to dynamic replication when they are used for real time service.

Scalable Access Platform (SAP) [3] for multimedia on demand supports scalability through a dynamic load distribution and a static replication of multimedia objects. Server utilization is improved by dynamically assigning the least loaded server for each user request. However, the selection process does not consider the network capacity and access requirements in terms of bandwidth and assumes that there are no delivery bandwidth constraints on the communication network, *e.g.*, between client hosts and media servers.

However, defining an adequate criteria for choosing servers is more important than finding an appropriate server. The loads to multiple servers must be balanced not only for improving resource efficiency but also for improving quality of service to clients. As network traffic increases enormously, service quality is largely dependent on network status especially when the services are provided from a relatively long distance away, running on wide area network (WAN). If the future network status could be identified, better services will be provided by selecting a server along which the network is lowly congested.

This paper first presents an enhanced version of distributed multimedia server system, called *Hierarchical Access Multimedia System (HAMS)*. *OPNET Modeler* [4] is used to show how the quality of service is varied with network load in addition to system load and to model and evaluate the proposed HAMS system.

Organization of this paper is as follows. Section 2 shows the related work on multimedia service systems. Section 3 discusses on network measurement and network information which can be used as network load information. In Section 4, our proposed scheme for distributed multimedia server, HAMS, is presented with the corresponding service procedures. Simulation model using OPNET Modeler [4] is explained in Section 5, which also provides the performance evaluation comparing with SAP model. Concluding remarks are drawn in Section 6.

2. Related Work

One of important characteristics for media server is *scalability*, which depends upon user demand, data size and data placement techniques. Data distribution techniques such as *striping* and *replication* is discussed in [5][6][7]. *Redundant array of inexpensive disks (RAID)* technology makes it possible to achieve high bandwidth requirement for multimedia service because multimedia data can be striped across a number of disks [6][7].

Data striping has an advantage of well-balanced load by decoupling an object's storage from its bandwidth requirement, but *wide striping* requires communication and synchronization between nodes over which data is striped. Data replication is a good approach to reliability at the cost of extra storage capacity [5][6][7]. Trade-off between the degree of data striping and replication is sought in [5], where dynamic replication is used in conjunction with striping for scalable distributed continuous media server.

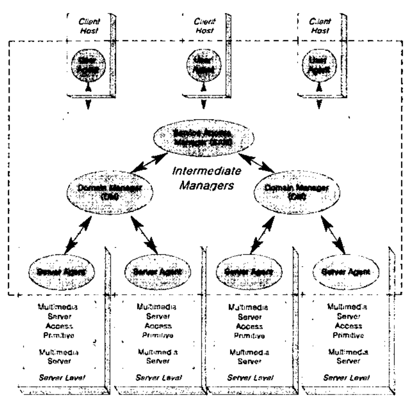

Figure 1. SAP System Architecture [3]

Scalable Access Platform (SAP) [3] for multimedia servers is a generic platform for scalable access to multimedia-on-demand systems. Scalable access to multimedia objects through dynamic load distribution reduces service reject probability and improves resources utilization by balancing loads among servers. A user's request is rejected only if none of the servers in the system can satisfy the request. The criteria to select the least loaded multimedia server is a function of users' QoS requirement, the user's host capabilities to display the requested multimedia object, and the current workload of the multimedia servers.

Figure 1 shows the architecture of SAP multimedia service system. There are two basic components - the *user agent* at the client host and the *server agent* at the server. The user agent acts as the user access interface; it controls user access to the requested multimedia objects and checks if the required QoS parameters are satisfied. The server agent interfaces with the multimedia objects' storage server. It manages access requests to the multimedia objects supported by the server and maintains the server load information.

Additionally, there are a number of management components as intermediates between user agents and server agents such as *service access manager (SAM)* and *domain manager (DM)*. So as to reduce the overhead incurred by the load distribution, the concept of *management domain* is introduced to which multimedia servers belong. A DM takes role of managing access to the multimedia servers it aggregates. SAM is responsible for a set of domains grouped by a certain policy. It collects both functional and management information on the domains and manages user accesses to multimedia servers by directing user requests to the adequate domains based on load information and QoS requirements.

3. Network Information

Internet is a best-effort network without any support for reservation or performance guarantees. It is so dynamic and large that it is very difficult to analyze the performance and status of the Internet [8][9][10]. Instant status information of the Internet can be easily obtained using several utilities while prediction for guaranteeing future availability of the Internet can not easily be obtained.

However, *network information* such as bandwidth availability and network traffic is needed to provide time-critical multimedia service in wide area network. As opposed in local area network, in wide-area Internet, the factors to select a server must include network status information as well as server load information to provide better service. In order to do that, *distance* [11] between servers and *round-trip-time (RTT)* can be measured. [10] measures the delay and hop-count between hosts using probing utilities such as *ping* and *traceroute*. The delay in the Internet depends upon factors such as physical distance, distance to the backbone, and traffic conditions. Especially, [10] emphasizes the geographic distance as one of the factors and the similar delay distribution between hosts within the same continent. Using network utilities, such as *ping*, periodically actual information can be obtained [10].

The network information, which is used in this paper, is the average of round-trip time (RTT) of probing packets between clients and servers.

4. Proposed Scheme

The architecture for a multimedia server, Hierarchical Access Multimedia System (HAMS), is based on SAP [3]. The approach to utilize and manage network information is added to it. Figure 2 shows the architecture of HAMS.

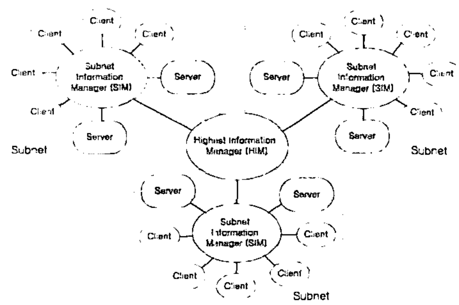

Figure 2. HAMS Architecture

Network information is utilized to choose a server among multiple replicated servers. Subnet is, in this paper, logical concept grouping a set of multimedia servers and clients according to geographical region in distributed environment. Each subnet consists of clients, multimedia servers, and a *subnet information manager (SIM)*. Every service request is sent to the SIM first and the SIM redirects the service request to a appropriate server or sends it out to *highest information manager (HIM)*. HIM not only maintains subnet load information and network information for each subnet but also redirects a service request from a client to a subnet which has least network information value between the subnet of the client and can accommodate the request. If a server is selected, it starts delivering the corresponding multimedia objects. During the service, the client measures RTT periodically between itself and the server. The measured RTT is sent to the SIM of the client. When the current multimedia service is completed, the average of measured RTT is sent to HIM as a inter-subnet network information. It is based on spatial stability [8] that nearby hosts show similar end-to-end throughput. The SIM updates the network load status based on the information received from the client. The SIM also sends subnet load information, which is the value of all servers' workload in a subnet, to HIM whenever it is changed.

5. Performance Evaluation

Figure 3 shows the overall network model designed by OPNET Modeler [4] for performance evaluation. It has 56 logical subnets denoted by heavily dark shaded octagon, 506 clients and 168 servers. In order to load traffic on network, every subnet has a dummy packet generator.

Eight subnets are aggregated into a logical subnet group connected with a router labeled with *'intsbn_router* Router No'. Each subnet group is connected to routers, *'L_Router'* or *'R_Router'*. All of network links being seen in Figure 3 among network components, such as subnets, routers, etc, have the same bandwidth as 155 Mbps. HIM is also connected to *R_Router* directly in Figure 3.

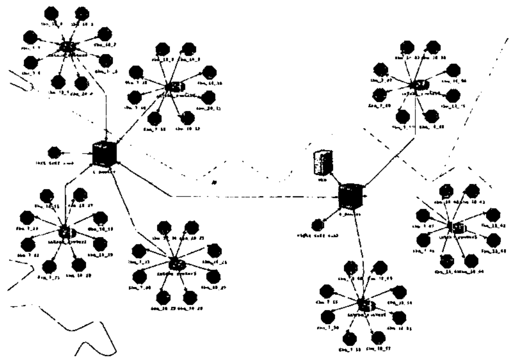

Figure 3. Network Model for Simulation

A server receives a service request and delivers a series of packets as a stream service if the load is not beyond its capacity. Whenever the load status of a server is changed, the server sends server load information to its SIM. In this simulation environment, a client requests a service periodically if any service is not provided and a server sends a packet every 0.5 second as a video stream.

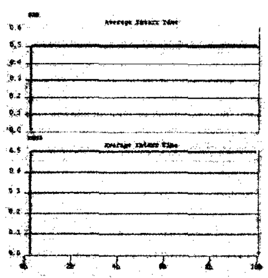

Figure 4. Average Packet Inter arrival Time

In Figure 4, simulation result shows that average inter-arrival time of packets at client side is longer than that of HAMS from around 8 hour in x axis.

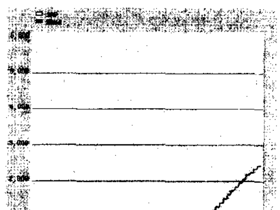

Figure 5. Late Packet Count

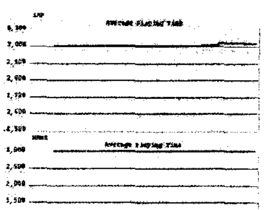

Figure 6. Average Playing Time

Figure 5 shows the comparison of count of packets which inter-arrival time is greater than 0.8 second. Before around 7 hour, the count of late packets is almost the same. However, after that, since the requests can not be accommodated in the same subnet, they are redirected to the servers in other subnet by HIM. In case of SAP, since service packets count over R_Router and L_Router is larger than that of HAMS, the slope is steeper than that of HAMS. When considering the number of clients, each client receive about 10 late stream packets in SAP and about 5 stream packets in HAMS until 10 hour respectively.

Intended playing time is 3000 seconds initially. Playing time is measured between first packet and last packet of stream at clients. Figure 6 shows the average playing time under two schemes. In case of SAP, from around 7 hour, average playing time is little longer than intended playing time, 3000 seconds. It shows that late packets affect playing time. At a client side, a service user under HAMS scheme can notice stable quality of service such as short-paused or freezed scenes.

6. Conclusion

We apply the average of RTT as a network information to the multimedia system, SAP[3]. The network information is obtained through sending probing packet during a multimedia service. Multimedia data moving over the Internet depend on recent network status. In case of multimedia service over network, network status is one of main factors under wide area network. In this paper, round trip time is used to obtain network information and a heuristic method to maintain measured network information is proposed. Through proposed approach, multimedia objects can be delivered to service clients with higher quality.

7. Reference

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