ABSTRACT

The goal of this paper is to summarize the currently used selection criteria for sources of multimedia traffic and to propose a new quality of service based criterion. During the last few years, a number of approaches have been established to distribute multiple servers over the network having all of them containing the same replicated content. This work was primarily pushed by distributed web services and by new peer-to-peer protocols. Unfortunately, all these approaches only apply to typical data transfers. In the case of multimedia streaming, the most important factor is the currently available transmission quality from the server towards to the client. Therefore, this quality criterion was chosen for a more intense study. All together we were able to propose a quality of service based selection process and to create a measurement environment to test the approach. The results of this research work are summarized in this paper.

Keywords: Server Selection, Selection Criteria, Distributed Systems, Quality of Service, IP Performance Measurements

1. INTRODUCTION

The utilization of the internet shows a growing demand for high-availability installations of multimedia servers. Especially in the areas of tele-learning and tele-medicine, the requirements on the availability of the video-on-demand services are very high. Additionally, more and more multimedia servers for home entertainment applications are being deployed. Typically, the demand for such a high availability is satisfied using replication techniques. The concept of employing more than a single server for a particular service allows one to increase the availability as well as to share the resources among a large number of clients.

It was shown by Dressler [9] that the availability is only a single pre-requisite. The available quality of service in the network is a major parameter for the successful transmission of multimedia traffic. In general, the network should be designed to solve this problem for the application by reserving resources or even by guaranteeing some minimum service quality [18]. Unfortunately, only a few parts of the internet are able to help the application in this way. Additionally, bottlenecks in the available resources are possible along the path from a server towards to the client. Therefore, the distribution of the servers with replicated content over the internet leads to the question how the client should select a particular server for a requested transmission. The problem is described in Fig 1. A client has to choose between numbers of available servers containing the requested content.

![Fig 1. Problem Description](image)

A major goal of this paper is to provide an overview to this selection process. Additionally, some of the most interesting approaches are discussed and a new criterion is introduced which allows one to incorporate the currently available quality of service in the network between the server and the client. The proposed methodology can be employed for unicast as well as for multicast transmissions.

The rest of the paper is organized as follows: within section 2 the classical selection criteria are summarized and the related work is discussed. In this context, the most interesting approaches introduced in the last decade are studied. Section 3 as the main part of this work introduces a new selection scheme based on quality of service oriented parameters. The measurement methodology for the proposed approach is described in section 4 and some measurement results are shown in section 5. A conclusion including a short summary finishes the paper.

2. CLASSICAL CRITERIA AND RELATED WORK

Before any new approaches are considered for discussion, the classical criteria for the server selection have to be summarized. The typically used criteria to select a particular server out of a pool of available servers containing the same replicated content are based on the...
techniques known from peer-to-peer networks [14, 15]. As an aside, the most recent methods came from the peer-to-peer research area as well.

**Classical Selection Criteria**

The typical process to select a particular source out of several available servers containing the same replicated content is divided into two steps:

1. preparation of a list of potential sources for the particular service;
2. test of the availability of each server.

The first step, the creation of a list of potential sources can be accomplished in various ways. Typically, a centralized approach is preferred. This scenario is shown in Fig 2. The client queries a well-known selection server, which provides such a list. This server may be used for load-balancing reasons as well since it might modify its answers based on the address and the properties of the client. Such an enhanced intelligence should be disabled if algorithms that are more sophisticated are used to process the received list at the client, e.g. if the proposed approach is being used. Other methods involve mechanisms like DNS round-robin or multicasting and anycasting techniques. Finally, statically prepared lists can be used, admittedly, such configurations tend to be inefficient.

![Figure 2. Selection Process](image)

Secondly, the received list is reviewed in order to find an appropriate server. In the simplest case, each server in the list is tried until a proper service can be established, i.e. the client connects to the first server on the list and, if it does not get the requested service, it goes further on testing the next server and so on and so forth. This procedure is repeated until an available server is found or the algorithm terminates with a failure.

**Related Work**

During the last few years, a number of approaches have been proposed which deal with the mentioned selection process. Typically, these works are based on the research on replication techniques for web services. Nevertheless, the concepts can be directly adapted to multimedia content.

Beside the classical selection criteria such as the availability, research papers from Zegura et al. [19] and Fei et al. [10] propose the measured round-trip time as a major criterion for the selection process. Guo et al. [12] summarize some selection algorithms such as the closest-server-first which is based on the number of network hops as the primary selection criterion. This method is also used by Guyton and Schwartz [13]. A more sophisticated approach is discussed by Carter and Crovella [4]. They introduce the measurement of the bandwidth and the network congestion for the selection of an optimum server. This approach is the most future-oriented one. Unfortunately, it is restricted to the selection between web servers. Carter and Crovella use an ICMP based measurement and discuss some heuristics for TCP (transmission control protocol) based network traffic [11]. This approach cannot be directly applied to UDP (user datagram protocol) based multimedia traffic.

### 3. Server Selection Based on the Available Service Quality

The limitations of the existing solutions are their restrictions to only a single - maybe a few - selection criterion. The quality of an active multimedia transmission depends much more on criteria such as the current packet loss ratio or the variation of the delay or “jitter”. Additionally, the application of IP multicast is increasing for multimedia distributions. Therefore, the selection process has to consider the special characteristics of IP multicast as well [1, 17].

The here proposed methodology goes a little further. The available quality of service (QoS) in the network [6] from the server towards the client is the main criterion for the selection. In fact, the selection process is divided into three steps by adding a further step to the classic approach:

1. preparation of a list of potential sources for the particular service;
2. test of the availability of each server;
3. measurement of the available transmission quality.

Thus, this approach can be directly applied on top of any existing scheme. Following the first two steps described in section 2 the currently available transmission quality between the potential server and the client is measured using the concept described in the following.

As already said, the proposed concept for the selection process is based on quality of service measurements in the network. The question, which has to be solved is, which server can transmit the multimedia content while complying with some minimum QoS requirements for the particular service. For example, a video transmission of a high quality MPEG2 encoded lecture becomes useless if the packet loss ratio between the server and the client is higher than about 5%. Other QoS parameters as important as the packet loss ratio are the delay and the jitter. Therefore, each service has to describe some minima for the different quality of service parameters in order to
allow one to apply these minimum requirements or "service demands" to the measurement results. Beside the description of the QoS minima, these minima have to be compared with the real behavior in the network at a particular point of time, the time of the occurring transmission. The available quality of service between each candidate server and the client must be tested. Nevertheless, we avoided either to define any order of this test or even to make it parallel or serialized. Of course, it must be considered that a parallel measurement might include interferences between each single test due to limited resources in the network or at the client. In the following, without loss of generality, we assume an ordered list of available servers as the result of the first two steps in the selection process.

Out of scope of this document is the final selection algorithm. Since several servers might meet the QoS requirements and one has to be chosen out of these. Another situation appears if there are available servers but none fulfills the quality demands of the application. Then, a decision has to be taken if the transmission should be rejected. Several candidate algorithms do meet the requirements of the clients but may lead to a different behavior of the entire complex system. Simulation techniques and practical tests are employed to solve this question. The results will be presented in a following publication.

4. MEASUREMENT METHODOLOGY

Until now, the selection criteria were discussed. The precise measurement methodology is presented in the following. The design goals for such a measurement environment can be summarized as follows:

- the impact on both, the network and the server, has to be minimal;
- it must be robust and perform properly under varying conditions;
- the measured quality of service parameters must meet the pre-requirements;
- the measurement must be scalable to a large number of concurrently working clients;
- an unlimited number of distributed servers must be supported.

Dressler [7, 8] proposed a framework for quality of service measurements in an IP multicast environment which was named multicast quality monitor (MQM). The primary concept of this framework was its service dependency. Such a behavior is just the required one for the examined application scenario where a number of distributed servers provide different service types. The MQM allows one to measure various QoS parameters depending on the actual demands of a particular service. For example, the reachability as a very simple metric can be estimated. Additionally, quality of service parameters such as the one-way delay [2] and the round-trip time can be measured. A new multicast ping mechanism was introduced to solve this task. Due to the working principle of IP multicast, a single request packet allows one to check the availability of the complete multicast network in addition to possible measurements of the delay (one-way delay and round-trip time). Furthermore, RTP (real-time transport protocol, [16]) streams can be initiated in order to measure the packet loss ratio [3] and the jitter [5]. In such a RTP based QoS measurement, a server is sending a packet stream.
encapsulated in RTP to a destination multicast group. Each participant of this group can use the received data in order to calculate the currently available transmission quality from the server to the particular client. Scalability issues on this model have been discussed elsewhere [8] or are currently work in progress (to be published), respectively.

It is obvious that the connection between the two hosts in Erlangen shows a much lower delay and a much lower delay variation. Nevertheless, the maximum delay during the measurement was about 160 ms with a mean value of 12 ms. Therefore, assuming a required maximum delay of 200ms, both servers might be selected for the requested service. Other quality of service parameters can be used for the further selection process or selection algorithms such as FCFS (first-come, first-served) or an administratively allocated priorities can handle the decision process.

A second test was performed using a RTP encoded packet stream, which was multicasted from Erlangen to a number of other universities. This test can be seen as if clients at all these involved universities demand some service from a server located in Erlangen. The packet stream was a continuously flow of packets with a bandwidth of about 1 Mbps. Fig 7 shows the results of this example. The received RTP packets were analyzed using the in the RTP header integrated sequence numbers to determine the packet loss ratio. The results are shown in a logarithmically scaled graph. It can be seen that the perceived packet loss ratio is quite good for the transmission from Erlangen to another host in Erlangen as well as to hosts in Munich and Eichstaett. On the other hand, the packet loss ratio towards Regensburg and Bayreuth, achieving an average of about 4% is relatively high. Depending on the quality demands of the particular service, these connections might be marked as unusable due to the high loss ratio. For example, a H.261 encoded video can still achieve a feasible quality whereas a voice over IP connection typically is considered inoperative in this case.

The multicast quality monitor can be used in an unicast scenario as well since that is, in the context of the MQM, only a simplification of the multicast case. For the server selection process, the multicast quality monitor was slightly modified in order to allow its application for the measurement of quality of service parameters as for the proposed selection criteria. In our case, the quality monitor consists of two parts: a daemon process on the multimedia server and a selection task on the client (see also Fig 4). The robustness and the scalability of the approach have been verified using simulation techniques and a prototypical implementation. Results of some sample measurements are provided in the following section.

### 5. MEASUREMENT EXAMPLES

In the context of the development of the multicast quality monitor, several measurements were executed [8]. The first example is a delay measurement using the multicast ping mechanism. A host in Erlangen tested the connectivity and the delay from itself to another host in Erlangen and a host in Regensburg. The results of this test are shown in Fig 6.

Other sample measurements have been executed (data not shown), mainly to test the proposed approach for its functionality and robustness. It was shown that a much more appropriate server selection can be achieved using the quality of service based approach than by only using the classical criteria.

### 6. CONCLUSIONS

Summarizing it can be said that the selection process based on the new quality of service based criterion allows a more intelligent and more purposeful selection of an
optimum source for the requested multimedia content. In the case of web servers or clients in a peer-to-peer network, the load of the server and the number of network hops may be good enough. Nevertheless, the QoS parameters such as the packet loss ratio play a large role in such a scenario as well, just because every TCP connection suffers from a high packet loss ratio in the network that leads to a dramatically reduced throughput. In the case of distributed multimedia servers, the usage of transmission quality oriented approaches is imperatively necessary.

REFERENCES


