# Multimedia Communication Over Distributed Systems

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## Abstract

*Distributed Multimedia Systems is an area of active commercialization and research. This technology is widely viewed as the next generation technology for computers and communication networks. This paper will discuss some features of the technology, protocols related to DMS, its architecture, synchronization and scalability. Also, we will see some of the current trends in this technology.*

## Introduction

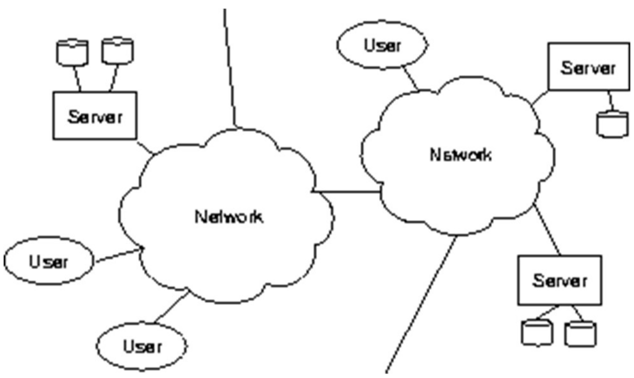
Research and development efforts in multimedia falls in two groups. One group concentrates on the stand-alone multimedia workstations and associated software and tools. The other combines multimedia with the distributed systems. The distributed multimedia system offers a **broader** spectrum of implementation possibilities in comparison to stand - alone systems. But in addition to the possibilities they all add a new dimension to the system complexity.

A distributed multimedia system combines a variety of multimedia information resources over a network into an application used by the client. In this manner the user can access different remote information sources and service. The system is based on the interaction between the user and the application. The user can control when to receive what data and also control the data flow. That means the multimedia system is neither control the programs they view nor schedule the viewing time of the programs to suit their preferences. The user in such systems is flooded with irrelevant information, without a possibility to choose only the information of the interest. This kind of distributed environment is capable of serving a large number of end users to concurrently access a large number of repositories of stored data and also with the option of manipulating the environment by making the broadcast interactive. The enormous communication bandwidth required, the Quality of Service (QOS) demanded a careful design of the system in order to maximize the number of concurrent users while minimizing the cost needed to obtain it.

The main component of a distributed multimedia system consists of major 3 components: Information (content) providers, a wide area network, and a multimedia client. There are many design issues in building each of the components. The breakthrough achieved in Digital Information Compression has helped to transmit the digital information in real time. In Section 2 we will discuss the architecture required of a Distributed multimedia system where we describe each of the system components. In Section 3 we will discuss about the Scalability issues obtained from such a multimedia system. In Section 4 we discuss some of the advances in the distributed multimedia systems and researches going on.

## 2. Architecture

Distributed multimedia system consists of three basic components: an Information server, a wide area network and a multimedia client on the user site.




### 2.1 User Terminal

A Multimedia terminal consists of a computer with a special hardware such as a microphone, high-resolution graphics display, stereo speakers, and a network interface. The user interacts with the system via a computer keyboard, mouse or a hand-held remote control. Many of the user terminals still resemble traditional computers. Because of this, additional development work is required before the terminals can meet the requirements of the multimedia data and the user.

### 2.2 Network and Communication

Multimedia communication differs from the traditional communication. The multimedia traffic requires transfer of large volumes of data at very high speeds, even when the data is compressed. Especially for interactive multimedia communication the network must provide low latency. Continuous media as video and audio require guarantees of minimum bandwidth and maximum end-to-end delay. The variation in delay referred to as jitter, and loss of data must also be bound.

Traditional networks are used to provide error- free transmission. However, most multimedia applications can tolerate some errors in transmission due to corruption or packet loss without retransmission or correction.

Some of the differences in the traditional and multimedia communication are given in the table below:

| Characteristics | Data Transfer | Multimedia Transfer |
|---|---|---|
| Data rate | Low | High |
| Traffic pattern | Burst | Stream oriented, highly burst |
| Reliability requirements | No loss | Some loss |
| Latency time requirements | None | Low (for example: 20ms) |
| Mode of communication | Point to Point | Multipoint |
| Temporal relationship | None | Synchronized transmission. |

The increasing popularity of the Internet and the fact that the infrastructure already exists suggest that the Internet could be used for distributed multimedia systems. The telephone and common antenna TV (CATV) cable networks are also a possibility to support interactive multimedia at user homes due to their wide deployment.

From the above discussion we have noted that the Traditional networks do not suit multimedia communication. Transmission characteristics of existing Ethernet and Internet Protocols (CSMA/CD, TCP/IP) do not support the low latency, high bandwidth requirements of the audio video-based applications.

Ethernet only provides a bandwidth of 10 Mbps. This is inadequate for most multimedia applications. Moreover, its access time is not bound, and its latency and jitter are unpredictable. New protocols which are considered for carrying multimedia data include the 100 Mbps Ethernet Standard, Distributed Queue dual bus (DQDB), Fiber Distributed Data Interface (FDDI) and Asynchronous Transfer mode (ATM). The first three have bandwidths of the order of 100 Mbps. ATM enables a bandwidth of 155 – 622 Mbps depending on the characteristics of the network.

FDDI in its synchronized mode has low access latency and low jitter. FDDI also guarantees a bounded access delay and a predictable average bandwidth for synchronous traffic. However, Due to its high cost FDDI is at the moment used primarily for the backbone networks.

Asynchronous Transfer Mode (ATM) is rapidly emerging as the future protocol for multimedia communication. ATM provides great flexibility in the bandwidth allocation by assigning fixed length packets called cells, to support virtual connections. ATM can also increase the bandwidth efficiency by buffering and statistically multiplexing burst traffic at the expense of cell delay and loss. For the Internet, the Internet Engineering Task Force (IETF) is working on a TCP/IP interface for ATM.

## 2.3 Multimedia Server

Current personal computers, workstations and servers are designed to handle traditional forms of data. Their performance is optimized for a scientific or transaction – oriented type of workload. These systems do not perform well for multimedia data, requiring fast data retrieval and guaranteed real time capabilities. The I/O capacity is usually a severe bottleneck.

### 2.3.1 Requirements for Multimedia Server are:

a) **Minimal Response time**: A crucial factor for the success of multimedia services is the response time seen by the client. The server must be able to minimize response time to live unto the expectations of the user.

b) **Fast Processing Capability:** To guarantee fast response time, clients should be processed fast and data access rates should be minimized.

c) **Reliability and availability:** Like any other server, multimedia server must be reliable. The larger the number of users and volume of data handled by the server, the more difficult is to guarantee reliability. To provide fault tolerance special hardware and software mechanisms must be employed. Since client requests may arrive at any time, the time the server is unavailable should be minimized.

d) **Ability to sustain guaranteed number of streams**: Another important factor is the maximum number of data streams the server can simultaneously handle. This affects the total number of clients the server can serve.

e) **Real-time delivery**: To be able to deliver multimedia data, the server should support real-time delivery. This poses profound requirements on the resource scheduling at the operating system level. The server should be able to guarantee real-time delivery for individual streams as well as for all the streams combined together. For this accurate real- time operating systems have to be developed.

f) **High storage capacity**: To be able to store multimedia data and a large variety of information the server must have a large storage capacity. To sustain the delivery requirements of multimedia data, the server may be required to compress and encode video and image data prior to transport or storage. The performance of compression and signal processing should be optimized. This might require special hardware.

g) **Quality of Service (Qos) requirements:** The Quality of Service (Qos) is a set of parameters describing the tolerable end-to-end delay, throughput, and the level of reliability in multimedia communication and presentation. Qos requirements of clients are an important factor that affects the usage of the server. The server should be able to provide and adapt itself to different QoS requirements, according to the characteristics of the client's terminal, the network connection and the requested data type.

h) **Exploit user access patterns**: The server should also be able to trap and exploit dynamic user behavior, minimizing system load and network traffic. For example, by analyzing data access rates and times, popular data could be distributed closer to users in periods of low network load.

i) **Ability to handle different types of traffic**: A multimedia server should be able to serve multiple real-time data streams simultaneously, but it must also be able to provide satisfactory service to non- real-time data. It should be able to handle control data encountered when loading new data from other servers or storage repositories, billing and accounting data and communication between intelligent personal agents. Agents are autonomous programs selecting and managing data according to user preferences.

j) **Cost effectiveness**: A very important requirement governing the future of multimedia servers is the cost effectiveness. The server must be affordable

### 2.3.2 Components of a multimedia Server

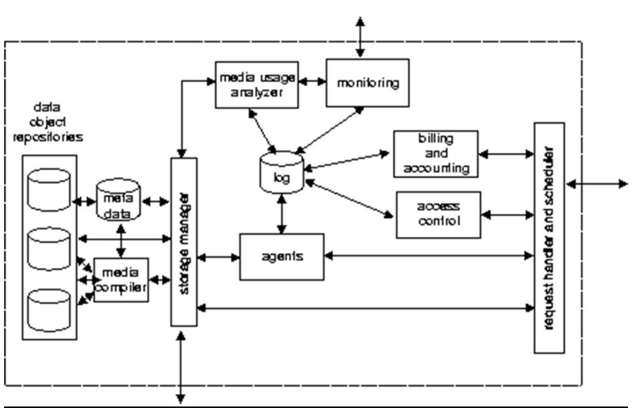



**Figure:** Possible components and their internal relationship in a multimedia server

To satisfy the stringent system requirements the server architecture is quite complex. The above figure presents possible components in a multimedia server and their internal relations. The internal structure of the server and needed components depends on the purpose of the server. The presented server architecture is based on consideration of interactive news system requires.

The scheduler and request handler take care of the I/O data flow of the server. It handles the requests and manages the data flow to and from the server.

To be able to restrict the access only to certain users or network domains, the server must include access control. The access control manages which requests are allowed. Since many planned systems will include commercial services a billing and accounting module must be present.

The server requires administration and supervision. For this all transactions are logged in a log repository and a monitoring tool is provided. Since there will be a huge amount of log data available, means for filtering out the interesting information must exist. This could be done by a media usage analyzer, which filters out the interesting log information and presents it in an understandable format.

To manage the large amount of data a storage manager is provided. The storage manager manages the data in the object repositories and the data flow. Information about the data, so called metadata, could be saved in a separate repository, facilitating the data management and retrieval. To make it possible to serve the data in different formats, the data could be saved in some specified format and then changed to the wanted format by a media compiler. The media usage analyzer could give feedback of usage patterns to the storage manager, helping to decide what information should be stored where.

To be able to manage the data effectively and to be able to offer personalized services, the system should also include agents. The agents would select what data to present to the user, according to user preferences and access patterns. In this manner each user would get a personalized service.

To decrease server load, the processing of requests could be distributed among multiple servers. Every server would be its own entity, but they could then be managed in a centralized or distributed manner. Such approaches need careful consideration and analysis, because of their complexity.

The design of a multimedia server needs thorough planning to meet the stringent requirements. Designing a high-performance multimedia server that can support multiple, simultaneous, full-motion video streams are still challenging. A great deal of work needs to be done in areas like real-time scheduling, parallel I/O, reliability, scalability, dynamic scheduling and caching techniques for multimedia data

## 2.4 Comparative Analysis of Protocols

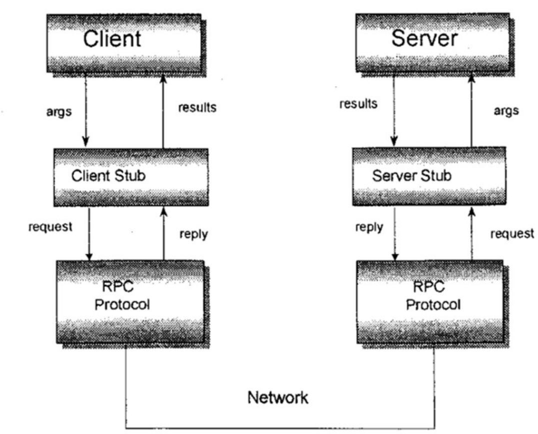
There is also some remarkable progress in video/audio compression algorithms, which reduce the video data stream to less than 1% at the sender site and reconstruct it again to a high-quality video sequence on the receiver site. In addition to this we use also some costumer tailored wavelet-based codecs.

Visual devices performing synchronous communication such as voice or videoconferencing over IP (VoIP/VCoIP) are now ubiquitous and raise new challenges for the Internet infrastructure. An approach for seamless integration [2] of real-time multicast mobility is a key. The multicast technique for live multimedia and a part of handover mechanism are performed on the buffered multicasting/switching agent (BMSA) in a wireless local area network (WLAN) [3].

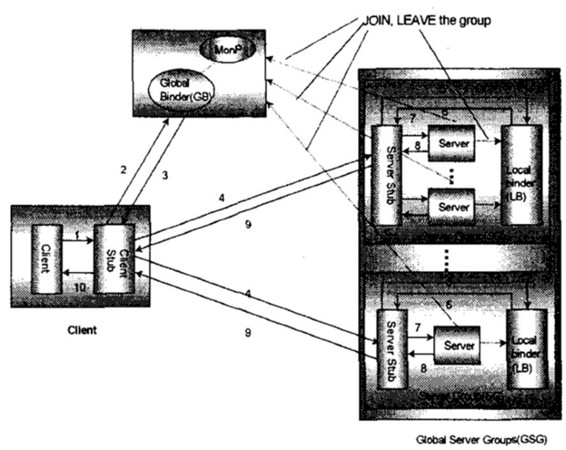
A simple scheme, compliant with current Internet infrastructure, for locating nomadic users at roaming sessions forms also part of our conferencing system.

It enables participants to share not only static documents like Power Point files but also any dynamic PC actions like mouse pointer movements or animations [1].

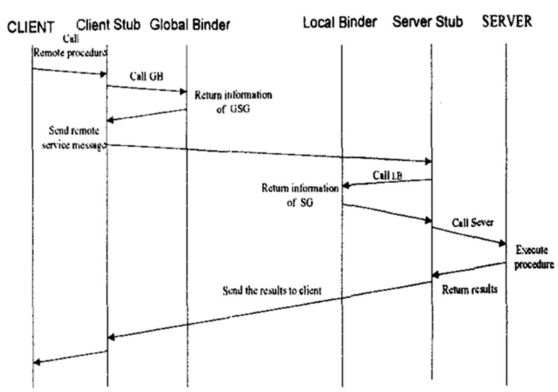
RPC (Remote Procedure Call) has been widely used for distributed application systems since it was implemented at [4]. RPC protocol transfers calling parameters and results in messages, so overload of communication can be reduced. It is very popular protocol in design of distributed application because of its simplicity and transparency. Numerous examples of different RPC services and implementations exist, including SUN RPC and XEROX RPC, which is popular commercial RPC systems, also RPC protocol of DCE (Distributed Computing Environment) has been used in distributed environment.




A Group Remote Procedure Call (GRPC) protocol can improve reliability, transparency and facility of classic RPC protocol. The group RPC proposed in this paper can be used in various applications such as video conference, replicated distributed database and management of distributed network.




GRPC is configured with calling client and server's response to the calling. Each server in GRPC system constructs a server groups (SG) by GRPC user request. Management information of each Server Groups (SG) is managed in Global Binder (GB) and management information of each servers in SG is managed in Local Binder (LB). The operation of GRPC protocol is described as follows. This is the operation of normal GRPC.[5]




The proposed GRPC system has the advantage of RPC system, such as simplicity and ease interface and it improves the reliability, facility of SUN RPC. GRPC has numerous applications.

GRPC is not yet developed, GRPC's compiler such as RPCGEN of SUN RPC system [5]. Need to yet experiment of implemented GRPC protocol with classic RPC.

Advances of optimal resource allocation for video communication over some major distributed systems including P2P streaming systems, wireless ad hoc networks, and wireless visual sensor networks. In general, the resource allocation problem in distributed systems can be formulated into a constrained optimization problem, with an objective to maximize (or minimize) a performance metric, subject to the resource constraints at each node. Since there is no centralized controller in the distributed systems, a distributed algorithm is efficient in terms of the scalability and the communication overhead.[6]

## 3. Scalability

A scalable system is one, which continues to work even though some variables in the system vary, usually to a great extent. A solution that works fine for a small problem set may turn out to be impractical for the same problem when scaled up to large size. To achieve scalability, the impact of varying variables must be minimized.

A concrete example of the definition above is a system where the number of users increases. If the system is scalable, the system should manage this increase without resource problems or performance bottlenecks. The system should withstand the increase without changes in system structure or application algorithms.

In a distributed multimedia system, the scalability is extremely important. These systems provide interactive services for a wide clientele. To maintain the clients the system must work fast and reliably all the time and withstand unexpected changes in the number of users and amount of data. This is especially important in a commercial environment. Without clients, the viability of the business would be low.

When designing interactive multimedia systems, special attention should be paid to the scalability of the system. It might be the crucial factor for the success or failure of the service.

**3.1 Factors causing Scalability**

a) **Growth of the user base**: A growing user base can cause serious scalability problems for servers. Requests from users add to the network traffic in proportion to the number of requests, which is proportional to the number of users. Some protocols even perform worse. This causes significant scalability problems for the network.

b) **Size of the data objects**. Particularly, the size of audio and video files strains the network and I/O capacity causing scalability problems.

c) **Amount of accessible data**: The increasing amount of accessible data makes data search, access, and management more difficult. This causes processing problems.

d) **Non-uniform request distribution**: The interests of users are not evenly distributed over the day and available servers. This puts strains on the servers and network at certain times of the day or at certain locations.

The non-uniform request distribution followed by the growth of the user base and the large size of the multimedia objects is the most serious problems in current systems. This while the non-uniform request distribution easily causes sudden unexpected load peaks, whereas the growth of the user base and amount of data is usually slightly more controlled.

Because of above-mentioned factors, the system might run out of resources, such as network, processing, and I/O or storage capacity. It is often very expensive to acquire more needed resources, or to have unused resource capacity in advance in the system. This is particularly valid for network capacity. Although there are enough resources available, resource allocation problems can sometimes occur due to the dynamic nature of the system.

In current systems it is the network bandwidth, and the I/O and processor capacity of the server and client that are the main cause of scalability problems.

Multimedia systems should be constructed to be more independent of resource limitations and allocation problems to guarantee scalability.

**3.1.2 How user experiences Scalability**

The user experiences the scalability of a system in how fast and accurately the system responds to actions. The response should be received in an acceptable time without any errors. These qualities can be measured via system response time, availability and reliability. We would not discuss these topics in this paper further as they need another paper to be written for discussing the issues in the Scalability.

## 4. Synchronization

Multimedia presentation requires the integration of multiple media streams of both continuous and noncontiguous streams. These streams have different temporal dependencies among the MUs of one or multiple streams. To ensure these relationships between the MUs of single and/or multiple media streams, a coordination process is required, which is called the multimedia synchronization. Typical synchronization solutions can be classified in to two basic types Intra-media synchronization deals with the reconstruction of the temporal relations between the MUs of the same media stream, at the presentation time.

**Causes of Asynchrony**

MUs of the media stream suffer different type of delays from the generation at source to presentation at receiver.[7] These delays can be different for different MUs depending upon the load at sender, network and receiver. These delay variations for different MUs cause asynchrony in the media presentation at the receiver. We can divide delays into three types: the delay caused by sender, network and by the receiver.

### INTRA-MEDIA SYNCHRONIZATION

The reconstruction of temporal relations between media units of the same continuous media stream is referred to as intra-media synchronization. For audio streams, the basic media unit is audio sample. The spacing between samples is determined by the sampling process. The goal of inter-media synchronization is to ensure the same spacing at the presentation time. For video streams, the basic media unit is the video frame and the temporal relation is the frequency of the video frames. The frame rate determines the spacing between The Fourth International Conferences on Advances in Multimedia frames. At presentation time, similar frame-rate has to be ensured by reconstructing the temporal relationship.

### INTER-MEDIA SYNCHRONIZATION

The inter-media synchronization is concerned with maintaining the temporal and/or logical dependencies among several streams in order to present the data in the same view as they were generated. At the receiver, MUs will not arrive in synchronized manner due to jitter in the network. [7]

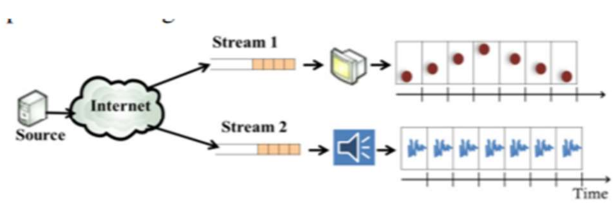



Figure 2. Inter-media synchronization.

### INTER-DESTINATION MULTIMEDIA SYNCHRONIZATION (IDMS)

The objective is to present the same stream at all the receivers in a group, approximately at the same time. To add to the complexity of the problem, these different receivers may be located at different Copyright geographical locations and may have different processing capabilities. These receivers may not only be of different type like smart phone and laptop computer but also may have the network connection of the different speeds. Network quizzes can be a good example of this scenario, where the objective will be to achieve the fairness among all the participants of the quiz. Solution will be required to display all the questions of the quiz to the entire participant at the same time.

## 5. Current Trends in DMS

Currently some of the distributed multimedia systems are:

a) **Video on Demand**: The consumer can select a video or any program on demand. The application consists of Interactive features like forward, rewind and pause.

b) **News and Reference Services:** News on Demand is similar to VOD but it provides sophisticated news retrieval and reference services that combine live and achieved video, access to textual data and still photography from various sources. The information is delivered based on a filtering criterion kept by the user.

c) **Interactive shopping and electronic commerce:** Home shopping will provide a customizable shopping environment.

Customers will be effectively and rapidly focus on the products and services that are of interest to them.

d) **Entertainment and games:** Interactive entertainment may become a frequently used service. Games will consist of simple applications that will be downloaded to the set top device thus not incurring the significant cost associated with the use of server and network facilities.

e) **Distance Learning:** Educational interactive programming and distance learning are areas where the research is going on. Current indications are there that these may become popular but not have sufficient commercial use to the providers.

## Conclusion

There is no single protocol that could address all the needs for a DMS architecture, lot of factors( bandwidth, number of users, security level , plethora of devices ) come into picture in deciding which protocol is suitable for the user, so user need to sacrifice some of the features and chose which protocol best fits his/her/organization's purpose.

DMS (Distributed Multimedia Systems) still has a vast scope to improve, with respect to the increasing demand of the users and the rate at which they are consuming the data. With the advance in networking have made some improvements in the way in which the streaming services are delivered to the user. And we need better protocols to support the requirements of the users and also the protocols need to be able to cover the wide range of media devices at the same time.

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