MULTIMEDIA APPLICATIONS – 2000
MEDA307

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OVERVIEW

The purpose of this report is to investigate the nature of multimedia data types and provide an overview of the behavior of these data types in a distributed network environment.

It is not in the scope of this report to investigate all digital data types that exist today.
Instead data types that are used in World Wide Web based distributed multimedia systems will be investigated together with the accompanying network technologies that are implemented.
I will not go into a great detail on the protocols, technologies and compression schemes that are used to deliver multimedia data, as this report is aimed to network administrators or to technically literate persons.

INTRODUCTION

About a decade ago the WWW browsing was a very dull process. All the information available was in text format. But with the advent of Mosaic, around 1993, Internet browsing became more exciting. Web pages started using a mix of formatted text and images. Today the WWW offers access to all sorts of information resources in all kinds of different forms, whether it is in HTML, Video, or a mixture of both. The emergence of new data types had as a result the creation of new services and applications.

With the rapid growth of the Internet evolution in the last decade, a vast amount of information is available today through the WWW gateway. The web has been transformed to an information superhighway with no physical limits.
The concept of time and space has changed, making two fundamentally different dimensions a single entity.
The Internet is at once a world-wide broadcasting capability, a mechanism for information dissemination, and a medium for collaboration and interaction between individuals and their computers without regard for geographic location.

Workstations have evolved into powerful multimedia machines that can produce a variety of data types, such as still images, video, and audio. The network that connects the stations together either in a LAN or a WAN has evolved as well, in order to support these new data types. The network infrastructure has now become an integrated communication system delivering rich information content to every connected user.

The transition of the worldwide network infrastructure from a voice network to an integrated services network that can carry simultaneously voice, images and video, shows the significance of multimedia broadcasting systems.

Telecommunication carriers hope to provide a network architecture that will be built now, offer high levels of scalability, will be widely adopted all over the world and be able to support future applications and user needs without having to reinvent the wheel.
The network should be able to adapt to the type of traffic (interactive traffic, high bandwidth for video applications, low delay for packet voice) in order to provide users with a satisfactory quality of service.

The majority of the Internet users today use a modem to access the Internet. A typical modem can offer connectivity speeds of up to 56 Kbps. While the Internet infrastructure is capable of carrying a wide range of data types at high speeds the local loop to the end users has not been upgraded, thus a bottleneck has been created. Technologies such as ADSL, ISDN and cable TV are the local-loop alternatives that can offer adequate speeds to distribute multimedia to residential customers.

MULTIMEDIA TRAFFIC CHARACTERISTICS

One term for multimedia systems is the use of computers to present text, graphics, animation, and sound in an integrated way. The complexity of traffic in a multimedia network is a natural consequence of integrating, over a single communication channel, a diverse range of traffic sources such as video, voice, and data that significantly differ in their traffic patterns as well as their performance requirements.

Multimedia data traffic has some special characteristics over the traditional data traffic. These special features are:

- Very high data rates
- Highly bursty traffic patterns
- Low latency and jitter
- Multicasting communication
- Synchronized transmission

MULTIMEDIA AND NETWORKING

The multimedia traffic patterns require some features that in networking environments can be difficult to be achieved. The main factors that influence multimedia over networks are:

- Throughput
- QoS guarantees
- Multicasting and broadcasting capabilities

THROUGHPUT

Any communication channel has a defined bandwidth associated. At the Table x.x the basic data rates are outlined together with the limitations each physical medium can have.

	Twisted Pair	Coaxial	Official fiber	Microwave	Satellite
Data Rate	1-100 Mbps	10 Mbps	400-500		
Interference	Electrical	Electrical	Immune	Solid object	Atmospheric condition
Distance	Up to 1 mile (1-2 Mbps for 1 mile)	2-3 miles	20-30 miles	20-30 miles	

However transmission speeds a lot higher than these can be achieved today. The Table in Appendix A outlines all the up-to-date transmission speeds. Therefore it seems like we can get speeds up to 1 Gbps in LAN topologies and up to 13 Gbps in WAN architectures or for backbone topologies.
The transfer rates shown in the tables refer to the total transfer capacity of the network and not to the achievable bit rate over a given connection between two end systems. This can happen because the access speed of a network interface is sometimes limited by other characteristics of the network topology used like congestion, lack of capacity or because the user has subscribed to a lower bit rate than the access rate. In real world most of the technologies are based on packet switching architectures thus the maximum access speed is available only when the network is being used only by one machine.

QUALITY OF SERVICE

On the Internet and in other networks, Quality of Service (QoS) is the idea that transmission rates, error rates, and other characteristics can be measured, improved, and, to some extent, guaranteed in advance.

QoS is of particular concern for the continuous transmission of high-bandwidth video and multimedia information. Transmitting this kind of content dependably is difficult in public networks using ordinary "best effort" protocols.

Quality of Service provides applications (or network administrators) with a means by which network resources, such as available bandwidth and latency, can be predicted and managed on both local computers and devices throughout the network.

There is a plethora of parameters that encompass QoS in networks. Here I will outline the most common ones.

Network delay related parameters

The overall transmission delay that is introduced by the network can include:

- Propagation delay: How long does it take the electrical, optical or radio signal to travel through a medium. Table x.x shows the various transmission delays.
- Switch Response time: All network cables have a limitation on how long they can be before signal degradation occurs. A good way to avoid this problem is to place switches at key points within the network fabric. Thus the overall Switch response time is Switch processing + Link output delay. Although most of today's switches offer very short switch processing delays the link output delay can have a great effect on the overall delay especially when congestion occurs.

Arc length	Delay terrestrial (ms)		
(Km)	Wire	Fiber	Radio
500	2.4	2.5	1.7
1000	4.8	5.0	3.3
2000	9.6	10.0	6.6
5000	24.0	25.0	16.5
10000	48.0	50.0	33.0
15000	72.0	75.0	49.5
17737	85.1	88.7	58.5
20000	96.0	100.0	66.0
25000	120.0	125.0	82.5

Table 8: Calculated Terrestrial Transmission Delays for Various Call Distances (Source: ITU-T Recommendation Q.706, Table 1)

- Jitter: It refers to the variation of the delay generated by the transmission equipment. Not predictable delay adds further limitations on some multimedia applications. Highly affected by the Switch Response Time.

Bandwidth allocation

- Packet switched networks: With packet switched networks all data packets share the bandwidth allocated to a connection. Whenever a lot of service requests travel through the same path every packet will eventually reach its destination but the service can degrade significantly.
- Circuit switched networks: With circuit switched networks the bandwidth allocated to a request is reserved until the connection is terminated. When there are a lot of requests the network will deny to serve the additional load. Moreover call set-up delay is introduced.

Error and Flow control

- Data loss: Networks may lose data or transmit corrupted data. When the transporting protocol detects an error in the data that is carrying it can either take the responsibility and ask for a retransmission of the data (like X.25) or just discard the data and leave it to the end-system application to decide if retransmission is needed (ATM does not offer hop to hop error detection/correction). The retransmitted information creates an additional delay. In real time multimedia applications a delayed information packet might not be much of a use to the application.

- Service guarantees: The best-effort nature of the Internet today is not ideal for real-time multimedia applications in a distributed environment. Moreover priority schemes for different data types are less used in a best effort methodology. Every user has equal access rights to the transporting medium. When guaranteed data flow over a given period of time is offered is usually accompanied with a higher cost for the service.

MULTICASTING AND BROADCASTING

Multimedia can be exchanged between two users but most of the times there is a need to transmit audio or video into a group of end users.

Traditional data streams that traverse the Internet are either point-to-point unicasts or broadcasts that transmit signals from one point to many, whether the end points want to receive the transmissions or not.

With unicast protocols the data is sent from a single sender to single receiver. Therefore when data is needed to be sent from one source to many destinations the same data is transmitted many times making very bad use of available bandwidth.

When a source uses broadcasting one copy is sent out but instead of going to every single recipient separately it is sent to a broadcast address. With broadcast the data goes to recipients that may not wish to receive the specific data.

IP Multicast sends out a single data stream that is picked up by only the end stations that want to receive it. For any transmission that comes from a single source and is intended for many recipients--such as a videoconference--IP Multicast is a more efficient mechanism for distribution.

Unfortunately, the majority of the routers on the Internet today don't know how to handle multicasting.

In 1992, some bright fellows on the Internet Engineering Task Force (IETF) decided that what no one would do in hardware, they could do in software. So they created a "virtual network" -- a network that runs on top of the Internet -- and wrote software that allows multicast packets to traverse the Net. Armed with the custom software, these folks could send data to not just one Internet node, but to 2, 10, or 100 nodes. Thus, the MBONE was born.

The MBONE is called a *virtual network* because it shares the same physical media -- wires, routers and other equipment -- as the Internet.

The MBONE allows multicast packets to travel through routers that are set up to handle only unicast traffic. Software that utilizes the MBONE hides the multicast packets in traditional unicast packets so that unicast routers can handle the information.

The scheme of moving multicast packets by putting them in regular unicast packets is called *tunneling*. In the future, most commercial routers will support multicasting, eliminating the headaches of tunneling information through unicast routers.

When the multicast packets that are hidden in unicast packets reach a router that understands multicast packets, or a workstation that's running the right software, the packets are recognized and processed as the multicast packets they really are. Machines (workstations or routers) that are equipped to support multicast IP are called *mrouters* (multicast routers). Mrouters are either commercial routers that can handle multicasting or (more commonly) dedicated workstations running special software that works in conjunction with standard routers.

Many definitions of multimedia information systems exist, one of them being computer systems that support interactive use of the following information sources:

- text
- graphics
- image
- voice
- video

The above list can be divided in to types of multimedia, temporal and non-temporal.

Textual data

A decade ago text would not make it into the multimedia team. Today though with the software packages available text can become a mixture of text and colours making it more attractive than it used to be.
Text can be letters, words, sentences and it typically refers to text stored in digital form as ASCII codes or as any other set of codes such as EBCDIC.

ASCII is a code for representing English characters as numbers, with each letter assigned a number from 0 to 127. The standard ASCII character set uses just 7 bits for each character. There are several larger character sets that use 8 bits, which gives them 128 additional characters. The extra characters are used to represent non-English characters, graphics symbols, and mathematical symbols. A more universal standard is the ISO Latin1 set of characters, which is used by many operating systems, as well as Web browsers.

Another set of codes that is used on large IBM computers is EBCDIC.
Text can be formatted as well by word processing packages or by mark-up languages. Some properties of text that can be specified are the font, alignment, margins etc.

HTML (Hyper Text Markup Language) is the authoring language that is used to create documents on the World Wide Web. HTML defines the structure and layout of a Web document by using a variety of tags and attributes. HTML is similar to the Standard Generalized Markup Language (SGML), which is a more robust version of HTML.

Text on the network

Within the PC data is transferred in parallel mode. Most modems today transmit data in serial mode. After a special chip in the PC called UART has serialized the parallel stream of data, the modem can sent the data over the PSTN. A standard V.90 at 56Kbps can send and receive 7000 characters per second. Even a modem of lower speed is adequate to display text. For this type of data the only QoS parameter that is of importance is the data loss, which can make the information unreadable especially if it is encoded in a specific format.

Image data

Still images and animation are the most common image data. Image is a media object that is made up of media elements i.e. pixels.
Digital data are represented in binary code. Pixels are referred to as the atoms of image data.
Pixels can have different pixel depths:

- 1 Bits per Pixel: 2 Colours (Usually Black and White)
- 8 Bits per Pixel: 256 Colours or Shades of Grey (0-255)
- 16 Bits per Pixel: Thousand of Colours or Shades of Grey
- 24 Bits per Pixel: Millions of Colours

There are many colour models:

- Grey Scale - Ramps
- CLUT - Color Lookup Table
- RBG - Red, Green, Blue (Additive)
- CMYK - Cyan, Magenta, Yellow (Printers)
- HSL - Hue, Saturation, Lightness
- HSV - Hue, Saturation, Value
- YUV - Luminance, Chrominance (PAL / Video)

The human eye contains Red, Blue and Green Receptors Many Display Monitors Use Red, Blue and Green Guns RGB is an Additive Color Model. The more of each colour added the closer we get to white Models the way light-based colour works in the physical world.

65535,0,0
Red
0,0,0
Black
65535,65535,65535
White
0,65535,0
Green
0,0,65535
Blue
24 Bits of Colour Data per Pixel
8 Red, 8 Green, 8 Blue

For example a picture of 640x480 pixels with 24 bits per pixel takes up 1Mbyte. A simple animation, which is a simulation of movement created by displaying a series of pictures, can have a large number of 1Mbyte images. The only solution to reduce the storage requirements and the time that takes to transmit an image over a network is compression.

Compression

Data compression is based on exploiting certain features of the data to allow for greater reduction of body of data. There are two types of data compression algorithms-lossless and lossy.
Lossless compression preserves the original data in a way that an exact copy can be recreated. The most common lossless data compression algorithms are based on the LZ77, LZW, RLE, and Huffman encoding.
Lossy compression allows some changes from the original data, often used to compress sound and images where loss of quality might not be noticed. Better compression ratios can be achieved than lossless techniques.
The most common compression techniques that can compress an image up to a ratio of 2,000:1 will be outlined below.

Run Length Encoding (RLE)
This technique is mostly used to compress medical images that need to be reconstructed without any loss of information. RLE is easy to implement and does not take much processing power.

Huffman coding
It uses either a tree or a lookup table to find the codes used in place of the original data. This technique is used in Fax machines and as part of the JPEG compression algorithm.

Joint Photographic Expert Group (JPEG)
This is the most commonly used lossy algorithm for compressing photographic images. JPEG achieves very high compression ratios by taking advantage of the limitation of the human eye to perceive small colour details.

Portable Network Graphics (PNG)
It is a new bit-mapped graphics format similar to GIF. PNG was approved as a standard by the W3C to replace GIF. GIF is mostly used for small animation schemes. It can store many images in a single file and display them as animation.

Images on the Network

Images are not really affected by network delay. With progressive jpeg formats an image displays progressively in a Web browser. The image will display as a series of overlays, enabling viewers to see a low-resolution version of the image before it downloads completely. So even for slow connections the end user does not experience great delays. Images can load the network only if the image is in an uncompressed format or in a lossless compression format. New ways of making visual animations have evolved the last couple of years, like Flash Maker, Java, and DHTML, which have evolved from the need to deliver animation through slow connections. Image manipulation packages have the choice to optimize an image for use on the Web.

With such an all-network encompassing definition, QOS functionality requires cooperation among end nodes, switches, routers, and wide area network (WAN) links through which data must pass. Without some level of cooperation among those network devices, the quality of data transmission services can break down. In other words, if each such network device is left to make its own decisions about transmitting data, it would likely treat all data equally, and thus provide service on a first come–first served basis. Although this may be satisfactory in network devices or transmission media that are not heavily loaded, when congestion occurs, such service can delay all data. With this information, we can extend the definition of quality of service—it allows preferential treatment for certain subsets of data as they traverse any QOS-enabled part of (or devices in) the network.

Appendix A

Carrier Technology	Speed	Physical Medium	Application
GSM mobile telephone service	9.6 to 14.4 Kbps	Radio frequency in space (wireless)	Mobile telephone for business and personal use
High-speed circuit-switched data service (High-Speed Circuit-Switched Data)	Up to 56 Kbps	RF in space (wireless)	Mobile telephone for business and personal use
Regular telephone service (POTS)	V.90 Up to 56 Kbps	Twisted pair	Home and small business access
Dedicated 56Kbps on frame relay	56 Kbps	Various	Business e-mail with fairly large file attachments
Digital signal X	64 Kbps	All	The base signal on a channel in the set of Digital Signal levels
General Packet Radio System (General Packet Radio Services)	56 to 114 Kbps	RF in space (wireless)	Mobile telephone for business and personal use (available in 2000)
Integrated Services Digital Network	Basic Rate Interface in ISDN: 64 Kbps to 128 Kbps Primary Rate Interface in ISDN: 23 (T-1) or 30 (E1) assignable 64-Kbps channels plus control channel; up to 1.544 Mbps (T-1) or 2.048 (E1)	BRI: Twisted-pair PRI: T-1 or E1 line	BRI: Faster home and small business access PRI: Medium and large enterprise access
IDSL	128 Kbps	Twisted-pair	Faster home and small business access
Enhanced Data GSM Environment (Enhanced Data GSM Environment)	384 Kbps	RF in space (wireless)	Mobile telephone for business and personal use (available in 2001)
Satellite	400 Kbps (DirecPC)	RF in space (wireless)	Faster home and small enterprise access
Frame relay	56 Kbps to 1.544 Mbps	Twisted-pair or coaxial cable	Large company backbone for LANs to Internet service provider ISP to Internet infrastructure
digital signal X/T-carrier system	1.544 Mbps	Twisted-pair, coaxial cable, or optical fiber	Large company to ISP ISP to Internet infrastructure

Universal Mobile Telecommunications Service (Universal Mobile Telecommunications System)	Up to 2 Mbps	RF in space (wireless)	Mobile telephone for business and personal use (available in 2002)
E-carrier	2.048 Mbps	Twisted-pair, coaxial cable, or optical fiber	32-channel European equivalent of T-1
T-carrier system (DS1C)	3.152 Mbps	Twisted-pair, coaxial cable, or optical fiber	Large company to ISP ISP to Internet infrastructure
IBM Token Ring/802.5	4 Mbps (also 16 Mbps)	Twisted-pair, coaxial cable, or optical fiber	Second most commonly-used local area network after Ethernet
digital signal X/T-carrier system	6.312 Mbps	Twisted-pair, coaxial cable, or optical fiber	Large company to ISP ISP to Internet infrastructure
Digital Subscriber Line	512 Kbps to 8 Mbps	Twisted-pair (used as a digital, broadband medium)	Home, small business, and enterprise access using existing copper lines
E-carrier	8.448 Mbps	Twisted-pair, coaxial cable, or optical fiber	Carries four multiplexed E-1 signals
cable modem	512 Kbps to 52 Mbps (see Key and explanation)	Coaxial cable (usually uses Ethernet); in some systems, telephone used for upstream requests	Home, business, school access
Ethernet	10 Mbps	10BASE-T (twisted-pair); 10BASE-2 or -5 (coaxial cable); 10BASE-F (optical fiber)	Most popular business local area network ()
IBM Token Ring/802.5	16 Mbps (also 4 Mbps)	Twisted-pair, coaxial cable, or optical fiber	Second most commonly-used local area network after Ethernet
E-carrier	34.368 Mbps	Twisted-pair or optical fiber	Carries 16 E-l signals
Digital signal X/T-carrier system	44.736 Mbps	Coaxial cable	ISP to Internet infrastructure Smaller links within Internet infrastructure

Optical Carrier levels (OCx)	51.84 Mbps	Optical fiber	ISP to Internet infrastructure Smaller links within Internet infrastructure
High-Speed Serial Interface	Up to 53 Mbps	HSSI cable	Between router hardware and WAN lines Short-range (50 feet) interconnection between slower LAN devices and faster WAN lines
Fast Ethernet	100 Mbps	100BASE-T (twisted pair); 100BASE-T (twisted pair); 100BASE-T (optical fiber)	Workstations with 10 Mbps Ethernet cards can plug into a Fast Ethernet LAN
Fiber Distributed-Data Interface	100 Mbps	Optical fiber	Large, wide-range LAN usually in a large company or a larger ISP
T-carrier system (DS3D)	135 Mbps	Optical fiber	ISP to Internet infrastructure Smaller links within Internet infrastructure
E-carrier	139.264 Mbps	Optical fiber	Carries 4 E3 channels Up to 1,920 simultaneous voice conversations
Optical Carrier levels (OCx)/Synchronous Digital Hierarchy	155.52 Mbps	Optical fiber	Large company backbone Internet backbone
E-carrier	565.148 Mbps	Optical fiber	Carries 4 E4 channels Up to 7,680 simultaneous voice conversations
Optical Carrier levels (OCx)/Synchronous Digital Hierarchy	622.08 Mbps	Optical fiber	Internet backbone
Gigabit Ethernet	1 Gbps	Optical fiber (and "copper" up to 25 meters)	Workstations/networks with 10/100 Mbps Ethernet will plug into Gigabit Ethernet switches
Optical Carrier levels (OCx)	1.244 Gbps	Optical fiber	Internet backbone
SciNet	2.325 Gbps (15 OC-3 lines)	Optical fiber	Part of the vBNS backbone
Optical Carrier levels (OCx)/Synchronous Digital Hierarchy	2.488 Gbps	Optical fiber	Internet backbone

Optical Carrier levels (OCx)/Synchronous Digital Hierarchy	10 Gbps	Optical fiber	Backbone
Optical Carrier levels (OCx)	13.271 Gbps	Optical fiber	Backbone