Interactive Multimedia on the Web

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INTRODUCTION

Personal computing, multimedia, and computer networks have experienced a tremendous boom during the past decade. From expensive, stand-alone MPC-1-compatible PCs that landed in the marketplace in the early 1990s to the popularization of the Internet, particularly the World Wide Web, the production, archiving, and distribution of multimedia has evolved from a few, technologically limited devices to a plethora of hardware and software available for these tasks. It is now possible to develop higher quality multimedia content, in less time, and distribute it to a much wider audience (using the Web as opposed to CD-ROMs) than anyone could have imagined a decade ago.

The Internet has become ubiquitous and is quickly extending its arms to the wireless arena. The hunger for multimedia-rich content over the Web has fostered developments in many fields, from the technological infrastructure necessary to carry multimedia data, to the tools used to create, manage, and distribute multimedia content. Interactivity is the key concept in many such applications, such as games, maps, and distance learning applications. In the first part of the chapter, we define the concepts of multimedia and interactivity, particularly on a Web-based context, and present a summary of the network technologies that enable transmission of interactive multimedia information over the Web. In the next section, we show the process and related languages and tools for creating interactive multimedia Web pages. Finally, we present an overview of current interactive multimedia applications and services.

WHAT EXACTLY IS INTERACTIVE MULTIMEDIA?

We start by conceptually defining “multimedia” and “interactivity” in the context of Web-based applications. The term multimedia has been frequently used to mean the combining of text, graphics, images, sounds, and video on one page or presentation. According to this definition, most of the pages currently available on the Web are inherently multimedia. For the discussion that follows, it is important to know the following. (a) multimedia content that combines only text, images, and animations (for which there is a built-in HTML support) is different from applications that use video clips, animations, and sounds (for which third-party products—usually available as browser plug-ins—are required). A multimedia-rich HTML page consisting exclusively of text, JPEG images, and animated GIFs would belong to the first category, whereas a page that loads a Macromedia Flash movie would belong to the second group. (b) Multimedia information that is delivered without user interaction is different from multimedia contents that change dynamically in response to the user’s inputs. The streaming of a pre-recorded video clip would be classified under the first group, whereas the constant updating of a screen in a multiplayer Web game would qualify as an example of the second case.

MULTIMEDIA NETWORK TECHNOLOGIES

There are five main types of communication network technologies used to carry multimedia traffic (Halsall, 2001): telephone networks, data networks (including the Internet), broadcast television networks, integrated services digital networks (ISDN), and broadband multiservice networks, such as B-ISDN. In this chapter, we focus mostly on the Internet. Besides enabling a number of interperson communication tools, such as e-mail, the Internet also hosts a large number of interactive multimedia applications stored in Web servers.

Characteristics of Multimedia Traffic

Interactive multimedia may be real-time or non-real-time information. Real-time, or continuous, information is transferred from source to destination as it is generated...
Multimedia traffic can be classified into two main types: constant bit rate (CBR) and variable bit rate (VBR). Audio streams, for example, are typically generated at a constant rate, determined by the sampling frequency and number of bits per sample used to convert the audio information into digital format. Video streams, on the other hand, exhibit VBR, even though the frames that make up a video program are generated and displayed at a constant rate. This is due—among other things—to the fact that most video compression algorithms use differential techniques that employ fewer bits on frames that resemble previous frames.

The transfer of multimedia information streams between any source and destination of can occur in a number of different ways.

- Simplex: Information flows in one direction only.
- Half-duplex: Information flows alternately in both directions.
- Full-duplex: Information flows in both directions simultaneously.
- Unicast: Information flows from the source to a single destination.
- Multicast: Information flows from the source to multiple destinations, comprising a subset of the nodes connected to the network.
- Broadcast: Information flows from the source to all destinations connected to the network.

In the case of half- or full-duplex communications, the flow of information can be symmetric, where each party sends a comparable amount of information to the other, or asymmetric, where the flow of information is much higher in one direction than in the other. The Internet uses packet-switching techniques to transfer information between two end computers using intermediate nodes—routers—along the way. This mode of operation is also sometimes referred to as store-and-forward, indicating that there is a built-in delay in the process that occurs every time a packet arrives at a router and waits for the router's decision (upon looking at its routing tables) as to where the packet must be forwarded next. The sum of the store-and-forward delays in each router contributes to the overall end-to-end delay between source and destination. The average of this delay is known as mean packet transfer delay and the variance is usually known as delay variation or jitter. The inevitability of these delays is one of the technical challenges behind enabling interactive multimedia applications on the Web.

Besides the delay limitations, the Internet has another characteristic that makes for less-than-ideal conditions for carrying multimedia. It offers a best-effort service to its end users, which means that the TCP/IP-based transfer of packets is subject to errors (damaged packets, lost packets, timeouts, etc.), and the typical way to handle such errors is to discard packets and (optionally) request/retransmission. Because much of multimedia traffic may be sensitive, retransmissions are usually not desired, because they add up to traffic inside the network and also because by the time the retransmitted packet arrives, it is no longer needed. A common way of handling with lost/retransmitted packets while providing the user with the illusion of continuous flow of information is the use of buffers at the receiving side.

Designers of networked multimedia applications usually specify the minimum network requirements that must be met to enable the application to work. These requirements are collectively known as network Quality of Service (QoS) parameters. Examples of QoS parameters are maximum packet size, average bit rate, average packet error rate (PER), mean packet transfer delay, worst-case jitter, and transmission delay. In addition to the network QoS parameters, the application itself has QoS parameters associated with it, such as the required bit rate or mean packet transfer rate, the maximum start-up delay, the maximum end-to-end delay, the maximum jitter, and the maximum round-trip delay. To simplify the process of determining whether a network meets the QoS requirements of a particular application, several service classes have been defined, each of which contains a specific set of QoS parameters. A network may support two or more service classes, in which case different classes are usually assigned different priorities.

### Standards for Multimedia Communications

Multimedia information is typically transmitted in compressed form over the Web. Many standards have recently been developed for image, audio, and video compression and transmission. The most important standards are as follows.

- **MPEG-1**: The first widely deployed standard proposed by the Motion Pictures Expert Group (MPEG). It aims at audiovisual encoding at a bit rate of 1.5 Mbps, which allows for VHS-like video with stereo audio to be encoded and which is stored in a CD-ROM. The best-known contribution of the MPEG-1 standard is its layer III audio compression, popularly known as MP3, which caused an entire revolution in the music industry.
- **MPEG-2**: Enables the transmission of audio and video over broadband networks. It aims at encoding digital TV (and HDTV) signals and has been widely used in the consumer electronics field, from delivery of TV programming via personal satellite (dish) systems, to DVDs, to personal digital video recorders such as TiVo.
- **MPEG-4**: Follows an object-based representation approach to audiovisual scenes, where each scene is composed of objects, both natural and synthetic. MPEG-4-based systems are not yet fully deployed at a consumer level at the time of this writing. It is expected, though, that the object-based nature of the standard will significantly enhance interactive multimedia applications.
- **MPEG-7**: Standard that describes multimedia content, enabling users to search, browse, and retrieve multimedia
CREATING INTERACTIVE MULTIMEDIA WEB PAGES

Contemporary tools for designing Web pages (such as Macromedia Dreamweaver and Microsoft FrontPage) allow the inclusion of multimedia objects, such as videos, images, animation, and audio, in Web pages. To play sound, animation, and video, the user system may require plug-ins, which are small programs that work in cooperation with a Web browser. Some plug-ins have become very popular, so Netscape and Microsoft browsers have built them into their latest versions. Popular multimedia plug-ins include RealNetworks’ Real Audio and Real Video, Apple’s Quick Time, and Macromedia Shockwave and Flash. Besides plug-ins, which allow multimedia objects to be included in Web pages, more sophisticated Web pages also include Java Applets and VRML (virtual reality modeling language) three dimensional (3D) images. Java Applets are programs embedded in Web pages (in HTML code) and used to create multimedia Web pages that include animation, sound, images, and videos. The Applet runs locally on the client machine, which is running a Web browser. VRML is a generic text-based language used to construct 3D images and 3D text for Web pages. A VRML document is an ASCII file, much like an HTML document. In VRML, the Web designer specifies objects—called nodes—that define shapes and their attributes. These nodes create 3D scene graphs, which a VRML browser renders. Examples of nodes include cube, sphere, cone, cylinder, rotation, and scan.

Although including all these components makes Web pages multimedia rich, it does not make them interactive. The complete process of creating interactive multimedia Web pages, and the related tools and languages, is shown in Figure 2. This process is described next.

The original (home) Web pages, hosted at a server, include multimedia objects (such as music, sound, images, animations, and video clips), Java Applets, and VRML images. To provide interactivity, a Web designer should also apply client-side and/or server-side scripting.

Client-side scripting includes CGI (Common Gateway Interface) scripts that provide interactivity by processing and responding to user inputs. When a user submits an HTML form, a program that resides on the server system receives and processes the form’s content. This program then creates an HTML document dynamically, which the server displays back to the user on the client machine. CGI scripts are usually created using Perl, JavaScript, or VBScript.

Perl is an interpreted scripting language for processing data collected from HTML forms, which is well suited for text manipulation. Its features include flexibility, compact, form, security, and support for file and database operations.

JavaScript is another scripting language that is used to create and process Web pages with HTML forms. However, the browser, and not a program on the server, executes JavaScript; adding interactivity and dynamic content to Web pages.

Java Media Framework (JMF) tools provide the integration into Java applications and Applets of a wide range of audio and video formats, advanced imaging, animation, 2D and 3D graphics and modeling, as well as speech and telephony support. The JMF consists of a suite of Java media APIs (Application Programming Interface). JMF player API is used by applications and Applets to create and control media playback. Java 2D API (2D) and 3D API (3D) provide sets of classes for writing 2D and 3D graphics applications and Applets, respectively. Java Advanced Imaging API allows sophisticated image processing to be incorporated into Java Applets and applications.

VBScript is a scripting language from Microsoft that is based on Visual Basic, which is used to create interactive multimedia Web pages. Like JavaScript, VBScript statements are embedded in an HTML code, which a browser executes. VBScript provides access to OLE (Object Linking and Embedding) objects, called ActiveX controls.

ActiveX is an OLE object, which is a class library that contains a complete set of functions for manipulating an
object. The code for an OLE object already exists, so programmers can include the objects in applications quickly and easily. ActiveX controls provide programmers with a way to extend browser capabilities and create a wide range of Web site capabilities. Some examples of ActiveX controls include button (control to display various frame sequences), chart (enables the programmer to draw various types of charts with different styles), and gradient (shades the area with a range of colors).

Server-side scripting provides an effective way to dynamically build documents in response to client (or user) requests. As shown in Figure 2, server-side scripting uses information sent by clients, information stored on the server, and information from the Internet to dynamically create Web pages (in XHTML or XML), which are then sent back to the client.

Active Server Pages (ASP) is a popular server-side technology from Microsoft, which is processed by an ActiveX component (server-side ActiveX control) called a scripting engine. An ASP file has an extension .asp and contains XHTML tags and scripting code. The VBScript is most widely used for ASP scripting, but other languages, such as JavaScript, can also be used.

Scalable Vector Graphics (SVG) is a Web standard that specifies the language for describing two-dimensional graphics in XML. It will provide the next-generation Web browsers with native support for multimedia. SVG allows for three types of graphic objects: vector graphic shapes (e.g., paths consisting of straight lines and curves), images, and text. Graphical objects can be grouped, styled, transformed, and composited into previously rendered objects. Text can be in any XML name space suitable to the application, which enhances searchability and accessibility of the SVG graphics. The feature set includes nested transformations, clipping paths, alpha masks, filter effects, template objects, and extensibility. SVG drawings can be dynamic and interactive. The Document Object Model (DOM) for SVG, which includes the full XML DOM, allows for straightforward and efficient vector graphics animation via scripting.

In summary, a number of tools, languages, and components, which are introduced in this section, are used to create contemporary and effective interactive multimedia Web pages.

TOOOLS, SERVICES, AND APPLICATIONS

Today, there is a wide range of interactive multimedia services and applications on the Web. In this section, we discuss the basic services and applications as well as related tools. The list of these services and applications is given in Table 1.

Multimedia Portals

Market environment is changing rapidly and therefore new functionality is important for gaining competitive advantage. Time-to-market is critical, and businesses need to integrate systems, automate processes, and provide each other with access to key functionality. Recently, Web portals evolved as a single, integrated point of access of information, applications, and people. Web portals are Web sites that offer a great deal of...
content and services. They integrate new content with existing content, server-side applications, and Web-based services. There are two basic Web portals: (a) public portals, such as Yahoo, which bring together information from various sources, applications, and people, and which offer personalized Web sites; and (b) enterprise, or usiness, portals, which give employees access to organization-specific information and applications.

In another classification, a horizontal portal provides a gateway to a broad range of information, whereas a vertical portal provides in-depth information about a specific topic. Multimedia portals are special Web portals that offer multimedia services, such as streaming video, audio, interactive banners, and animation (Dimitrova et al., 2000). Multimedia portals can be classified as belonging to one of the following groups. (a) Entertainment portals typically offer personalized music, television, and movie news. For example, a portal from Warner Brothers, shown in Figure 3, provides features such as an e-mail center; customizable music, television, and movie news; a chat room; and interactive banners, and animation (Dimitrova et al., 2000).

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Table 1 Interactive Multimedia Services and Applications on the Web

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>Multimedia portals (sample URL:<a href="http://www.etniverse.com/">http://www.etniverse.com/</a>)</td>
<td>Give users single, customizable access to multimedia services, including video, audio, animation, interactive banners, etc.; can be classified as entertainment, educational, and information portals.</td>
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<tr>
<td>Interactive e-learning and distance learning (sample URL:<a href="http://www.click2learn.com/">http://www.click2learn.com/</a>)</td>
<td>Applications include a wide variety of media files to interactively explain complex concepts; distance learning allows customers to subscribe to online courses taught at remote sites.</td>
</tr>
<tr>
<td>Media sharing (sample URL:<a href="http://www.ic.media.mit.edu">http://www.ic.media.mit.edu</a>)</td>
<td>Provides collaborative music and video production by a group of artists from dispersed locations.</td>
</tr>
<tr>
<td>Interactive multiplayer games (sample URL:<a href="http://www.sierra.com">http://www.sierra.com</a>)</td>
<td>Games in which multiple players participate over the Internet.</td>
</tr>
<tr>
<td>Participatory publishing</td>
<td>3D content that allows users to fly through virtual space.</td>
</tr>
<tr>
<td>Interactive Web maps (sample URL:<a href="http://www.archaeology.usyd.edu.au/research/time_map">http://www.archaeology.usyd.edu.au/research/time_map</a>)</td>
<td>Web content that users, along with authors, can contribute to and influence.</td>
</tr>
<tr>
<td>Multimedia search over the Web (sample URL:<a href="http://www.broadcast.com/television">http://www.broadcast.com/television</a>)</td>
<td>Time-enabled maps that typically display archeological and historical data.</td>
</tr>
<tr>
<td>Integration of the Web with traditional media (sample URL:<a href="http://www.parallelgraphics.com">http://www.parallelgraphics.com</a>)</td>
<td>Web-based search systems that provide search results as images and audio and video files on a single result page.</td>
</tr>
</tbody>
</table>

Interactive E-Learning Tools and Distance Learning Applications

The Web coupled with multimedia content has the potential to change how people are educated. Contemporary e-learning tools allow the development of online interactive learning applications. An example of such a tool is ToolBook Instructor and Assistant (http://www.click2learn.com), which supports a wide variety of media files, including sound, animation, streaming media, and still images. Some interactive learning applications using ToolBook include innovative technical and maintenance training, electronic service manuals, and software training courses. Figure 4 shows a screen from the interactive Boeing 777 course, showing how skilled aircraft mechanics share techniques for installing safety hardware in confined spaces.

Distance learning allows remote participants to receive classes over the Internet. Advanced distance learning systems include a real-time interactive virtual classroom, which allows a remote participant not only to receive a live class feed but also to interact in a live class using audio and video over the Internet (Deshpande & Huang, 2001).

Media-Sharing Applications

Media sharing includes the design of tools that support collaborative music or video production by a group of artists from geographically dispersed areas. A sharable media project team at MIT Media Lab, led by Glorianna Davenport (http://www.ic.media.mit.edu), has developed a set of tools that allows online groups of filmmakers to collaborate on the same film project by contributing...
and sharing material, and to comment on one another’s creations (Kelliher et al., 2000). An example from this project is PlusShorts application, which is implemented as a Java Applet, and which allows distributed groups of users to contribute and collaborate in the creation of shared movie sequences.

RocketNetwork (http://www.rocketnetwork.com) has developed a tool for online musicians that provides simultaneous access to audio files and allows the collaboration of musicians and producers. This system, referred to as “global production network,” allows the dynamic updating of files from anywhere in the world. Applications include sound track production for film, TV, and radio, and sound tracks for broadcast media.

The system is based on a RocketNetwork’s central server, which coordinates sharing, dynamically updates, and distributes audio and MIDI (Musical Instrument Digital Interface) files.

Figure 3: An example of the entertainment portal from Warner Brothers. (From http://www.entertaindom.com.)

Figure 4: Boeing 777 interactive maintenance course created using the ToolBook e-learning tool. (From http://www.click2learn.com.)
Multiplayer Web Games
Interactive multiplayer games allow multiple players to participate in games over the Internet. The challenge of Web-based multiplayer games is in the quality of the connection and the ability of the designer to implement the plot in a cyberspace way. Real-time games also require that players visit a chat room and register and that all clients be synchronized. Figure 5 illustrates an example from the game Half-Life, created by Sierra.com (http://www.sierra.com).

Web 3D Virtual Environments
Support for VRML in Web browsers allows developers to present their content in 3D rather than just as documents. The user can "fly" through virtual space and experience a real car, house, or town. The browser requires a plug-in, a Web browser that provides complex VRML rendering. Figure 6 illustrates the Cortona VRML plug-in, by ParallelGraphics for a 3D model of a sport car.

The same company, ParallelGraphics, offers Outline3D, an interior design application that enables users to quickly customize a virtual environment specific to their design needs (http://www.parallelgraphics.com). Potential applications include (a) a 3D room for potential buyers to view the finished interior design of an office or a home, and (b) real estate applications, for real estate agents to show customers the look of their future home.

Participatory Publishing
Participatory publishing refers to Web pages where readers can contribute and influence the content along with authors.

An example of participatory publishing is WebTour, an application developed by the Siemens Research Center in Princeton, in which viewers can make verbal comments and dynamic annotations or drawings to illustrate some points. The system is capable of recording, playing back, storing, searching, and distributing personalized dynamic multimedia annotation on Web documents in the form of guided Web tours.

Potential applications of participatory publishing tools, including WebTour, include the following.

E-commerce: When a customer enters the Web site of a retail store, a Web clerk greets the customer and guides him/her through various Web pages explaining key products and adding advertisements when necessary.

Corporate Intranet: Different users, such as employees and/or customers, can make annotations on the same Web document and share ideas.

Distance learning: A teacher can make annotations on Web pages explaining complex problems. The annotations could then be retrieved by students and played back.

WebTour is implemented using open Web technologies described earlier—standard browsers, Java, dynamic HTML and JavaScript, and Active Server Pages.

Interactive Web Maps
Interactive Web maps are time-enabled maps created from distributed databases. Interactive maps typically display archaeological and historical data, such as historical maps and images, the growth of cities, the spread of dynasties and empires, or the distribution of archeological sites. However, there is a wide range of other applications, which could include time-stamped data. Interactive Web maps could also link map objects to images, other Web pages, multimedia, or a database. In addition, interactive
INTERACTIVE MULTIMEDIA ON THE WEB

Figure 6: VRML model of classic sport cars. The navigation buttons allow the user to change views, open the door, and change the car’s movement. (From http://www.parallelgraphics.com.)

features include zooming and panning, temporal filtering, data-driven hotlinks, and other functionality.

An example of a tool for creating interactive Web maps is TimeMap, from the University of Sydney (http://www.archaeology.usyd.edu.au/research/time_map). Figure 7 illustrates an interactive map developed by the TimeMap team for the international Dunhuang project and the British Library. By selecting an area and clicking the mouse, the viewer can access another interactive screen (Figure 8). This interactive map allows the viewer to select and view archeological sites, monumental remains, routes, and so forth.

Multimedia Search Over the Web

Today, there are more than 275 million multimedia files on the Web. On average, Web surfers interact with sites containing multimedia content up to 25 times longer than with sites with static content.

FAST Multimedia Search (http://www.fastsearch.com) is currently one of the largest integrated multimedia search products on the Internet, allowing users to receive results for image, audio, and video files on a single, results page. Users simply search by keyword, and as a result, all retrieved multimedia files are accessible from the results.
Figure 8: The user can select to view archeological sites, monumental remains, routes, and so forth. (From http://www.archaeology.usyd.edu.au/research/timemap.)

Figure 9: Lycos offers the largest integrated multimedia search engine on the Web. It includes 60 million images, sounds, and videos. (From www.multimedia.lycos.com.)
Another, more advanced search of the multimedia repository is content-based retrieval, where the user provides information about the actual contents of the image, audio, or video data, rather than just keywords (Marques & Furht, 2002). A content-based search engine translates this information to query the multimedia database and retrieve the candidates that are likely to satisfy the user's request.

An example of a commercial content-based image retrieval system is a product suite from LTU Technologies (http://www.lututech.com), which includes five products: Image-Filter, Image-Indexer, Image-Seeker, Image-Shopper, and Image-Watcher. The core of the system is a high-level perceptual image analyzer that is capable of indexing, recognizing, and describing images according to their visual features. Figure 10 illustrates the operation of the system.

**Integration of the Web With Traditional Media**

There is a growing trend in integrating the Web with traditional media, such as radio and television. As the streamed multimedia protocols for audio and video have matured, a number of radio and television stations have begun offering live and near-live audio and TV content over the Web. Examples include Yahoo! Broadcast radio and television Web sites (http://www.broadcast.com/radio and http://www.broadcast.com/television).

In addition, some programs are capable of supporting active user feedback, and even participation, so we can
expect a number of new video-on-demand and interactive TV applications.

CONCLUSION
The synergy between new multimedia technologies and the Web have brought new delivery mechanisms and new types of applications. We are still in the first phase of this marriage, where we are faced with such technical challenges as how to efficiently transmit multimedia data over the Internet and how to best use our new tools. However, the focus is already moving to new areas, such as a new kind of mass media. How to better access the Web, reach and involve their audiences, and how to users can better access the Web’s wealth of multimedia information (Wynblatt et al., 2000).

APPENDIX
The following is a list of Web resources.

ActiveX An OLE object, which is a class library that contains a complete set of functions for manipulating an object. It is used to create a wide range of Web site capabilities.

Client-Side Scripting Scripts embedded in Web pages that provide interactivity by processing and responding to user inputs.

Constant Bit Rate (CBR) A type of network service in which the amount of network traffic follows a regular pattern, proportion to the amount of information that is being transferred.

High Definition Television (HDTV) An imaging system with a resolution of approximately twice that of conventional television in both the horizontal and vertical dimensions, and a picture aspect ratio of 16:9.

Java 3D (J3D) API Provides a set of classes for writing 3D graphics for Java applications and Applets.

Java Applets Programs that are embedded in Web pages and can be used to create multimedia Web pages.

Java Media Framework (JMF) Tools that provide the integration into Java applications and Applets of a wide range of audio and video formats, advanced imaging, animation, 2D and 3D graphics and modeling, as well as speech and telephony support.

JavaScript A scripting language that can be used to create interactive multimedia Web pages.


Mean Packet Transfer Delay The average value of the overall end-to-end delay between source and destination in a packet-switched network.

MPC-1 Part of a set of standards that defined minimum hardware and system software specifications for PC hardware for the earliest multimedia PCs. MPC-1, particularly, was based on Intel’s 386SX processor. The last MPC standard published was MPC 3. There are currently no plans for the publication of any additional MPC standards.

Motion Pictures Expert Group (MPEG) Responsible for definition of several standards widely adopted for encoding, compression, and description of audiovisual contents.

Packet Switching Refers to a switching technique by which the information to be transferred between two end computers is divided into packets and relayed through intermediate nodes (routers) along the way.

Quality of Service (QoS) A collection of application and/or network requirements that must be met to enable an application to work on a specific network.

Streaming Refers to the continuous transfer of information from source to destination.

Variable Bit Rate (VBR) A type of network service in which the amount of network traffic may follow an irregular pattern, mainly because of the nature of compression algorithms used at the source.

VBScript A scripting language from Microsoft that is based on Visual Basic. It is used to create interactive multimedia Web pages.

Virtual Reality Modeling Language (VRML) A text-based language used to construct 3D images and 3D text for Web pages.

CROSS REFERENCES
See Active Server Pages; ActiveX; Circuit, Message, and Packet Switching; Collaborative Virtual Reality (Virtual Reality on the Internet); Java; JavaScript; Multimedia; VBScript (Microsoft Visual Basic, Scripting Edition); Video Streaming.

REFERENCES


