Integration of Multimedia and Satellite Technologies for Teaching and Learning

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Abstract

This paper presents a study on integration of multimedia and satellite technologies for education. We design an experiment with use of both technologies on the Internet and WWW platform to provide a hybrid information delivery system for teaching and learning. The experiment, one of Pennsylvania Link-to-Learn technology testbeds, is to assimilate, deploy, and evaluate a hybrid information delivery system that integrates broadband capabilities of direct broadcast satellite (DBS) and the peer to peer attributes of Internet technologies using satellites. The hybrid system was designed to integrate networked, broadcast, digital, interactive and multimedia technologies for delivery of media rich content to targeted users. With the use of large screen multimedia PC/TV convergent systems, multimedia-based teaching materials can be comfortably viewed by all students in the classroom and can be easily manipulated by the teacher via wireless controls. This research demonstrated the use of these technologies in selected K-12 classrooms and community agencies in the Lehigh Valley of eastern Pennsylvania, USA.

Keyword: Multimedia, direct broadcast satellite (DBS), DirecPC, K-12 education.

1. Introduction

The emergence of Internet and World Wide Web technology as a transport for distributing and accessing teaching and learning resources has provided opportunities to create new and unique learning environment. Riley [3], U.S. Secretary of Education, acknowledged this phenomenon connecting every school in America to the Information Superhighway, and helping every teacher develop the tools and skills they need to enhance student learning through technology are two of the goals of the technology literacy challenge for the U.S. Department of Education in the 21st century. However, limited bandwidth of the Internet is one of the obstacles that currently hinders the quality and speed of instructional materials delivered over the Internet. In addition to limited bandwidth, many of rural areas do not have the infrastructure to provide the Internet access.

For educational purposes, data transmission speed and bandwidth are crucial to high quality educational materials delivered via the Internet. Conventional LAN based network may provide the transmission speed needed, however, it is sometimes too costly for some schools who are not able to afford to implement or even impractical for the schools in rural areas. According to the Communications Industry Researchers (CIR) report, the broadband satellites provide a promising alternative to conventional LAN based network solutions. To facilitate students and teachers access to the Internet at low cost, thus enabling them to receive a variety of instructional materials, such as images, audio, animation, and video efficiently, the hybrid system of broadband satellite and the Internet may provide one solution especially for schools in the rural area.

The purpose of this project was to assimilate, deploy, and evaluate a hybrid Internet and Direct Broadcast Satellites information delivery system linking digital content with targeted K-12 schools. The hybrid system was designed to integrate networked, broadcast, digital, interactive and multimedia technologies for delivery of media rich content to targeted users. By means of large screen multimedia PC/TV convergent systems, multimedia-based teaching materials can be comfortably viewed by all students in the classroom and can be easily manipulated by the teacher via wireless controls. This project demonstrated the use of these technologies in selected K-12 classrooms and community agencies in the Lehigh Valley of eastern Pennsylvania.[1] For example, curriculum-based video clips on Coral Reefs off the coast of Florida and Jason Explorations were either digitized / archived on a video server or broadcast via DBS satellite transponder to stand-alone learner workstations. That is, digital resource materials could be received on demand or on a scheduled basis from the Hughes satellite transponder via the Internet browser and a 24-inch satellite dish wired to a desktop computer in a classroom.

2. Project Goals and Objectives

The goals of the this project were: to assimilate, deploy, and evaluate a hybrid Internet and Direct Broadcast Satellite (DBS) system linking digital content with targeted K-12 schools in the region with advanced digital telecommunications, computing, and information technologies for the purpose of creating and delivering enhanced interactive broadband learning media; to create networkable interactive digital multimedia learning materials to be deployed through a regional digital library; and to foster innovation and experimentation in the design, development, and deployment of digital learning materials utilizing delivery systems capable of accommodating different learning styles based on either learner-controlled and/or teacher-controlled learning environments.

2.1 Objectives

The objectives of this testbed project were to create and evaluate the following infrastructures for the creation and distribution of digital media learning resources:

(a) A single stand-alone DirecPC workstation with access to both the Internet and Direct Broadcast Satellite transmission of media resources (Test Sites: Bethlehem, Parkland, Centennial, Hispanic American Organization, WLTV Channel 39, Service Electric Cable Company, and Lehigh University),

(b) A DirecPC workstation with access to Direct Broadcast Satellite transmission of media resources for distribution on a LAN (Test Site: Schnecksville Elementary School, Parkland School District),

(c) Satellite digital video media (MPEG I) transmitted from the Direct Broadcast Satellite and redistributed to project partners.

(d) A single stand-alone DirecPC workstation with a portable receive dish that can be repositioned as the Educational Space Shuttle travels to diverse and remote locations to redistribute media resources received from the Direct Broadcast Satellite,

(e) Create curriculum-based digital media resources for archival to and distribution from a Regional Digital Distribution Center at Lehigh University.

The content delivered in these test environments were the Video feed and Internet resources created for the JASON IX: Oceans of Earth and Beyond expedition, the CNN video feed from the Hughes transponder, and digital media content, Coral Reefs, created as a result of objective (e) above.

3. Partners

Partners collaborating on this project include the Bethlehem Area School District, the Parkland School District, the Centennial School, the Diocese of Allentown, the Hispanic American Organization, the area public broadcasting station (WLVT Channel 39), Service Electric Cable Company, and the Interactive Digital Multimedia Research and Development Laboratory at Lehigh University. Major corporations participating in this project on a contractual or service basis are Hughes Technical Operations Company and Service Electric Cable Company.

The immediate beneficiaries of this project were selected middle school age children in the Parkland School District, high school students in the Bethlehem Area School District, elementary school age children at Holy Child Elementary School, the severely emotional disturbed learners attending Centennial School, and the learner constituents served by the Hispanic American Organization of the Lehigh Valley. While elementary, middle, and high school age children were the primary beneficiaries of this test project, the benefits of these technologies can be extended to any individual or group of individuals in either a formal or informal setting depending only on the nature of the content to be delivered and access to Direct Broadcast Satellite and the Internet, and in some cases access to high speed ATM fiber networks.

4. Technical Description

The computing and telecommunications industry has drawn considerable attention with the emergence of two different but complementary technologies. The Internet has captured the imagination of the educational establishment, corporate America, and the individual consumer. More recently Direct Broadcast Satellite (DBS) systems have gained some prominence by offering high-speed data transmission (DirecPC) and broadcast quality television (DirecTV) to corporate America and into the home. The Internet has been characterized by a narrow bandwidth technology in most cases inadequate for serious interactive multimedia interchanges; impregnated with HTML formatted content; governed by a set of standard protocols (TCP/IP and HTTP); and generally perceived to have limitations of speed and service to remote areas by conventional means. Direct Broadcast Satellite on the other hand offers Internet access at speeds exceeding ISDN connections by a factor of 3 and at considerably less cost. DirectPC is a system with satellite down-link and a modem back-channel. Based on the study in[10] , DirectPC is one of the fast-Internet technology.

Direct Broadcast Satellite technology can deliver video on demand and high-speed connection to the Internet today. They provide five different services/bandwidths to transmit information based on the users' needs.[1,2,4,5]

1) Turbo Internet Service – based on TCP/IP protocols. Users can get 400Kbps average bandwidth from the total 24Mbps bandwidth.
2) Multimedia Service – provides 1.5Mbps bandwidth for MPEG-1 or AVI video broadcast or real-time media streams.
3) Package Delivery Service – can deliver file packages to users at 3Mbps speed.
4) File Broadcast – can transfer files to unlimited number of users using push technology at speed of 3Mbps.
5) Package Explorer – Users can download information package at the speed of 3Mbps.

The overall architecture of data transmission using DirecPC and PC/TV systems is illustrated at Figure 1.

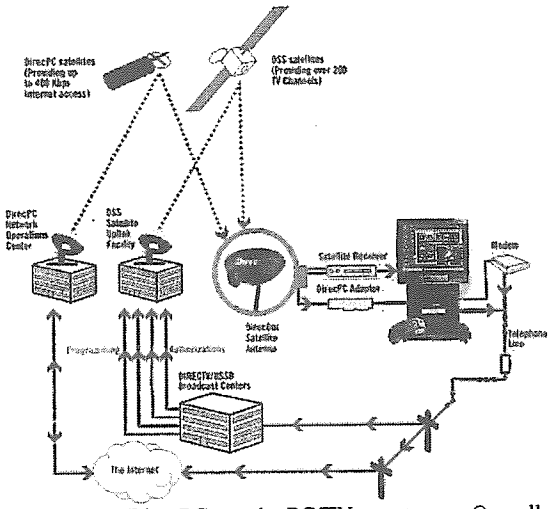

Figure 1. DirecPC and PC/TV systems Overall Architecture.

Direct broadcast to a host server and distributed via high-speed ATM networks on LANs and Intranets have been demonstrated to be an effective means for delivering interactive learning materials to the desktop. (See Figure 2)

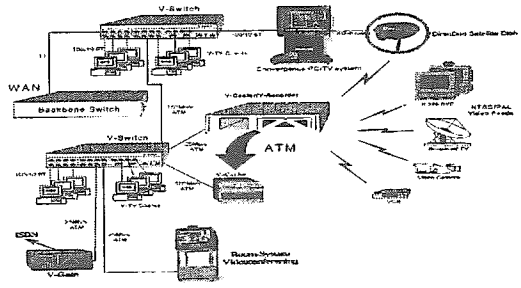

Figure 2. DirecPC with LANs and ATM architecture.

Unlike the point to point connectivity model of the Internet, the digital broadcast medium has demonstrated its ability to be used in real-time or in download mode to broadcast, multicast, and pointcast a set of educational materials and content on a pre-arranged schedule or on demand. Methodologies to capitalize on the broadcast medium also include the use of cable. Broadcasting can fully complement access to the Internet or can be deployed stand-alone, that is, without a terrestrial network. Direct Broadcast Satellite and cable networks have demonstrated their capacity to enable broadcast applications and services. In addition, standard developments such as Digital Video Broadcast (DVB) and recent deployment of DBS systems such as DirecTV and DirecPC have created ready access to the technology and the services and applications of broadcasting to the classroom.

Previously unrealized video on-demand, interactive television models and interactive multimedia applications have been replaced by the realities of the emergence of the massive deployment of DBS and the Internet. As a result access to DBS and the Internet can offer a competitive alternative or complementary adjunct to terrestrial network systems for delivery of the same services.

5. DBS/Internet/LAN Infrastructure

The DBS solutions are ideal for massive distribution of educational content organized for delivery to a single point client device or a Video Server for subsequent dissemination. The broadcast delivery mode enables the universal deployment of broadcast, multicast, and pointcast media. This therefore makes it suitable for :

- uniform content delivery to all schools and homes in a geographic region.
- targeted content delivery to a subset of very disperse schools, or
- targeted content delivery to only one target school in a remote region.

This implies that in addition to providing access to all forms of content anywhere, the same deployment over DBS can be configured to provide multilingual capabilities via audio tracks, multimedia tracks, or different text tracks. The Model exploits extensively the educational potential of standard formatted MPEG content, because of the rich set of educational content that can be packed in short clips of multisensory media and its applicability for transmission via Direct Broadcast Satellite.

6. Value as a Testbed

Direct Broadcast Satellite technologies conform to standard data transmission protocols that are compatible with most telephone, cable, and computer network systems. Consequently, the DBS technologies can be combined with any of the standard network systems to form regional hybrid network configurations compatible with a statewide telecommunications system as envisioned for the Commonwealth PEN network system.[7] DBS technologies are both competitive and complementary to terrestrial-based delivery systems. The DBS system offers the prospect of broad bandwidth distribution of curriculum-based media resources at an affordable cost to school districts. Indeed, DBS technologies provide the enabling technologies for video on demand or on a scheduled basis from regional, national, or international databases of mediated curriculum. In addition, DBS technologies promote the development of shareable curriculum-based media resources archived in digital libraries.

7. Evaluation Results

The outcomes and benefits projected for this project were measured against the following criteria: (1) system reliability, (2) information transfer rate, (3) ability to rapidly scale and deploy systems, (4) the quality of transmitted resources, (5) compatibility with existing terrestrial networks, (6) the competitive and

complementary nature of the DirecPC system; (7) user acceptability; (8) efficacy of procedures for creating curriculum-based media resources for archival to and distribution from digital libraries, and (9) adaptability to other communities. Instrumentation for assessing the project outcomes was developed to evaluate the project relative to the criteria listed above.

7.1 System reliability

The project personnel experienced problems with the initial setup of the Compaq Theatre, primarily with the 36 inch monitor (two of four had to be replaced) and problems with the TV tuner card for the Gateway System. On May 19th, 1998, the Galaxy IV satellite disappeared from its orbit and could not be contacted. Subsequently, the DirecPC dishes had to be repositioned to point to a new satellite, Galaxy III-R. The new satellite required an update in DirecPC software and the implantation of a new PCI card. The new PCI card created hardware conflicts with both the sound boards and the video cards on both the Gateway and Compaq systems. These problems were resolved by the project technician. The type of hardware and software problems encountered were not the type one would typically expect the classroom teacher to fix nor for that matter many computer technicians. One must understand however, the convergent systems were basically new technologies. It should also be noted that on the other hand, Compaq has discontinued the production of the PC Theatre and Gateway has enhanced their Destination System improving both the quality and size of their monitor with an improved computer box design having the analog and digital connections on the front panel of the computer rather than on the rear of the computer.

7.2 Information transfer rate

Multiple readings on different media applications were taken at three different times during the day: morning, noon, and early afternoon. See the matrix chart of times, file formats, encoded bandwidth rates, and download speeds [see Figure 3]. Use comparison charts: 56, 300, 500 kps.

Time	Format	bandwidth	10/14/98	10/15/98	10/19/98	10/20/98	11/02/98	11/10/98	11/11/98	Average
11:00AM	RealVideo	56k	47.9kps	46.5kps	45.8kps	46.5kps	47.7kps	45.6kps	46kps	**46.57kps**
		300k	286.8kps	277kps	283.7kps	261kps	317.7kps	292.8kps	317.8kps	**290.97kps**
		500k	227.5kps	239kps	238.9kps	223.8kps	236.7kps	238.9kps	206.5kps	**230.11kps**
	QuickTime	download	56.7kps	48k	46.8kps	43.4kps	45.3kps	46.4kps	20.1kps	**43.81kps**
		streaming	32.7kps	36.1kps	53.6kps	24.7kps	37.5kps	32.7kps	54.3kps	**38.8kps**
	Windows Media	High bandwidth	54.8kps	90.2kps	51.8kps	42.3kps	55.1kps	50.5kps	102kps	**63.81kps**
1:00PM	RealVideo	56k	45.5kps	45.8kps	45.7kps	45kps	33kps	47kps	45.6kps	**43.94kps**
		300k	295.2kps	307.6kps	312.9kps	298kps	313kps	275kps	318kps	**302.81kps**
		500k	256.4kps	155.2kps	208.7kps	239kps	228kps	237kps	208kps	**218.9kps**
	QuickTime	Download	45.4kps	54.4kps	53.6kps	31kps	30.1kps	53.7kps	33.4kps	**43.09kps**
		Streaming	32.2kps	71.2kps	45.3kps	23kps	13.8kps	31.2kps	31.2kps	**35.41kps**
	Window Media	High bandwidth	36kps	78.9kps	103kps	86.7kps	42.1kps	57.5kps	132.9kps	**76.73kps**
4:00PM	RealVideo	56k	45.8kps	44.6kps	45kps	48kps	45kps	45.7kps	41.7kps	**45.11kps**
		300k	265.5kps	214.3kps	276kps	284.2kps	217.8kps	309.6kps	318kps	**269.34kps**
		500k	236.7kps	229.6kps	239kps	236.7kps	234.4kps	238.9kps	236.9kps	**236.3kps**
	QuickTime	Download	14.2kps	40.8kps	39.5kps	48.7kps	51.2kps	46.7kps	45.1kps	**40.89kps**
		Streaming	2.3kps	10.2kps	32.2kps	69.3kps	23.4kps	20.5kps	64.7kps	**31.8kps**
	Window Media	High bandwidth	108.5kps	44.8kps	84.9kps	45.5kps	50.3kps	54.1kps	51.7kps	**62.83kps**

Figure 3. DirecPC transmission speed testing results.

7.3 Ability to rapidly scale and deploy systems

The DirecPC is a wireless technology with MPEG I and Internet distribution capability to anywhere in the United States and into parts of Canada and South America. Large scale projects utilizing the small dish technology have been or are being established in the rural communities of California and Nevada.

7.4 The quality of transmitted resources

Direct broadcast of MPEG I encoded video to client station via DBS produced VHS quality video, 30 frames/sec in screen size 320 x 240 pixels. The best quality transmission of RealVideo encoded video was done at 300 kps.

7.5 Compatibility with existing terrestrial networks

The DirecPC convergent system is compatible with and requires connection to a terrestrial Internet distribution carrier to request information to be down streamed to the DirecPC dish for individual consumption, LAN distribution, or WAN real-time terrestrial distribution systems.

7.6 The competitive and complementary nature of the DirecPC system

The DirecPC is competitive with terrestrial ISP providers on several accounts: First the DirecPC can be quickly deployed to geographically dispersed or remote users without an expansive infrastructure. And secondly, the dollar/speed trade-off is favorable for the DirecPC distribution system. New vendors such Skystream Inc. and others are beginning to offer satellite services.

7.7 User acceptability

Users' responses to a likert type attitude scale revealed a positive predisposition toward system as well as quality of content delivered.

7.8 Efficacy of media-based Instructional Applications

The Coral Reefs application [Figure III] was developed for distribution on the Internet via DirecPC. The DirecPC system permits faster access to digital resources than either 28.8kps, 56kps, or ISDN distribution system. Hughes had recently joined forces with Apollo Group to provide multimedia instructional resources for schools.

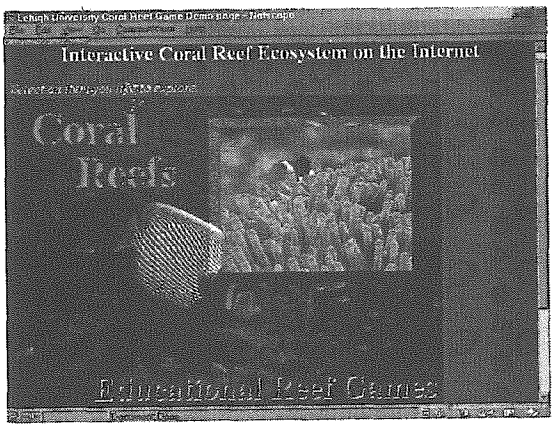

Figure 4. Coral Reefs Curriculum.

7.9 Adaptability to other communities

During the past 18 months DirecPC system have been widely adopted by schools in remote areas of Canada, California, and Nevada.

8. Conclusion

We found that users can deal with the new convergent systems and satisfy with satellite transmission from the results of the convergent technology survey. They would like to recommend these systems with hybrid satellite communication and multimedia PC/TV convergent technologies for use in teaching and learning.

Clearly, knowledge generation and learning now centralized and institutionalized will become distributed and individually paced. The combination of interactive television and the transition from a philosophy of mass communication to custom communication systems will increase both the level of user control and the complexity of design for distributed information and learning systems. It seems quite clear however, that these new systems are doomed to failure unless the learner is provided with some form of embedded help to acquire the prescribed domain knowledge. Hence the need to create new hybrid models for designing and delivering interactive mediated curricula.

The benefits of this testbed project included the identification of affordable communication structures that complement or extend extant infrastructures and add value to the educational process through the shared development and use of educational digital media resources.

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