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Digital Middletown Schools Project: A Glance to the Future

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This article reports on the deployment of a high-bandwidth wireless network for content distribution to two schools. The project, titled Digital Middletown, builds upon the sociological Middletown studies from the 1920s (Lynd & Lynd, 1929) to understand how "Middle America" reacts to and addresses societal change. We report on the deployment of different types of content by way of a high wireless bandwidth over long distances in an effort to establish a national prototype. As bandwidth becomes cheaper; compression and distribution technologies improve, new and more pervasive long distance high bandwidth wireless technology will make content such as high definition media files, synchronous videoconferencing, and simulations and games part of the educational process.

In 2004, Ball State University sought to comprehensively test the deployment and the usability of interactive media delivered over long distance high-bandwidth wireless technologies. Our project, titled the Digital Middletown

Project (DMP), investigates how the availability of a high bandwidth (30 Mbps) wireless network impacts the delivery of educational, entertainment, and social activities. Deployment of a high-bandwidth wireless network allows for content distribution to a wider geographic area than more traditional means (e.g., dialup, cable). The network provides a development ground for widespread distribution of content for testing and distribution directly into classrooms and schools. The project brings together full time staff in Information Technology, faculty in Teachers College, and staff in two elementary schools. Each group brought unique prior backgrounds, experiences, and perspectives to the planning and implementation process. Project partners included Gateway™, Proxim™, Alvarion™, MIT, Movielink™, and Discovery Company™ with support provided by the Center for Media Design at Ball State University and funding from the Lilly™ Endowment.

PROJECT DESCRIPTION

The Digital Middletown Project builds upon the sociological Middletown studies by Robert and Helen Lynd in the 1920s (Lynd & Lynd, 1929). Project goals continue Lynd's vision to understand how "Middle America" reacts to and addresses societal change. As trends point to a digital future rich with high definition video, simulations, virtual reality, and 3-D games, it is important to understand the issues related to implementation of very high levels of bandwidth along with the potential uses.

The goals of Digital Middletown centered on two domains of application: education and community. This report addresses the school network delivery typology. These goals included:

1. Installation of a wireless, high bandwidth network to two elementary schools.

2. Testing the value, impact, and educational potential of content using the network.

3. Facilitating collaboration between K-12 teachers and Ball State University faculty in the development of new digital teaching resources and the customizing of available resources.

4. Defining new educational content models and practices based on the application of digital animation or interactivity.

Relevant Literature

According to the Corporation for Public Broadcasting (CPB, 2003), home broadband use has increased in the past two years (2001-2003), from 10% to 37% with the average household income of a broadband family being $72,000. Children with broadband at home report that such high speeds affect both their online and offline activities, including schoolwork.

> For children ages 6-17 with a home broadband connection, 66% report spending more time online, 36% watch less television, and 23% get better grades, with 13% of parents citing their household broadband for their children's improved academics. Studies show that household broadband does not lead children down the path of academic incompetence, but instead encourages learning online, from which parents see great benefits to be gained. (CPB, 2003, p. 8)

There is a need to better understand the practical and realizable potential for the increased bandwidth that may soon become available to our schools to enhance the educational process and to develop the appropriate tools and infrastructure to support this. Seventy-two percent (72%) of small schools—those with fewer than 300 students—had high-speed access, compared to 85 % of all schools. Most of these small schools are in rural areas (National Center for Educational Statistics, 2001). In February 2004, the Pew Internet and American Life Project released a report that outlined how broadband adoption is growing in urban, suburban, and rural areas, though larger percentages for urban and suburban than rural users. Between 2000 and 2003, the study found that while the number of home broadband users grew from 8% to 36% of the online population in urban communities, and from 7% to 32% in suburban communities, the number of home broadband users in rural communities only grew from 3% to 19%.

In addition, the United States Congress' Web-Based Education Commission's seven areas for action related to improving learning in web environments (2001) include:

1. *Broadband access.* Powerful new Internet resources, especially broadband access, that are widely and equitably available and affordable for all learners.

2. *Professional development.* Continuous, relevant training and support for educators and administrators at all levels.

3. *Research and development.* New research on how people learn in the Internet age

4. *Quality of content.* High-quality online educational content that is widely available and meets the highest standards of educational excellence.

5. *Regulations and e-learning.* Relief from outdated regulations that impede instructional innovation in favor of approaches that embrace anytime, anywhere, anypace learning.

6. *Privacy and protection.* Safeguards to protect online learners and ensure their privacy, especially young children.

7. *Funding.* Sustained funding—through traditional and new sources—that is adequate to the challenges at hand.

In addition, the current National Educational Technology Plan released in January 2005, by the United States Department of Education and the Office of Educational Technology outline seven action steps to help states and districts prepare today's students for the future. Two of the action steps and recommendations are relevant to this discussion.

Broadband access:

1. Thoroughly evaluate existing technology infrastructure and access to broadband to determine current capacities and explore ways to ensure its reliability.

2. Encourage that broadband is available all the way to the end-user for data management, online and technology-based assessments, e-learning, and accessing high-quality digital content.

3. Encourage the availability of adequate technical support to manage and maintain computer networks, maximize educational uptime, and plan for future needs.

Move toward digital content:

1. Ensure that teachers and students are adequately trained in the use of online content.

2. Encourage ubiquitous access to computers and connectivity for each student.

3. Consider the costs and benefits of online content, aligned with rigorous state academic standards, as part of a systemic approach to creating resources for students to customize learning to their individual needs. (United States Department of Education, 2005).

Common themes in these reports and others center on broadband access to schools for the delivery of digital content/e-learning. In this article, we address the two themes in the process of deploying a high-capacity broadband wireless network to serve educational communities and the delivery of content to four elementary classrooms. By researching the educational and technical processes, we foresee offering a national prototype for the application of high bandwidth for classrooms and communities.

SCHOOL TECHNOLOGY CONTEXT

In October 2004, each school principal completed the School Technology and Readiness Chart (STaR Chart) Diagnostic Tool (CEO Forum, 1999) prior to participation in the project. This tool is designed to assess the progress of schools and districts in integrating technology into the curriculum. A subset of the resulting data specific to the goals of this project is shared in Table 1.

Table 1
Subset of Data from STaR Chart Diagnostic Tool

CONNECTIVITY	School 1	School 2
What percent of your classrooms are connected to the Internet?	More than 50% of classrooms are connected to Internet	More than 50% of classrooms are connected to Internet
How are the majority of users gaining access to the Internet?	LAN	LAN
What type of Internet connection does the majority of your computers have?	T1 line	T1
What percent of your students have an e-mail address provided by the school?	0-30%	0-30%
What percent of your teachers have an e-mail address provided by the school?	Over 80%	Over 80%
CONTENT		
Do most of your student use ***drill and practice programs*** on a regular basis as part of the curriculum?	No	No
Do most of your students use ***basic authoring applications*** such as word processors, spreadsheets, and drawing programs on a regular basis as part of the curriculum?	Yes	Yes
Do most of your students use ***advanced authoring applications*** such as web publishing software, presentation software and/or collaborative groupware on a regular basis as part of the curriculum?	No	No
Do most of your students use ***simulation software*** on a regular basis as part of the curriculum?	No	No
Do most of your students use ***CD-ROM research resources***?	No	Yes
Do most of your students use the ***World Wide Web*** on a regular basis as part of the curriculum?	No	No

This general assessment demonstrates a typical infrastructure and curricular use of computers for each of the two schools at the project outset. Like many K-12 schools, the schools in this project did not have ready access to computers for high-end multimedia creation or delivery. Each school's network included a T1 line with each classroom having at least one Ethernet port.

Network Infrastructure

The Digital Middletown Project (DMP) connects two area public elementary schools and a surrounding neighborhood to Ball State University's data network by way of Proxim Tsunami™ at 30 Mbps full duplex and Alvarion Breeze Access™ at 24 Mbps full duplex. The DMP infrastructure includes, long distance connections form base stations to subscriber units, and connections from subscriber units to classes and homes (Figure 1).

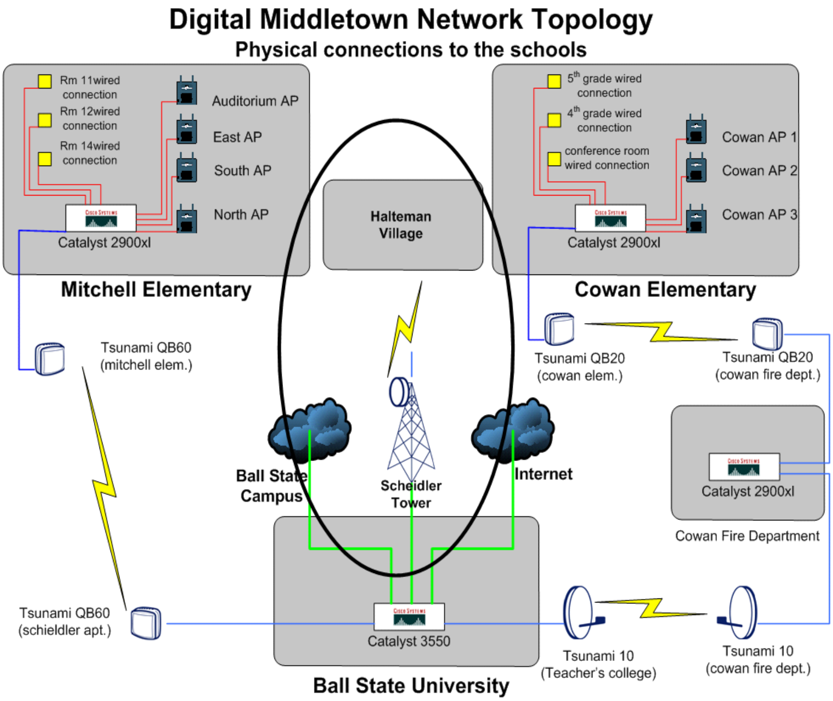


Figure 1. Digital middletown network typology

Participating schools. Mitchell Elementary School is located approximately one mile from the university. The school received a 60Mbps (30 Mbps symmetrical) half-duplex wireless backbone connection to Ball State University's data network. Within Mitchell Elementary School, data equipment was installed, providing 10/100 Mbps wired data connections. To supplement the wired connections, four "access points" were installed throughout the school. Each access point was configured with 802.11g radios. The access points provided all wireless connected devices the ability to connect at a shared speed of 54 Mbps.

Cowan Elementary School is located approximately seven miles from the university. This school was connected with a 24 Mbps (12 Mbps symmetrical) half-duplex wireless backbone connection to the data network. This first link connected Ball State University to the local fire department. Within the fire department, a network switch provided 10/100 Mbps data connections. From the fire department, another wireless point-to-point link connects to Cowan Elementary School. The wireless point-to-point connection from the fire department to Cowan Elementary School is a 20 Mbps half-duplex link. Within Cowan Elementary School, data equipment was installed, providing 10/100 Mbps wired data connections. To supplement the wired connections, three access points were installed. Each access point was configured with 802.11g radios. The access points provided all wireless connected devices the ability to connect at a shared speed of 54 Mbps.

Content. The deployment of the digital content to the neighborhood includes regular and high-definition movies, games, and regular and high-definition titles/modules from the Public Broadcasting Service, Discovery Communications, and Electronic Field Trips (EFTs). Following deployment and testing of the network, a range of content and capabilities were made available to participating schools through a campus portal (http://www.bsu.edu/digitalmiddletown).

DISCOVERY EDUCATION'S UNITED STREAMING™ VIDEO (HTTP://WWW.UNITEDSTREAMING.COM)

United Streaming is a digital library of over 40,000 standards-based video clips for K-12 classrooms. Teachers and students download or stream the video files to a local computer that can be inserted into presentation software or viewed as stand-alone. United Streaming also includes curriculum guides and quizzes as part of services with a subscription.

ELECTRONIC FIELD TRIP SERIES LIVE BROADCASTS (HTTP://WWW.BSU.EDU/EFT)

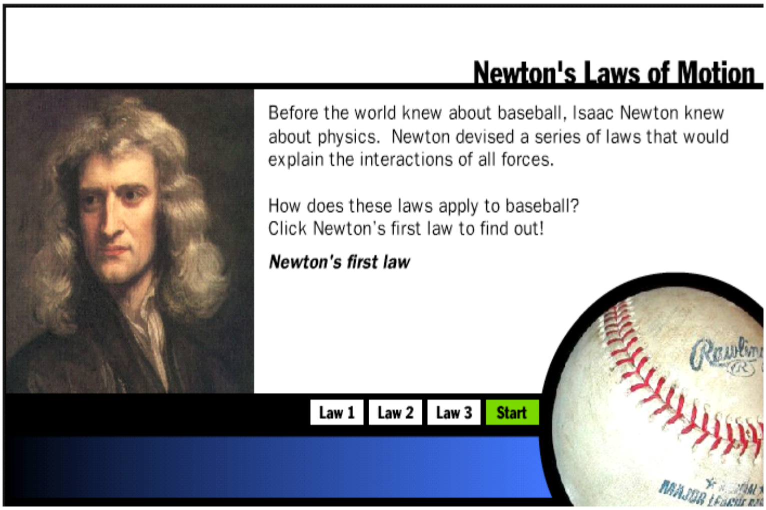
The EFTs are a combination of live, interactive broadcasts along with online curriculum. Many field trips feature partnerships with national institutions and museums such as the Smithsonian Environmental Research Center, National Air and Space Museum, and the National Museum of Natural

History among others. Teachers are provided with sample standards-based lesson plans and student activity guides.

VIDEO CONFERENCE CAPABILITY

In conjunction with the Electronic Field Trip broadcast in November 2004 at the Grand Canyon, classrooms in the Digital Middletown Project participated in a synchronous video conference activity with a Grand Canyon park ranger. Students engaged in discussion, activity, and hands-on projects centered on the topic of plate tectonics.

REPURPOSED ELECTRONIC FIELD TRIP INTERACTIVE MODULES (HTTP://WWW.BSU.EDU/EFT/DEV/DM_MODULE/01_SPRINGTRAINING.HTM)



Modularized web environments were repurposed from a prior live EFT broadcast titled Fastballs, Flips, and Physics (http://www.bsu.edu/eft/sandlot/). The environment includes text along with streamed video from the live program as well as classroom teachers demonstrating activities with students. The repurposed modules also include interactive simulations on various physics topics.

MIT REVOLUTION GAME—EDUCATIONAL ARCADE (HTTP://EDUCATIONARCADE.ORG/REVOLUTION)

Thumbnail image of courthouse scene

Revolution is a multi-player online role-playing game for secondary students situated during the American War for Independence developed with the assistance of Colonial Williamsburg. Each player navigates the space of the town, interacts with other players, and is given the opportunity to act in and react to various events that in one way or another represent the coming of the war. Players can explore and improvise their own narrative based on the resources available to them, as well as their interactions with other players.

Network results and recommendations. The transmission of high quality IP video benefits from adopting Quality of Service(QoS), which allows the wireless network the ability to prioritize real-time, low-latency traffic such as video. Additionally, a limited multicast capability is now a part of many wireless access point feature sets. Our findings also show that deploying amplified, non-diversity access points will extend distance but severely reduce the reliability of the signal, especially for users on the perimeter of the cell by allowing the Radio Frequency(RF) to fluctuate much more. As a result, we recommend utilizing QoS, multicast, and diversity whenever possible.

Reliable transmission of a high bandwidth, saturating video stream can be obtained by higher quality, and higher cost, radio equipment that provides a full-duplex data path. Particularly when traffic is congested onto a shared path such as a point-to-point trunk, the toggling between transmitting and receiving on a half-duplex path can be detrimental. As a general observation, we have learned that excessive amounts of bandwidth can minimize the effects of a half-duplex system but a full-duplex system can use the same bandwidth much more efficiently. While full-duplex systems are generally available for point-to-point wireless trunks, it is not generally available for access points or direct user association from a laptop or wireless card.

Content delivery results and recommendations. All content was available as video on demand files or live streams files through a Windows Media 2003 Enterprise Server. An agreement with United Streaming™ allowed us to view encoded traditional files available at a video server located at a United Streaming Web location as 300 kb video on demand (VOD) streams. We were successful in attaining 15-16 simultaneous access points on student laptops. The streams were low bandwidth adequate for viewing by one or two students. However, teachers displayed the streams through the projectors and by doing so, created a less than desirable outcome in video quality. Forcing the media viewer and the stream to full screen on the laptop for projection resulted in increased pixel size, thus reducing the resolution and clarity of the video stream. Consequently, it was suggested that we access the 1.5 mg streams available through United Streaming™. To increase quality we requested BetaSP copies of a subset of titles from United Streaming. We encoded the titles as standard definition VOD files (Windows Media 9 encoded at 640 x 480 at 2-3 mpbs) and are now available in 2 mpbs) streams. The high definition signal was successful only at certain bandwidths at Mitchell Elementary School. The 8 mbps 1080i HD signal was problematic in almost all delivery methods. Less buffering and blocking occurred when we used the wired connection through the Catalyst 2900xl switch at the schools. The 6 mpbs HD signal using the wireless access points had similar blocking and rebuffering results as the 8 mps 1080i signal on the wired connection.

The Electronic Field Trips were delivered through the network at a 3-4 mps live stream rate with only minor rebuffering and blocking outcomes. During the testing stages, Cowan Elementary School with the least amount of total bandwidth, was affected more frequently with buffering and blocking than Mitchell Elementary School. When we connected to the live EFT stream at 4 mps and two other data connections for web browsing there was an increase in blocking. When a second 4 mps connection was attempted, the connection rebuffered and blocked significantly. With a 300 kps signal we were able to sustain at minimum of 15 simultaneous connections at Cowan Elementary School. However during the actual web cast, we eliminated the extra connections so that the blocking at Cowan Elementary School was limited.

Participating schools had access to content files encoded at 300 kbps, 2-3 mbps and 6-8 mbps. The 300 kbps files were not adequate for large group presentations using the data projector (1024 x 768 native resolution). However, they were more than adequate for students viewing with the laptops. The 300 kbps VOD stream did not seem to deter the experience or the frequency in which the students accessed the United Streaming titles when given an assignment using the laptops. When using the same United Streaming content in a large screen environment the files were encoded at 2-3 mbps (standard definition [SD] DVD quality), which provided a streaming VOD file that was as good as the original edited master tape provided to us by United Streaming™ (SP Beta format). When showing the high definition (HD) VOD files at 6-8 mbps (HD 1080i) the data projector provided a high quality video signal surpassing the 1024 x 768 digital map size of the data projector. The projector scaled the image accordingly and the result was a very high quality video image with limited blocking and rebuffering.

SUMMARY

Our experience in exploring the potentials of high bandwidth wireless infrastructure and deploying rich media content over a wireless network to area schools serves as one model for others who seek to respond to the call of providing robust delivery solutions for educational purposes.

Much still needs to be accomplished to meet the ambitious goals of K-12 wireless broadband access in relation to digital content delivery set forth by the National Educational Technology Plan and other commissions. As bandwidth becomes cheaper; compression and distribution technologies improve, new and more pervasive long distance high bandwidth wireless technology, such as 802.16, will make content such as high definition media files, synchronous videoconferencing, and simulations and games part of the educational process.

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Note

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