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Abstract

This paper describes how a broadcast education infrastructure can be used to access a digital library of K-12 content. Technical references to prior research and development done in support of this concept are provided. The main goal of this paper is to relate those concepts and technical developments to a solution that emphasizes the role of the teacher. The framework for this solution, EduPort/DBS, attempts to bring tools and technical options to bear on a system for education infrastructure.

Introduction

There are many questions regarding the quality and value of what is learned from television, but there is no question that television is a widespread, visual, virtual, and powerful learning environment. In the Middle East, for example the number of households that have TVs was estimated in a recent survey to be 50 million. Doordarshan, which means television in Hindi, India's state-run broadcaster, accounted for $3.57 billion of TV revenue last year, according to the Indian Market Research Bureau. The cable explosion that began only five years ago is acclimating subscribers in leaps of million, in a nation of 920 million people. The success of television in developing countries shows an acceptance rate similar to what has been experienced in North America. People everywhere accept, like, and enjoy television.

Behind the success of television, as an information medium, lies a very powerful concept for network infrastructure: the broadcast model. Deployed as a broadcast infrastructure for the dissemination of information, "television" can be leveraged to address the serious problem of global education. But, the number of educational approaches deployed, mostly analog broadcasts and live video has limited effectiveness over the use of satellites. More importantly, the effectiveness of any educational environment is limited by the role that the teacher can play in it. Until now, the teacher has played a very insignificant, if any, role in the use of television as an educational tool. Certainly the teacher has no explicit control over television broadcasts, possibly no input at all.

Taking advantage of new opportunities offered by Digital Broadcast Satellite (DBS) solutions, a new global education infrastructure can involve the teacher much more and in critical roles. A new broadcast system (for equity access) coupled with a complementary information organization model and guided in its use by teachers (for content convergence) can become a powerful and efficient, universal and global educational force, that can be deployed at moderate cost, and can reach remote locations with or without coupling with the Internet [1]. This system can provide true equity access and quality. Again, more importantly, is the fact that such a

system may depend on the teacher's ability to guide content convergence, more than on the teacher's ability to teach.

While the teacher has been the trusted vehicle for learning, a fundamental concern held by many, is that we cannot trust technology to be a vehicle for learning. Technology is equally not a vehicle for equitable distribution of educational resources and opportunities, in fact, a more recent but equally profound concern, is that technology can have a very differential effect on educational opportunity: the new class of *have and have-not* set of issues. Public policy recommendations have emerged along side the new waves of technologies as a requirement for equity access [2]. One problem is that solutions that can satisfy the goals of public policy for equitable distribution of educational resources have not been forthcoming. It is good to demand connectivity, but connectivity, as currently advocated, will always tend to be differential. Even if the connectivity problem is resolved, the problem of actually learning over a network must still be conquered. That problem, we believe, is not in the educational resources or the delivery mechanism, but in how to converge on the benefits of specific educational content via some educational process. It should not be ignored that the convergence factor has in the past been attained with the aid of a teacher.

Basic Options

Given the various, feasible technology-based opportunities for distribution of content, and for the building of education infrastructure, how can a *least common denominator* be found to exploit all of them in a complementary fashion? This would certainly reduce teacher training, and improve on equity access for students. The blackboard has been such a common tool for all teachers, over all time, anywhere in the world. Can a technology tool become as pervasive, indispensable, and as universally intuitive to use: a tool of the trade? The television, as a *teacher tool* not a *teaching tool*, has just that potential. Currently three approaches [3] dominate curriculum design in the digital form, and for the use of educational multimedia:

- ✓ stand-alone
- ✓ the Internet
- ✓ digital library

Each carries educational advantages and disadvantages. The stand-alone approach is best exemplified by CD-ROM titles. Contained, localized, limited by copyrights and lack of portability, this solution cannot be easily combined with the predominant networked direction that educational technology is following.

The Internet approach, the hallmark of networking, while supportive of many different educational uses (e.g., communications, collaboration, and content movement) is best exemplified by the World Wide Web (WWW or Web) when it comes to educational uses. A *Web page* can easily compete with any CD-ROM in functionality. Web pages support interactivity, hyperlinking , and rich media types. The Internet, however, limits the value of the Web because it is unable to deliver, at any level of classroom practicality, rich media, for example, video, complex graphics, animation, simulations, and virtual worlds. Interactivity and hyperlinking, like rich media types, are also severely limited by the slow bandwidth of the Internet. It is not the form and function of the Web, but Internet delivery of Web pages that is limiting.

These presumably effective computer-based educational "opportunities" or features (i.e., rich media, hyperlinking, interactivity) can then best deployed stand-alone in dedicated environments, captured in CD-ROM form for portability, or downloaded for reserved use. Then,

again, continuity and sustainability are impacted by the deficiencies of both the stand-alone and Internet approaches. It is not possible to provide all the features (as in a CD-ROM), and the networking with either one approach, in any useful fashion, to support curriculum for 13 years in every subject area, every day of the school year. Teachers could not, and do not, depend on either approach for accountability to curriculum. The problem is not only poor and insufficient connectivity, but also insufficiency of enabled content.

Digital library, on the other hand, in its purest form, addresses the need to more effectively harness content. The *atoms to bits* metaphor [4] captures the essence of this "new", or newly redefined approach. By representing (capturing or encoding) content in digital form we create more opportunities for finding it and transporting it. By separating digital content from the tools that are used to manipulate it we create more opportunities for using it and learning from it. Research and commercial initiatives in digital library integrate with both the Internet and a suite of technology hardware and software tools. Yet, the definition of digital library is still subject to interpretation, making it difficult to decide how to apply the approach systematically to any domain.

One possible definition consistent with the atoms to bits metaphor is that of *a library of digital objects representing physical media*. Such a resource, where content is separate from context, and from packaging, is the first step in being able to achieving convergence over the value of content. Another way to define a digital library, as a *virtual library*, a *library without walls*, adds potential to the value of the approach for equity access. Deployment, whether local or regional, over the Internet or as broadcast solution, of a true digital library for education, is a step towards enhanced teacher participation in the application of the technologies. How digital library enhances the role of the teacher is a question related to the use of content.

Role of the teacher

Because of all the many available options (within the established approaches) for teaching and learning with technology, a great deal of emphasis is being placed on teacher training. Perhaps the reason why it is so necessary to train teachers in the use of educational technology is because teachers do not participate in the design and development of the technologies themselves, or in the development of applications of the technologies. While developing interactive multimedia courseware is beyond the capabilities and possibilities for most teachers, selecting, compiling and converging on the *use of content* is not, teachers do that routinely. Facilitating that task with the use of technology, with a digital library, should be an improvement, not an added burden, and should require minimum training. And, facilitating that task should also enhance, rather than diminish, the role of the teacher.

Secondly, while content application is part of an accepted role for a teacher, curriculum design is not. Most teachers are not curriculum design theorists, anymore than they are multimedia programmers. Typically teachers follow a curriculum, but they do not design it. Equally, teachers use content but, for the most part, do not create it. Teachers are not engaged in the design and development of curriculum or content, they are engaged in *teaching*, something that computers and communications need not redefine, only support.

A digital library, stocked with content that has been well indexed with respect to curriculum goals and standards, can be a valuable resource for any teacher. Giving the teachers an avenue for annotating that content with respect to classroom use would make it richer and more valuable to

all, it would also extend the role of the teacher beyond a particular classroom, the best form of *distance education*. The role of the teacher in the digital world is most critical for the purpose of harnessing content.

Nature of the solution

Most technology-based education carried out today gravitates around CD-ROMs, the Web, and the Internet (e.g., connectivity via modems to schools, and e-mail). The most basic questions that have been raised and explored [5] relating to the "big problems" that would be addressed by these solutions are:

✓ improved learning ✓ accessibility ✓ cost

The reality is that these technology driven solutions still do not provide equal access to educational content over the largest possible population of students, cost effectively. The problem of impact is more profound. Before CD-ROMS, the Web and the Internet, the educational communities were already bewildered and confused by technology [6], the impact has been an unknown. Today, answering questions of impact remains a dangerous speculation. In the meantime while accessibility has increased without established results [7], so has cost.

A new *content infrastructure*, based on the digital library approach, to capitalize on the broadcast medium is possible. Such a solution has been proposed to address problems of educational quality and equity, for large regions of the world [8], in particular for geographically remote and underprivileged regions. It is possible to provide access to specially prepared or *enabled content* over a satellite infrastructure, thus in the absence of a wired infrastructure, and provide access with a device as simple as a digital settop box, thus in the absence of a PC, and with interactivity even in the absence of a return channel.

The global reach of the solution makes it suitable for the home, the school, and the library for delivery over settop boxes or PCs. Since the solution is regionally oriented, because of the nature of the DBS medium, it is best deployed as *curriculum oriented*, over a broad base of "globally" useful content. That is, usage commonality in terms of *educational standards*, *language*, and *geography*, bind together the deliverable content. Expert focus for choosing these sets of *global parameters* is suitable for centralization of services, consistent with the broadcast service model. The receiving environment, under the guidance of the teacher, makes the solution suitable for decision making with respect to content, and facilitation with respect to the use of content or more precisely the *usage parameters*: how specific content is grouped together and how it is used.

Some fundamentals

The Internet brings together three major constituting elements:

1. A network to which most people attach via telephone modems
2. A set of de-facto standards (HTTP, HTML, TCP/IP, browsers, etc.)
3. A vast amount of content mostly embodied in the form of WWW home pages

The Internet is used in its mostly point-to-point connectivity, to request information, to browse the Web, and to send and receive e-mail.

Now let's consider the fundamentals of the educational process. The educational process is made up of the following:

- ✓ A curriculum that deploys content and activities
- ✓ A teacher or tutor that manages the process
- ✓ A set of lectures, drill and practice, homework, hands-on and other activities
- ✓ A set of evaluation practices that measure if knowledge has been obtained

Interaction is part of every aspect of the educational process, exercised as person to person directly, or person to machine, or person to person via machine.
Overwhelmingly, we keep coming back to the basics:

- ✓ curriculum/content
- ✓ teacher/facilitator
- ✓
- ✓ work/activities
- ✓ assessment

An education infrastructure should incorporate all of these elements, including the best possible facilitation system, ideally technology. Content, in digital library form, can be infused with knowledge about the other aspects of the educational process.

Several waves of technologies have been used to facilitate education. The mainframe was too expensive to place in every school, but was certainly used effectively for the administrative needs of the education infrastructure. We have never stopped putting PCs in the classroom, even though it has not been determined if and by how much these tools improve education. More recently multimedia, CD-ROMs, and Internet access, have all been added to the use PCs in the classroom, creating more uses for the tool.

The reality remains that no matter what tool is used to facilitate education, it is the role of the teacher that determines how much it is used, and how effective the tool becomes as part of the educational process. *Teacher training* is the biggest concern and most advocated way to improve the use of technology in education. Since the teacher is already part of the process, does it not make sense to put the teacher in the technology equation, instead of just training the teacher on how to use technology?

The EduPort/DBS approach

EduPort [9] was designed to use a digital library and to be compatible with the broadcast medium, combining all the elements of the process, in a more accessible, more cost effective solution. With a digital library as a tool, content can be made available already infused with knowledge about the content itself, ways to use it, forms of assessing for new gained knowledge, examples of how to deploy it, ways to move on, and learning possibilities to move on to, *all the strands of learning*. What is learned from the educational process can then be reflected back in the library, as new content, linked to the process itself. A connection between process and material can then be made in a sustained, systematic fashion. Aggregation of content, information, and knowledge can be coordinated, and then shared broadly via an applicable networked infrastructure. Enabling this resource and making it universal (all forms of content), and global (as a worldwide tool) is sensible, but is it possible, or feasible?

Such considerations must be made a-priori, with respect to the digital library design decisions. Regarding global access, those decisions need not be made just for that portion of the world connected to the Internet. Our initiative was to combine specific applications of digital library with DBS to come up with an education infrastructure that can work together with the Internet or other network, or can be deployed stand-alone in a variety of configurations for all access environments and cost models; and, it can also be simpler to use.

Facilitating the education process

What good is developing the most compelling, media rich and fully interactive CD-ROM if the vast majority of students in the world will not be able to use it? What is the purpose of tuning down the experience so that it can be networked over the Internet, if the vast majority of students around the world are not connected to it? That realization has led to cries by governments to wire all the schools. The Internet will continue to evolve providing broader access and greater functionality, and schools will continue to be wired. But that is not unlike the move to put libraries, telephones, fax machines, and computers in the schools. The real challenge is how to provide equal access and global reach in a timely and cost effective manner, while technology evolves, while connectivity is deployed, and while actually achieving educational benefits.

Digital Broadcast Satellite (DBS), cable and wireless are all networks that can enable broadcast applications and services. The nature of the medium and the characteristics associated with the client player or receiving devices (settop box and remote control) do not require explicit control by the teacher, but do involve guidance relating to the selection of materials. That is, available materials are scheduled as requested by the teacher for a given timespan during which the materials are available. These timespans can correspond to curriculum plans, courses, or geographic locations. Selection would be based on the basis of content convergence with educational goals and over a general time and place: specific requirements. A digital library that accommodates these kinds of requests must be engineered for that purpose.

An equitable solution

A Digital Data Broadcast (DDB) solution that delivers to Digital Video Broadcast (DVB) settop boxes interactive content using the so-called "carousel" model has been proposed [1] as an equitable solution for education infrastructure. This solution can work in the absence of a return channel for interactivity, creating "perceived interactivity" by virtue of the speed of the broadcast transport mechanism. This method capitalizes on the success of DVB or DBS settop boxes, which can be readily obtained as a consumer items for prices under $400.

The educational DBS solution is based on standard developments such as Digital Video Broadcast (DVB) and recent deployments of DBS such as DirecTV(TM), DirectPC(TM), and Echostar/Dish Network. These technologies have created ready access to the services and applications of broadcasting. For example, the investment required by a school (in the EduPort/DBS model) can be as low as a single PC. This makes the infrastructure feasible and physically accessible to students anywhere, even from their homes.

The most important advantage of this solution is that it can be deployed where terrestrial wired networks are not available, or not likely to become a reality in the foreseeable future. That permits a developing country, or a rural area in a developed country to use the same digital

content that is being enabled for other solutions, with some reorganization. It also opens widows of opportunities for inner cities and underprivileged areas that for different reasons are also outside the connected world of information. While disconnected from the Internet, underprivileged and rural areas are in touch with the world of broadcast television. This solution leverages the existence of those technologies, and the existing expertise to use it.

The following are the delivery options available to the combined model:

1. A single stand-alone PC or TV client with access only to DBS
2. A single PC or TV client with access to both DBS and the Internet
3. A PC or other Gateway/Server connected to DBS, which in turn enables an intranet within the school to interconnect to a set of PCs via an intranet or LAN
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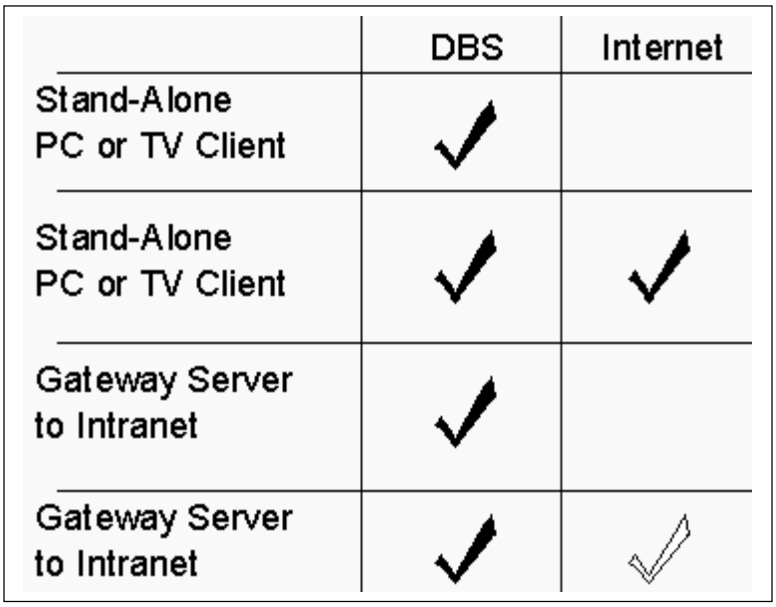

Figure 1. Deployment options possible with the integrated Internet/DBS access solution

These options correspond, and are the best combination of the two successful models for information delivery, DBS as in DirecTV (TM), and the Internet as in today's low-bandwidth point-to-point connectivity. The socioeconomic implications of combining these models in a single solution will be massive because it will allow so many more countries to revamp their education infrastructure. The most important consideration is how to enable content that has been developed for one or the other access medium.

Details of the Solution

DBS settop boxes are being used today to receive and decode MPEG2 video and audio content. Prepared content for these settop boxes can be carousels of MPEG I-frames, where each page of information is placed together with its related navigational hyperlinks, and hot-keys, that is, it can be interactive. Interactivity without a return channel is achieved by the design of the carousel, which is cycling (i.e., being repeated) in a very short interval, usually measured in seconds, and by a compatible organization model to maximize the carousel design. The latency (response time) is predictable in terms of average and maximum for going from the current page to the selected page via one of the hot-keys, and that is the number of the page in the hyperlinks.

This solution provides that least common denominator that can be implemented for delivery over satellite, to complement the Internet, where possible, or alone, for maximum flexibility. A school or home can connect over Ku-band satellite, just like is done in DirecTV(TM) and other DVB

systems, to receive content using a small antenna. The solution also extends to delivery of other than MPEG I-frame objects, such as HTML objects to PCs, NCs, and gateway servers for dissemination of prepared content. The teacher becomes a critically important factor in the solution, because the selection of MPEG objects for broadcast or download must be mediated by an expert who can make "best decisions", since in the broadcast medium, the choices apply to large groups.

Since the solution can be deployed as a complement to the Internet, using the Internet as return channel where possible, selections can be made by interacting with the digital library. It would be possible to design applications, in a *teacher scenario* used to facilitate the creation of lesson plans or curriculum blocks, as described in EduPort [10], that can be delivered as requests on a *playlist*. The broadcast would follow the playlist to schedule access and/or download of content. In the total absence of a return channel, other means, such as telephone or mail communications would still allow a teacher to have input into the process. If desirable those selections can be made ahead of time for a given period of time, maybe a school term or semester. Departures from the scheduled programming can be achieved by making requests, using any possible mechanism of communication with the broadcasting center.

Elements of the solution

The solution is comprised of four elements as follows:

1. A content creation and enablement complex
2. A broadcast center
3. A broadcast network
4. A set of client receivers

Content creation and enablement complex

This is the most vital and possibly most misunderstood element of the solution, because less attention is generally given to content enablement compared to connectivity and the development of isolated software tools. In many instances content enablement is being equated with the development of WWW home pages, and the assumption is made that all the content that will ever be needed for education is being put on the Web. In reality, content enablement should be curriculum driven and should be part of an organized and systematic deployment effort, with proper guidance from teachers. That is, teachers must participate in the cataloguing and indexing of content, an aspect of the technology solution that teachers are already trained to support. This could assume that curriculum remains the same, and that curriculum is not designed by the teacher, but that new, creative, and relevant ways to apply it are.

On the other hand, curriculum development can be associated with the organization of content. Curriculum design theory, and curriculum modeling can play an important role in content enablement for this solution. Within the framework of EduPort a particular curriculum model can be used to guide the selection of content, to create lesson plans or curriculum blocks [11]. Certainly the WWW home page format can be used as the content and information exchange standard that it has become; but the Web a generic tool only enables, and does not provide an organizational scheme for any application domain. The role of the teacher in this solution is not to create curriculum, but to deploy it and illustrate it with teaching exemplars, and insightful knowledge. That can be captured in Web pages. But those Web pages must be organized such

that they can reflect curriculum and curriculum models, as it is done with EduPort, so that knowledge can be exchanged along with the content.

The broadcast center complex

After the content is ready for dissemination and broadcast, it is the function of the broadcast center to schedule, manage, update, monitor, and maintain the broadcasting operation of the solution. This could be done as a lights out 24 hour a day operation. The operation could also be remotely connected to the final broadcast facility, which could host a much larger video delivery center linked to the content enablement center. Almost none or little development of the content might happen here, the DDB operation could be an extension of the DVB operation at the broadcasting center. In other cases the broadcasting center and the content enablement center could be the same facility.

The broadcast network

The preferred network for broadcasting of digital video (DVB-DDB) is satellite. Consumer oriented deployments such as DirecTV (TM) have been successful gaining more and more customers and sometimes taking customers away from lower quality analog cable infrastructures. The most common satellite deployment is the high power Ku-band system that uses small 18 to 36 inch antennas. Around the world Ku-band transponders can be leased from satellite infrastructure companies such as Intelsat and PanAmsat. There are vertically integrated satellite companies such as DirecTV International (DTI), Echostar, Astra, and others with transponder licenses that can be leveraged for education infrastructure.

All of the US and most of the areas of all continents are covered by at least one transponder, at about 27 Mbps per transponder with as high as 33 transponders per satellite slot. It is important to realize that for linking to the home as another education *(home) scenario*, it is highly desirable to have the same dish that brings entertainment also bring this education solution. The reason is because it is important in the home not to have to reorient the receiving Ku-band antenna. On the other hand, for the school, the libraries, the community centers, and businesses, for the *classroom scenario*, the education infrastructure need not be the same that reaches the home, but the content from the same organized library should be available for presentation in multiple user scenarios.

Client receivers for broadcast education infrastructure

The fundamental receiving device is a simple DVB settop box that is mainly an MPEG demultiplexer with an MPEG decoder, some memory of the graphics capabilities, a simple runtime environment and operating system, and a processor. This is a consumer item. Within the possible options cited, the same can be accomplished with PCs, and NCs; and gateway servers can also play a role for downloading of content. The environment expected in these devices is HTML decoding browsing capabilities, and HTTP or TCP/IP addressing if necessary. All of these user environments are geared to the deployment of an education infrastructure that reaches the home, the school, and other learning centers, coordinating and connecting the content to the user scenarios: classroom, teacher, and the home.

Nebraska Pilot Project

The prototype tested in Nebraska included all the options of the integrated Internet/DBS solution as described in Figure 1 and illustrated in Figures 2 & 3.

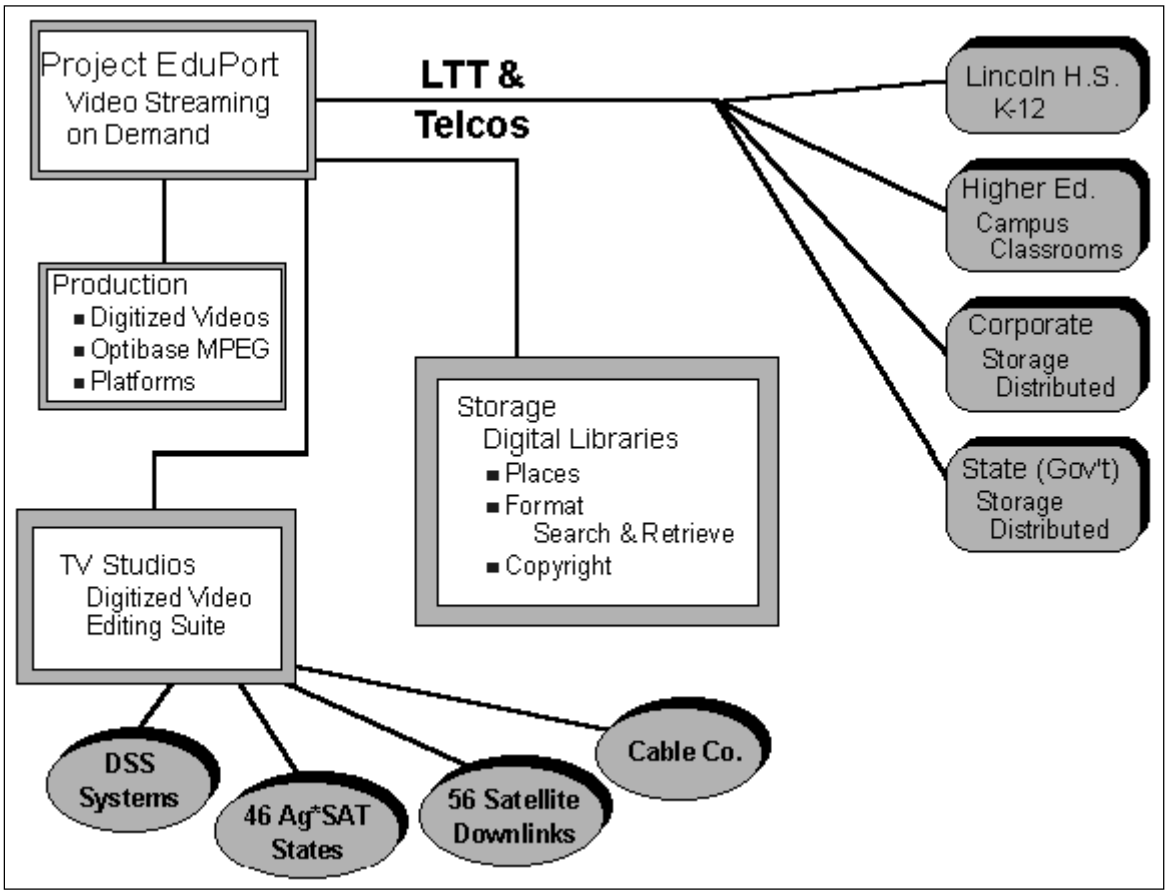

Figure 2. Elements of the solution combine to provide an integrated system

End-to-End Solution

The end-to-end solution as exemplified in the pilot project in Nebraska involved the production laboratory resources of the University for video editing and digital development. In addition the computer systems, otherwise dedicate to IT processing for traditional university operations, were adapted to create a digital library for post-digital production storage and service. Fundamentally the university computing resources were used as a serving center for the application, in the absence of any existing infrastructure for that purpose. Telephone facilities were dedicated from the local telecommunications carrier to connect this serving center to the local High School were the content would be accessed by teachers and students. A pilot infrastructure was thus designed and created by the requirements driven from the EduPort application.

Potentially, such an infrastructure could be used to deliver media services of this kind to State and local government agencies, business and the university campus itself. In addition the availability of satellite links and cable would have made it possible to access homes and remote

areas in the State and the nation. All these possibilities were demonstrated by means of application scenarios demonstrated at the High School. The broadcast scenario was actually delivered via the satellite and digital receivers. The design goal was to help envision how the design of the system could take advantage of all delivery resources to create a universal access solution. This universal access solution is a realistic solution for teachers and students, for use from school and from home. This solution makes the role of the teacher broader in that by definition is impacts the home in a very direct and tangible way. Teachers can affect the fabric of a community via the intervention of technologies that support the role of the teacher, the value of learning and the goals of the school.

A pilot site in Nebraska

The University of Nebraska is enriched by two organizations that together can provide the coordination of resources need for a complete EduPort/DBS solution, end-to-end. The Nebraska Division of Continuing Studies hosts the largest High School in the world with an enrolled class of 87,000 students. This organization can easily become part of the content enablement complex. And, Nebraska Educational Television (NETV) with a nationwide transponder footprint can become the broadcast center complex of the infrastructure and also provide the network for the infrastructure.

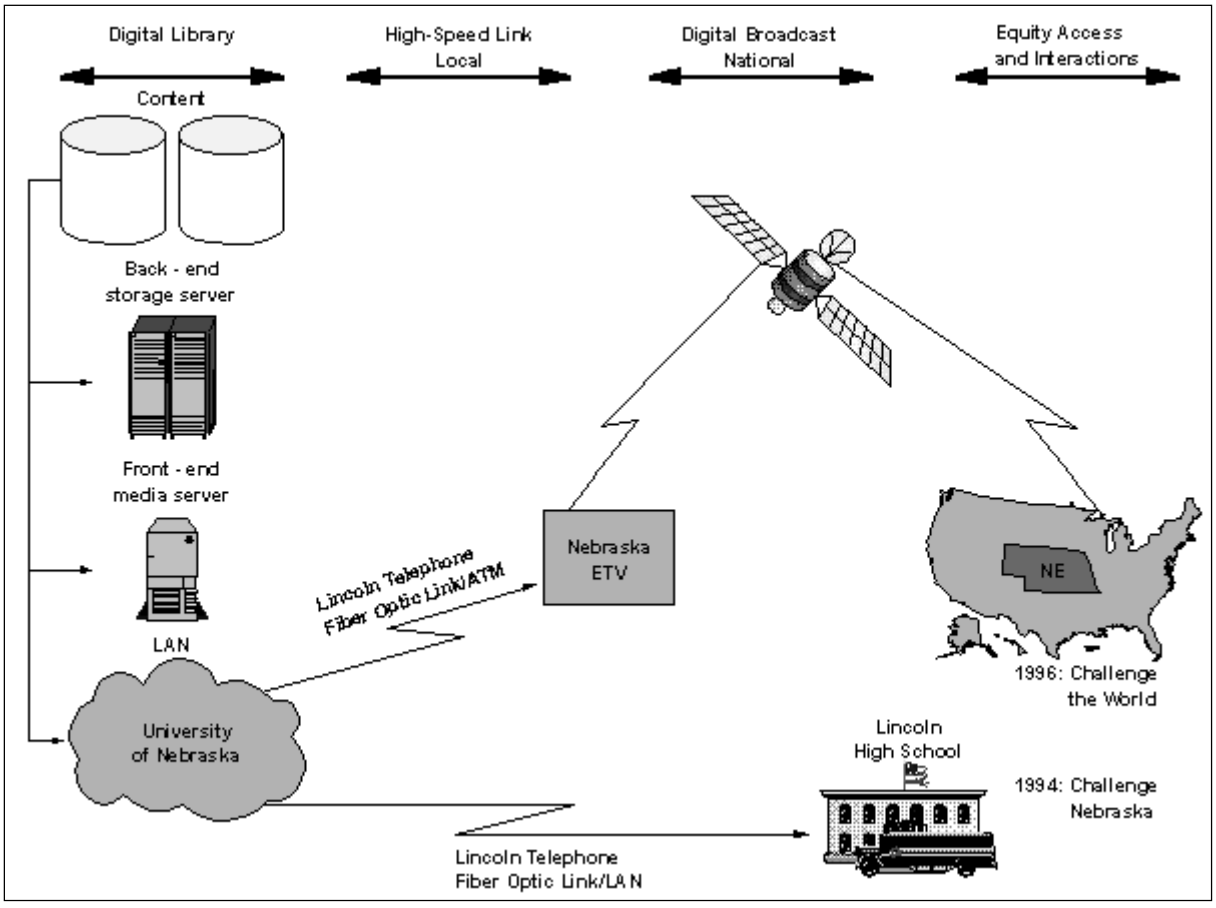

Figure 3. System integration and interoperability provide an open solution

In a recent development NETV converted to DBS advancing the deployment of the pilot, which until now had been focused on content enablement and hardware deployments for digital library. More specifically, the content creation and enablement complex at the University of Nebraska is well advanced and well connected to a large population of wired clients, on the Internet and via high capacity Intranets, both on campus and out to the schools. With the addition of DBS as a complement to the wired infrastructure, the potential for creating a statewide or even a national education infrastructure is rapidly moving towards reality.

The following chart illustrates the Nebraska pilot and it's potential partners. Project EduPort brought together a vision of interoperability among high schools, universities, state and local governments, corporations, broadcast media and communication companies. Delivering MPEG streams from large storage centers of digital libraries via terrestrial networks and most recently via satellite broadcasts to all Nebraskans is the goal of the University.

Summary and conclusion

The Nebraska Division of Continuing Studies, like many other such institutions around the world, has confirmed what the United Kingdom Open University first discovered thirty years ago: that it is possible to educate large numbers of people, at a distance, in a cost effective fashion. Printed material is still the predominant medium used by both institutions to disseminate content. Technologies are struggling to improve on that model by enhancing learning with rich media and interactivity, and by increasing access. Cost effectiveness remains an issue hard to address with technology.

The EduPort/DBS solution presented begins to address the problem with a cost effective model, without sacrificing the existing learning potential that is associated with rich media and interactivity, while increasing the access scale by many orders of magnitude. Our efforts, in collaboration between the University of Nebraska, many content providers, and IBM, have been in behalf of all students and teachers in the world. This is an attempt to propose, define, and pilot what we believe is a massive distance learning solution. Special attention has given to the issues of content as related to the role of the teacher. We see the role of the teacher as a key element of the solution.

We also believe that the potential of this solution is orders of magnitudes larger than any other current effort. This solution would support almost complete *open enrollment* and be replicable worldwide. Much work is yet needed in terms of deployment; therefore the ideas are presented openly so that various interpretations can be realized. The technologies are available. Eventually, collaboration among all seeded projects can be coordinated, perhaps through UNESCO, an organization that has interest in equity and global education deeply at heart. Such coordination will speed up impact by many times more than the sum the collaborative parts.

The greatest gift that can be given is the opportunity to learn, because learning is the ultimate freedom. That gift is at hand.

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