A Universal and Global Education Infrastructure

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"My fellow citizens of the world ask not what America will do for you, but what together we can do for the freedom of mankind." **J.F.K.**

Abstract

The following is a technical contribution to the cause of worldwide education, presented to the United Nations Educational, Scientific and Cultural Organization (UNESCO) on the occasion of a world congress held on the dawn of the 21st Century. The problem of education infrastructure as the foundation for equity access to educational resources for all the nations and citizens of the world is complex and delicate. In this document the authors make recommendations based on many years of research dedicated to studying and developing technologies that might be deployed, and propose a solution that might be implemented to solve this problem.

Introduction

Two fundamental deployments in networked infrastructure have received a lot of attention because of their massive consumer and business application, namely the Internet and direct broadcast satellite (DBS) [1]. Internet and DBS are not new technologies but have been recently deployed in large quantities thus driving the price of the technology, infrastructure, and access to consumer affordable levels. Internet deployment in education (just like deployment of PCs in schools) has been touted as a means for bringing the information highway to the classroom (corresponding to bringing computers to the classroom). However, access to these technology tools (information highway or computer) can be made as an analog to providing access to libraries and books without the guidance required to use them and learn from them. Teachers and librarians teach and guide students, not technology tools. In many cases tools, whether print or computational, are only as good as the teachers who guide their uses; and too often their failures have been attributed to poor teacher training relating to their application.

For many years, there has been the promise of technology for enhancing education infrastructure, starting with the PC and now the Internet. In the US, for example, the ratio of PCs to students in schools is estimated at 1 to 6, and 50% of schools are already connected to the Internet. In spite of this increased focus in the penetration of technology, as reflected in the many updates from the daily press, it has not been clearly established that these tools translate into tangible benefits for all students. But even worse, they have not yet translated into improved access to educational resources for underprivileged students or remotely located students, the very minimum these tools should provide, and the place to start. More specifically, the promise of technology has only benefited isolated pockets of students with technical readiness and resources, and educators competent and oriented enough towards the technologies to be able to guide their use. For the rest the benefits will come later, gradually, some day. In conclusion, the utility of technology for the purpose of learning is somewhat inconclusive, benefits that are in fact realized are not equitably distributed, and even access to the technology, benefits aside is biased in favor of the already privileged by location and status. Isolation and separation do not lead to progress and neither does isolated successes. We must find a more equitable way, and also a better way.

Motivation

In the US there are an estimated 10 million total users of the Internet. A population in excess of 250 million and the fact that our pre-college student population alone is close to 50 million dwarfs that number. Even so, any other region of the world does not match the explosive growth of the Internet in North America at large, with South America lagging behind the Middle East and Africa in the number of Internet hosts. Still today, only 2% of Africans have phones and only 1% has computers. That, more clearly, puts into perspective the level of connectivity (or lack thereof) to sources of information that we have been able to achieve in developing countries and for students anywhere in the world.

Now consider that there are nearly six billion people in this world capable of learning, and geographies that will make penetration of wired and complex technologies very slow at best. There are places in the world where the Internet via a wired infrastructure will simply never reach. There are problems that its organizational model cannot approach. Consider scenarios where a teacher has limited knowledge of a given subject matter, or must provide guidance to all students in a rural setting, all grades and subjects, or might even have to serve several schools in different villages. Consider the abundant cases where there are no trained teachers or formal schools. Consider that any teacher, tutor, or facilitator in any setting, can always use expert knowledge and information tailored to the educational process; and that students in most parts of the world, without sophisticated tools to learn for themselves, need teachers. In addition, there are 250,000 hospitals in the world, 60,000 of which are in China alone. Education in health caring for patients and practioners is as fundamental to the well being of people as literacy is, if not more. Then consider the problem of providing educational resources in more than 100 widely spoken languages, some counts put the number of spoken languages at close to 200. Not only connectivity deployment, but also content development must be approached realistically, in the global view.

The challenge is to find a suitable universal development model, and a mode of connectivity that can bring about a balance between quality and equity educational opportunities for all people. The problem is one of providing universal (relating to content) and global (relating to reach) educational resources through the use of technology. This is the problem that until now could not be approached massively and systematically through the use of technology. Paradoxically, that is the most complex problem that technology can solve in the domain of education, as opposed to "improving learning". Information and communications infrastructures for the 21st Century promise to address the problem of equity access, and indeed that is doable. However, the existing solutions cannot begin to deal with the issues germane to universal and global scalability of education infrastructure, thus the technologies will in all likelihood fail to reach, and will likely fail (again) to improve learning, in the global view. But, similar technologies can be applied to a different solution.

Rethinking Infrastructure

The Internet has evolved into a massively de-facto definition of three fundamental elements:
A networked infrastructure to which most people connect via narrowband modems,
A set of transport protocols (TCP/IP and HTTP), as well as content development standards in the form of HTML documents, and a vast amount of developed content organized in the form of World Wide Web home pages. Most users of the Internet "browse" or "surf" the web looking for interesting content, not unlike what people do with TV channels. There is a difference between browsing or surfing and exploring or investigating. Knowledge exploration, leading to inquiry-based learning requires access to exactly the right materials. Search engines driven by general-purpose schemes are not a substitute for knowledge organization models. There is no substitute for curriculum. This highlights a fundamental concern held by many, that we cannot trust technology to be a vehicle for learning. The problem is not in the tools or in the delivery mechanism; the problem is in their inability to converge on the benefits of specific educational materials.

A new broadcast system (for equity access) coupled with a complementary information organization model and guided in its use (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. This system can provide true equity access and quality. There is great potential in the use of this technology, perhaps the answer to the problem of global education. But we must clearly understand the technology options, and clearly state the education problem being addressed, then, propose a solution.

Project EduPort

Project EduPort [2] started at the IBM Thomas Watson Research Center, precisely to achieve that kind of understanding. Networked, broadcast, digital, interactive and multimedia technologies were included from the start taking advantage of early research results. Other technology developments that were taken into consideration had to do the advancing paradigm shift from physical to digital content form (digital libraries), and the anticipated merging of functionality found in information access devices (PC, TV, telephone).

The research goal of the project was to define a model for educational uses of these technologies that would be consistent with the digital, universal and global direction in which they were headed [3], as well as with current changes in pedagogy from didactic and behavioral to constructivist (guided learning-by-doing) in approach. The educational problem being addressed was to provide equity access for all students to quality educational resources.

A demonstration was put in place that showed how these technologies would work together, creating a new infrastructure environment. New information gathering and knowledge construction models were designed to target the new infrastructure. The end-user devices were conceived as simple and ubiquitous, a TV-like model. Since the use of digital broadcast was anticipated (for the purpose of reaching globally), and the growth of the Internet was taken into consideration (as a standard for interacting with content at various levels of sophistication) no constraints were imposed on the scale of the infrastructure, its reach or scope. The concept of EduPort is to reach every student in the world with essential content of any form.

The EduPort Model

In computer-based approaches to constructivist education, building blocks of available information, content and materials are used to "construct knowledge" about a particular theme. These approaches complement multimedia, enhance in-person and hands-on learning, and allow for the composition of themes and the construction of knowledge. The EduPort project exemplifies another and complementary dimension of constructivist learning by providing a framework to prepare content and knowledge building blocks. A warehouse of digital materials represented in MPEG form and organized and exploited in the form that is now referred to as "digital library" represents a new resource for education and other domains. EduPort uses a content organization scheme meant to take advantage of the openness of the digital library concept for collaboration in a large authoring space, and to generalize multimedia design approaches. Coupled with a new approach for broadcast publishing, this concept can be extended globally.

Organization of EduPort Content

Modular pieces of content, referred to as Media Objects, in the form of digitized video clips, scanned images or text are stored in an object library and accessed from a media server. Information associated with each Media Object is kept in the form of an EduPort Home Page, deployed as both catalog and user interface, and accessed, along with the content, from the given infrastructure. Links to the educational context of each content object are contained in the Data Objects (metadata), and are independent of any particular use of the content.

Information about an interdisciplinary experience, teaching exemplar, student project, etc., identified as a coherent entity, composed of content and knowledge relating to how the content is being used in each case, is also kept in this catalog. These are referred to as Curriculum-Media Blocks. A Media Block characterizes the content thematically and relates it to specific learning goals. Information that binds content to curriculum contained in the Data Objects is employed by the Media Blocks to exploit the content. A Media Block is inspired (or triggered) by the construction of a curriculum block [4].

The EduPort Framework

This approach intends to provide access to source materials, and a framework for their application, re-use and sharing of experiences. More specifically, it is a framework for the development of education infrastructure that can be implemented collaboratively and be tailored to individual needs. It requires, not necessarily the development of new materials, but reorganization of targeted materials, and redesigning of application uses. It facilitates moving to a universal opened digital content space and to a global and digital collaboration environment. The EduPort framework utilizes de-facto information standards resulting from acceptance of the World Wide Web (HTTP, HTML, MPEG, GIF, TIFF, etc.). The design of this model is prompted by the question of how to implement a vision of infrastructure and connectivity to sources of content on a truly global scale, without building dependencies to pre-authored courseware.

Direct Broadcast Satellite (DBS)

Unlike the point to point connectivity model of the Internet, the digital broadcast medium can be used in real-time or in download mode to broadcast, multicast, and PointCast a set of educational materials and content on a global scale. Methodologies to capitalize on the broadcast medium also include the use of cable and wireless broadcasts called "wireless" cable. Broadcasting can fully complement access to the Internet or can be deployed stand-alone (without a terrestrial network).

The nature of the medium and the characteristics associated with the client devices (player or receiver) do not require explicit control by the educator, only guidance relating to the selection of materials. That is, available materials are scheduled or requested a-priori by the educator for a given time span during which the materials are available. These time spans can correspond to curriculum plans, courses, or geographic locations.

Digital Video Broadcast (DVB)

DBS, cable and wireless are all networks that can enable broadcast applications and services. In addition, standard developments such as Digital Video Broadcast (DVB) and recent deployments of DBS such as DirecTV (TM), DirectPC (TM) and Echostar/Dish Network have created ready access to the technology and the services and applications of broadcasting. Previously unrealized video on-demand, interactive television models and interactive multimedia applications have been replaced by the realities of massive deployment of DBS and Internet. As a result, access to DBS and the Internet are available at low cost. For example, the investment required by a school (in the EduPort model) can be as low as a single PC or TV (as described below). This makes the infrastructure feasible and physically accessible to students anywhere, even from their homes.

The following are the delivery options available to the EduPort/DBS Infrastructure:

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 a LAN,
4. A PC or other Gateway/Server connected to both DBS and the Internet, which in turn enables an intranet within the school to interconnect to a set of PCs via a LAN.

Player or Receiver Device

Access to DVB from a TV requires a Digital Set Top Box (Digital STB). By stand alone we mean without a wired network, but connected via a broadcast network to the content warehouse.

Therefore possible modes of connectivity are:

1. Stand-alone using only the broadcast medium, and
2. DBS coupled with the Internet for back-channel capabilities.

These solutions are not meant to be totally exclusive of other applications and services, for example use of PCs with stand-alone applications or PCs connected to the Internet. Use of DBS can be made to complement Internet access and PC applications. More importantly, where there is no access to the Internet and even in places where there are no PCs, DBS can be accessed with one TV, a Digital STB, or a digital DBS network PC appliance in a minimal configuration.

The following figures 1- 4 illustrate the options available in this solution:

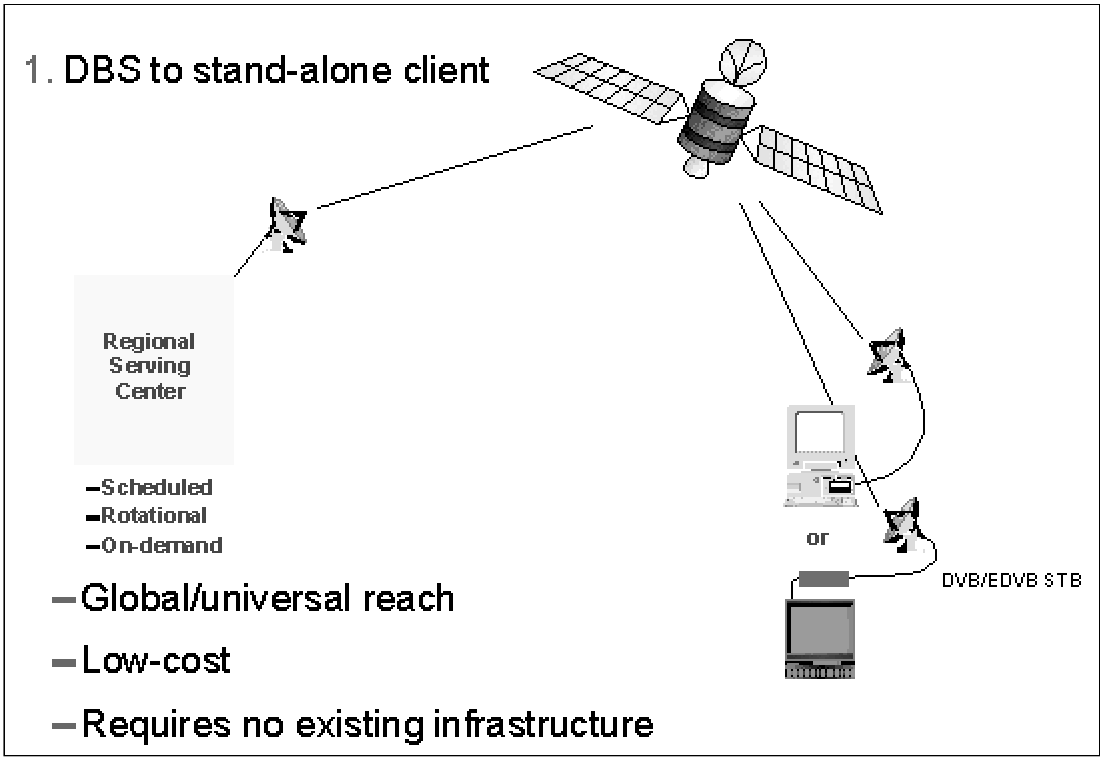

Figure 1. Single stand-alone PC or TV client with access only to DBS.

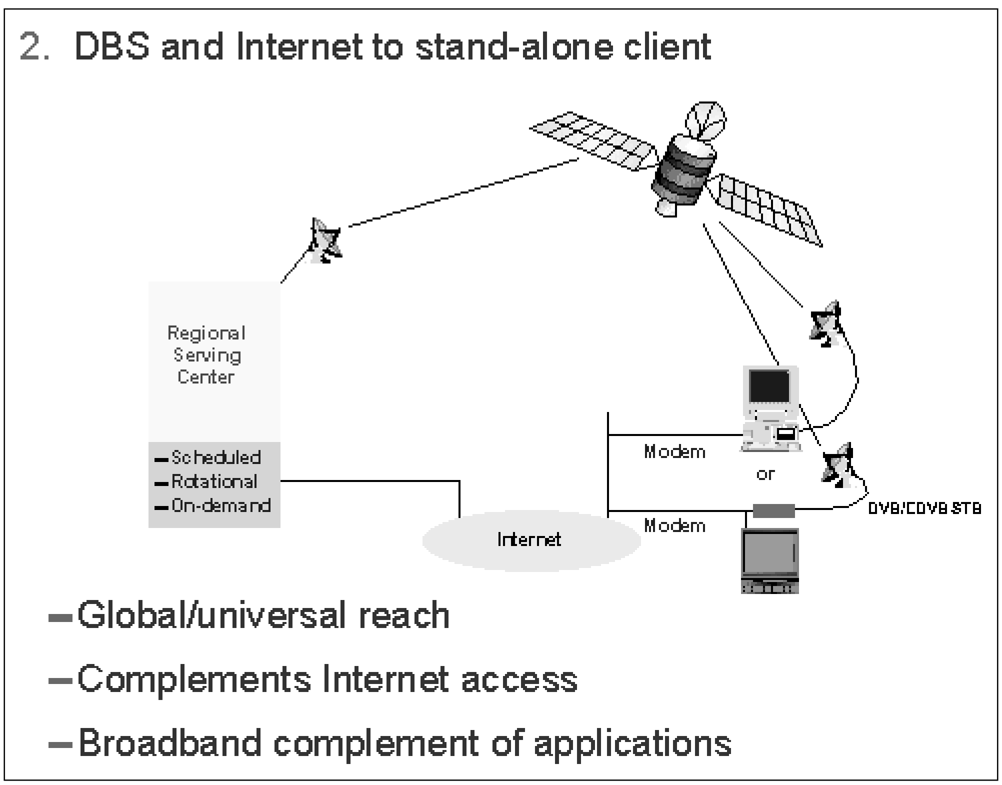

Figure 2. Single PC or TV client with access to both DBS and the Internet.

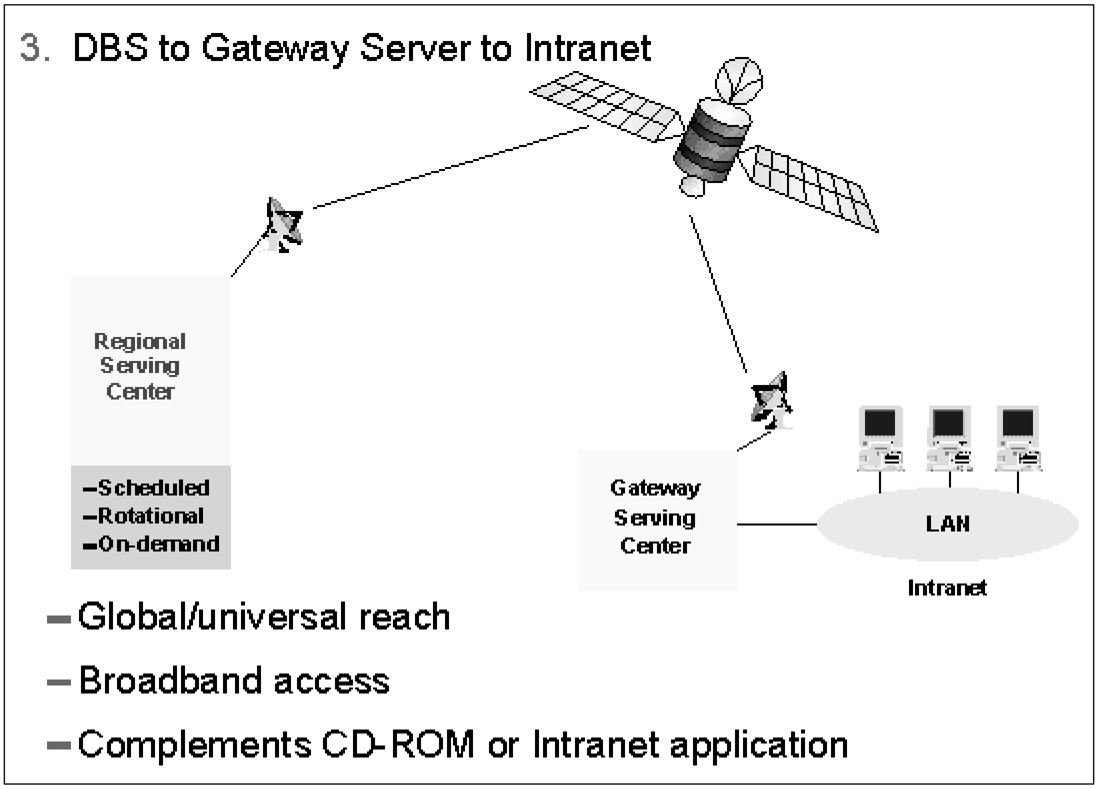

Figure 3. PC or other Gateway/Server connected to DBS and an intranet

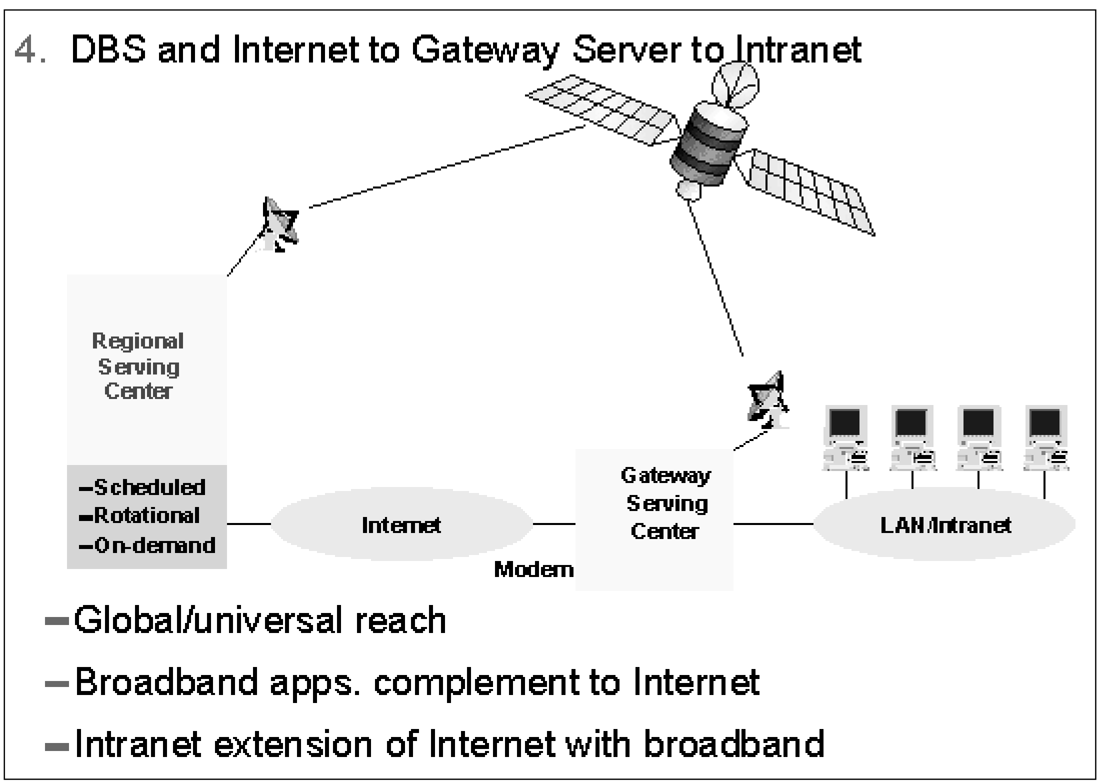

Figure 4. PC or other Gateway/Server connected to both DBS and the Internet and an intranet

DVB and Digital Compressed Video and Audio

DVB has evolved to provide the means for distribution of digital compressed video and audio via the MPEG transport and encoding standard. More recently, this same standard has been enhanced for the distribution of information such as multimedia and other data content. Digital Data Broadcast (DDB) is an IBM solution for the delivery of information using the same broadcast system and DVB headend and clients. IBM's DVB and DDB solutions share many common elements.

The key feature of DDB is the use of *carousels of information* that rotate updated or scheduled information, very much like a "disk in the sky", which is received by the end user playing or receiving device for immediate or delayed playback. Because of the high-speed data broadcast capability, the user will experience "apparent interactivity" without the need for a dedicated back-channel. User interactions extract the desired data segment from the carousel. The scope of the application programs can range from mainly text with simple graphics to rich multimedia depending upon the capabilities of the set-top box. An option for the user interface applied in EduPort is to use the hypertext markup language (HTML) for content authoring and cataloguing. Internet or any other applications that are either PC or TV oriented can be accessed in this way. EduPort/DBS combined with DDB, provides an "educational WebTV" like solution through the DVB system.

The following illustrates the EduPort disk in the sky concept:

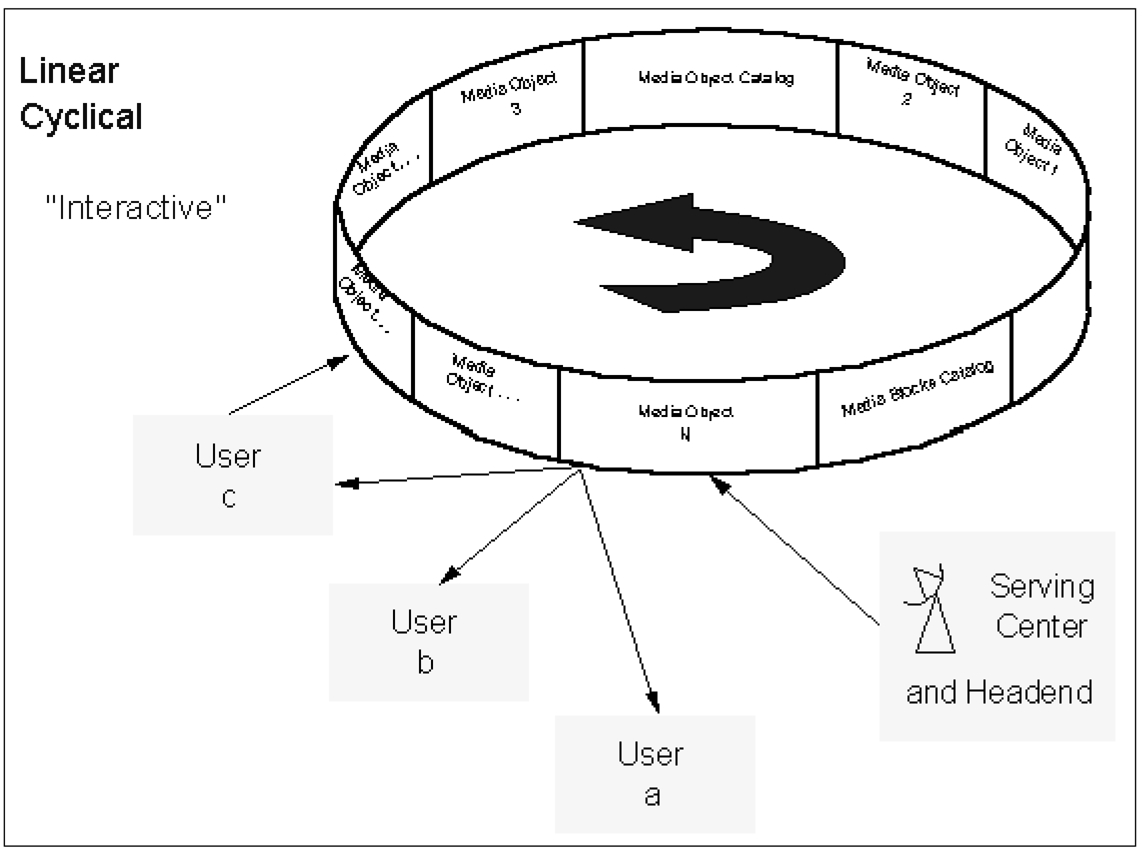

Figure 5. Visualization of a “disk-in-the-Sky”

The EduPort/DBS Infrastructure

The DVB and DDB solutions are ideal for massive distribution of educational content organized in the EduPort Model, to a single point appliance or a Gateway/Server for dissemination. The broadcast delivery mode also enables universal deployment of broadcast, multicast, and PointCast media. This therefore makes it suitable for:

- ✓ Uniform content delivery to all schools
- ✓ Targeted content delivery to a subset of very disperse schools
- ✓ Targeted content delivery to only one target school in a very remote location

This implies that in addition to providing universal (all forms of content) access and global (anywhere) connectivity, the same deployment over DBS can be configured to provide multilingual capabilities via audio tracks, multimedia tracks, or different text tracks. Multi-ethnic or multi-regional content can be deployed, or special delivery can be directed to any one target school on an *exceptional, scheduled, or rotational* basis. MPEG content is particularly suitable for those purposes. The EduPort model exploits extensively the educational potential of MPEG content, because of the rich set of educational content that can be packed in short clips of multisensory media and its applicability to DDB.

Broadcast Server and Super-Headend

In a DBS system the broadcast super-headend is connected to a media server that is delivering the updated, scheduled or rotational information and digital video. The server at the super-headend is where the content to be delivered is stored, and where it should reside just prior to delivery. Any form of distribution or access mode can be used to get "prepared content" to the broadcast server. In addition, any *conditional* (guided) access is generated at this point. That is the sense in which the EduPort Model considers teacher guidance requirements. All content is multiplexed for transport over the DBS system to the global locations illuminated by the DBS.

Regional Serving Complex and Gateway Server Center

The back-end server, super-server, or sets of (media) servers reside at a Regional Serving Complex where the warehouse of content is maintained. These servers are different from the Gateway/Server in scale and function. A media server in the Regional Server Complex is used for broadcasting via a super-headend. The role of the Regional Serving Complex, however, is larger than that of transmitting content. It serves as a regionally based center for the retrieval, dissemination, and aggregation of content, and for the provision of technology assisted educational services.

The Gateway/Server Center is more community oriented and could be housed in a school, county center, co-op, or other independent entity with focus on services to the community. This organizational approach provides a framework for the development of education infrastructure that can be implemented at the national level and tailored for use locally. The DBS serving-center concept that would work in concert or in the absence of the Internet infrastructure, is illustrated in Figure 6.

The following illustrates regional distribution of EduPort content:

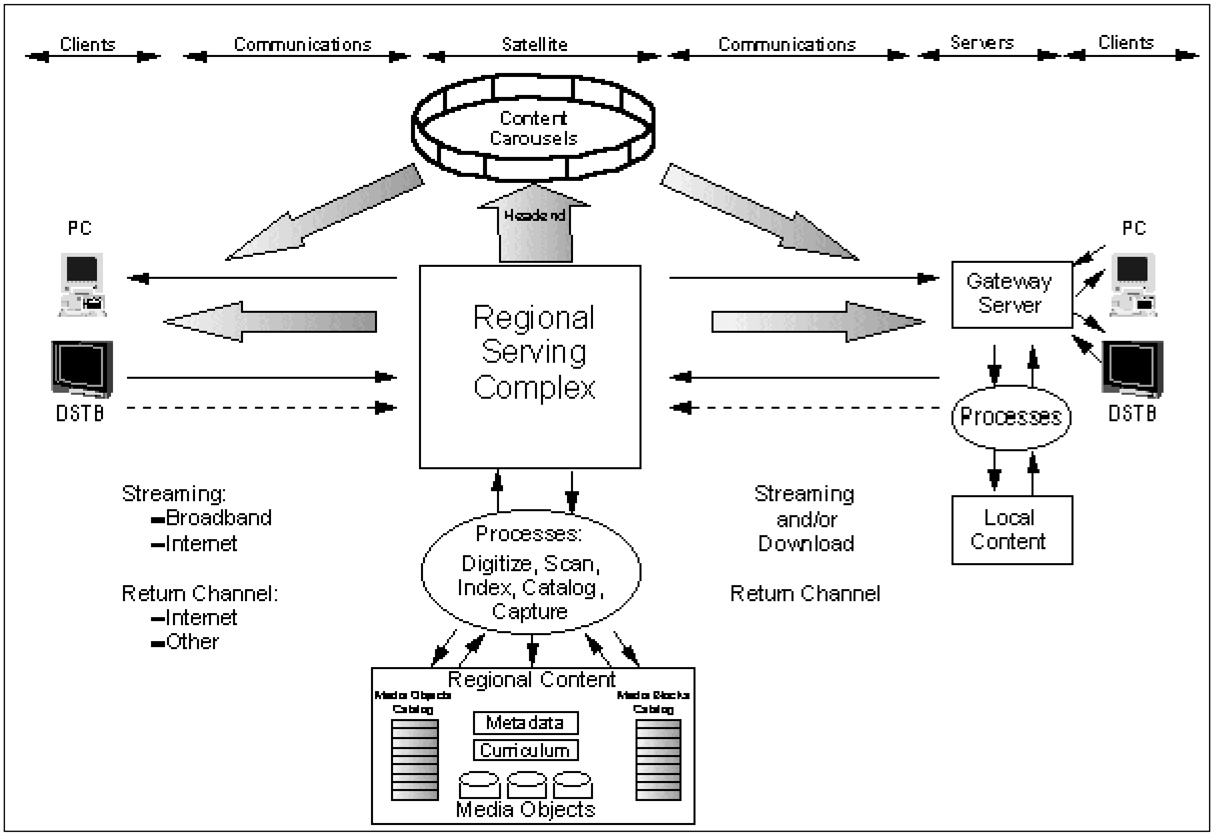

Figure 6. Diagram of the “distributed DBS serving-center” concept.

Summary and Conclusions

A *universal and global education infrastructure* solution is proposed that can work stand-alone or to complement any other infrastructure. For this system the educational content can be organized and delivered via the EduPort/DBS Infrastructure. EduPort/DBS and DDB, in concert combine to present a universal and global education infrastructure solution over DBS never before attempted. The model is intended for guided use (conditional selection) of content. Existing content and information can be organized in this model to be useful for deployment by means of the infrastructure proposed.

A DBS-based system, such as the one proposed, 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. The educational DBS solution is based on IBM's DVB and DDB, consistent with currently available technology; and on the EduPort research project, consistent with current educational practices and needs. In particular, this solution presents the only universal and global education infrastructure yet attempted, and has been designed to solve very real and very severe educational problems worldwide.

Rererences

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