Building a DVR for Educational Applications Serving the Under-Privileged

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1. Background: the Digital StudyHall Project

Digital StudyHall (DSH) seeks to improve the standard of education available to the poor in slum and rural schools in South Asia. DSH digitally records live classes by the best teachers, in local languages and according to local curricula, collects them in a large distributed database, and distributes them on DVDs to poor rural and slum schools. Teachers at such schools use the DVDs through "mediation" to explore better pedagogical practices and deliver better lessons. A mediator will periodically play the video for a short period of time, pause the video, and, while mimicking, embellishing, and tailoring the content contained in the video, deliver a highly interactive lesson modeled after the video teacher. These interactive activities may include conducting board work, asking critical questions, and organizing role-plays. This process not only delivers to students quality instruction that they could not access otherwise, it also helps train the local teachers as they learn from the expert teachers featured in the videos.

An important part of the project is the grassroots production of a comprehensive and freely accessible video database of K-12 curricula, covering all subject matters, all grade levels, all languages, and all state and national syllabuses. In short, this effort is about the construction of a "people's database of everything," built by the people, for the people. Content from this database is distributed on DVDs to pilot rural and slum "spoke" schools, which are given at least a TV, a DVD player, and power equipment to display the content. DSH has four operational "hubs" today, in Lucknow, Calcutta, and Pune in India, and in Dhaka, Bangladesh, which are responsible for content production (in a local language), content dissemination in its neighborhood, teacher training, monitoring, and evaluation, and interacting and sharing with other hubs. At each of these hub locations, DSH has partnered with a local center of educational excellence, where local teachers and student audiences are sourced and paired together to ensure that the content being produced at each hub is appropriate for its local audience.

In DSH, the end users, or the "fringe," use simple, cheap, and practical devices like TVs and DVD players, while the "core," run by the various "hub" organizations, contains the intelligence, storage, and communication means to drive these fringe devices, uniting them into a coherent whole, providing functionality above and beyond what these fringe devices are capable of in isolation today. Indeed, we may think of the TVs and the DVD players in the system as extreme versions of the "thin clients" and the inter-connected hubs as "the cloud."

Inspired by DSH's efforts in education, Digital Green seeks to disseminate targeted agricultural information to small and marginal farmers in India using digital video and mediated instruction. Digital Polyclinic is another effort in Lucknow which disseminates targeted preventative health-care practices to villages and slums and trains front-line health workers using mediated instruction and digital video.

In a recently published preliminary six-month evaluation of DSH in three spoke village schools around Lucknow, DSH demonstrated that average student scores increased 174% over a six month period, 32% of the children increased their scores by more than 200%,
DSH school children scored 381% higher in English midterm tests and 297% higher in math than their counterparts in a non-DSH control school. In addition to a dramatic rise in test scores, the local teachers demonstrated significant improvement in their grasp of subject matter as well as pedagogical skills, and the classrooms showed significantly increased student participation.

Since the inception of the project in July of 2005, DSH has accumulated more than 1000 high-quality recordings of live lessons staged by the best teachers at the hubs, and about 400 other pieces of content, which include science course-ware, digital stories, recordings of drama performances, and other student projects. The languages used in the content include Hindi, Bengali, Kannada, Tamil, Marathi, and English. DSH is currently reaching out to approximately 40 slum and village "spoke" schools. In August and September of 2008, we are planning to launch similar pilots in Pakistan and Cambodia.

2. Motivation: DVRs as the "Spoke" Devices

At the earliest stage of DSH, in 2005, we used a laptop to play the DSH videos and drive the TV in a village classroom. We very quickly concluded that the laptop was not a good idea. The computer was difficult for village teachers to learn to use, became a distraction, was susceptible to faults (including software problems such as viruses), and was expensive. We simply switched to DVD players, which were cheap, relatively reliable, and simple to learn and use.

In the past three years of DSH operations, the DVD players have served us well. However, it is not without its problems. It takes time and effort at the hubs to burn the large number of DVDs to be distributed. (This problem might become much worse as we go to scale. Our attempts of automating the disc burning process using robots have been less than satisfactory.) DVDs may get easily scratched. A large stack of DVDs is a poor way of organizing a large and growing video library at a village school---there is no easy way of browsing and searching content as one must manually and repeatedly insert and remove discs. Furthermore, as our video library grows, an interesting phenomenon we may wish to exploit is establishing and following linkage among the different content: instead of being a grab-bag of a large number of isolated pieces, the video database becomes more like the Web or Wikipedia, where the inter-linking inside an encyclopedic corpus is a crucial aspect of its richness. Organizational schemes, such as this type of inter-linking among the different pieces of content, are practically impossible to implement in a big stack of DVDs.

In the past year or so, we have been contemplating what is the ideal device for DSH: it should largely retain the simplicity, reliability, and low cost of a "non-computer" device, while offering more flexibility and more power to further the DSH goals. It is a shared device: placed in a school or in a "community center." Such a device would become the next step in the evolution of a "thin client" that would allow us to connect the under-served population to "the cloud," an educational content production infrastructure embedded inside and operated by our partner hub organizations. With a little more "intelligence" added, such a device could also enable more interesting peer-to-peer interactions (such as peer voting for or ranking of content), so that the system we are building is no longer restricted to a one-way street of content pushing from hubs to spokes.

The pursuit of such a DSH spoke device is also helped by recent technology developments. For example, the "Neuros OSD" (which stands for the "open source device") is a Linux box that is designed to be an open source video recorder and player and priced at about $150. More recently, the Netflix Roku box, priced at only $100, allows customers to stream free videos from Netflix. The cost of storage continues its exponential drop and we are
beginning to be able to afford to put a significant amount of storage in a spoke school device. Wireless (3G) connectivity is becoming increasingly pervasive. All these developments point to the feasibility and desirability of creating a low-cost yet powerful device that may elevate the power, richness, and scale of DSH to the next level.

3. Stages of Developing the Spoke DVR

The first step is simply a hard drive-based video library and player. Today, the DSH hubs already run software that we have built for organizing and transmitting the growing repository of DSH videos. This software allows browsing, searching, inter-linking, communicating with peer repositories, DVD burning, local language support, and many other features. In the first step, we would build and embed a streamlined version of this software into a low-cost Linux-based video device, tailored for our spoke schools, replacing the DVD players. In this initial step, the device would still have no way of communicating with the outside world, except for the "sneaker net" approach that we have always used to ship content to our schools in DSH. It would allow village schools to better organize and access their video libraries.

In the second step, we will add some form of communication capability to the DVR boxes. One of these capabilities is the ability of downloading or recording the DSH educational videos. In countries or states where we are able to work with government entities to obtain broadcast TV airtime, the DVRs will be programmed to record the DSH programs off the air (potentially during off-peak hours). [Recording the programs first (instead of attempting to get the students and teachers to watch the programs live) is important for the pedagogical approach of DSH: as we explained in Section 1, the "mediator" teachers must be able to frequently pause the video while proactively engaging the students in various types of interactions.] Even in the case of using broadcast airtime, it may be necessary for us to be able to communicate with the device digitally (via a cell connection, for example) so that commands such as recording schedules can be downloaded into the device ahead of time.

In the cases where we are unable to obtain TV broadcast airtime, we may consider using donated or discounted 3G bandwidth (again, during off-peak hours) to send videos to the proposed DVR devices. This is less economical than using broadcast airwaves but offers a great deal more flexibility (in terms of, for example, specially tailored content). Using peer-to-peer propagation (where, for example, one DVR, upon receiving content, forwards to two other peer DVRs nearby), we may be able to propagate content relatively efficiently to a large audience without being bound by a small number of hub bottlenecks. We can see that such a network of DVRs can operate in a way that can perhaps be dubbed as something like "BitTorrent TV."

The wireless communication capability built into the DVRs can do more than just downloading recording schedules or videos. As mentioned earlier, viewers may vote for or rank the videos; they may be required by the hubs to report their usages for supervision and monitoring purposes; kids may be occasionally required to take "tests" supplied by the hubs. The possibilities are many.

At this point, one may wonder why don't we just put a generic computer in the village school and be done with it. The answer: the DVR being discussed here is a computer, except for the following key points. First, it is critical that we articulate the specific and compelling content and applications to be deployed on such a device, regardless what it is called. DSH video sharing is such an example. Second, it is also important that we keep the interfaces simple and familiar: video players, operated by remotes, and cellphones are useful metaphors that people feel comfortable with. Therefore, in building such a device,
we must strike a balance between putting in enough power and interesting features of a small set of "killer apps" to truly get the under-served population connected and not overburdening the system with unnecessary complexity that can hamper the usability, reliability, and frugality requirements.

With these principles in mind, in step three, let us speculate about what more functionalities we may not want to include and what we may. Examples of the types of applications that we will not want run on these devices will be things like Microsoft Word or Microsoft Powerpoint. Examples of the types of applications that may be naturally synergistic to the DVR applications that we have discussed, the types that we may wish to include, will be things such as a "visual voice mail" program that allows the users of the network of DVRs to send and listen to messages to/from each other, video uploading and exchange if we add a webcam to the DVR box--these are the type of applications that should mesh well with a sort of a "BitTorrent appliance" that we may want to build. With applications like these, the DVR devices could potentially be used for purposes other than the non-profit DSH applications: it may be an interesting device for people to communicate with each other and share entertainment content with, and for such purposes, the carriers powering such devices might be able to charge a fee, part of which could be used to subsidize the educational activities enabled by these devices.

A goal of the DSH project is to approximate the Internet philosophy without mandating the brute-force replication of a conventional PC-only or broadband-only infrastructure. Our emphasis is on compelling local content, local applications, applications that could make a difference in people’s lives, and exploiting simple, familiar, and easy-to-use metaphors. We believe the DVR project proposed in this writeup is an example step in that direction. (In a companion paper, we discuss another example, a community radio-based system that shares this philosophy.) With such systems, we wish to build a "Web 2.0"-like system accessible to the vast underprivileged population, so that a much bigger segment of the society can contribute and share content on "the network" and reap the benefits that have been so far beyond their reach.