"BitTorrent TV + Netflix" for Disseminating Lesson Videos to Disadvantaged Rural Schools in India

Randolph Wang

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Describe your idea clearly (details of problem being solved, solution specifics including technology components):*

The Digital StudyHall project (DSH, http://dsh.cs.washington.edu) seeks to improve education for poor children in rural and slum schools in India. One may think of it as the educational equivalent of "Netflix meets YouTube." The best grassroots teachers and other volunteers are filmed as they teach the local state curriculum in their local languages, while practicing the best interactive pedagogy; the community video processing stations pool these contributions into a networked database; from there, lesson videos are compiled into coherent sequences and burned onto DVDs; these DVDs are shared with poor schools, which are given TVs, players, and electrical equipment to play the discs; not relying on passive TV-watching, teachers at these recipient schools, though less knowledgeable, are trained to actively "mediate" the video lessons by imitating and embellishing the activities contained in the videos during pauses. This model helps train the local teachers and deliver quality instruction to underprivileged children. Those recipient teachers who have shown the greatest improvement participate in future filming, and see their own lessons used by even more peers.

The poor schools that we reach have no land-line connections and they are extremely resource-constrained---most do not even have functioning toilets; (we will discuss the electricity situation in a later section;) DVDs and DVD players have been an effective way of getting to them and they have served DSH well in the past three years: they are cheap, easy to learn and operate, and more reliable than computers. They also have big problems: discs are easily scratched in daily use and need to be systematically replaced; burning discs at the community hubs are time- and labor-consuming; a stack of discs is a poor way of managing a growing library that already numbers thousands of videos today; and the lack of means of communication severely limits the functionality of these players, in terms of sharing and monitoring, for example. These problems grow worse as DSH scales.

In this proposal, we explore a better video player, armed with a wireless connection, for use in slum and rural school classrooms for the purpose of sharing DSH video lessons. This player will be an inexpensive embedded Linux device (along the line of an Intel Celeron- or Atom-class device), equipped with a large amount of disk storage and a cellular data card. Instead of DVDs, the thousands of DSH lesson videos will be stored on the internal hard drive, accessed through a database interface in a local language, and organized as a "video Wiki." The lessons on these devices will be refreshed through the use of a combination of "sneaker nets" (an approach that we use today) and the cellular connection. (We shall
address the limitation of the cellular connection, in terms of its bandwidth, reliability, and cost, in our answers to a later question.)

In addition to being used to exchange a fraction of the videos, the wireless connection on these devices also enables other functionalities of the proposed video players. For example, village teachers and students may rank the videos in the system; the usage information communicated to hubs can enable community-based monitoring and quality-control programs; network-wide tests or competitions based on the video lessons may be conducted through these devices to complement the curriculum. In short, the wireless connection on these devices enables us to knit the individual devices into a coherent global whole, allowing the under-served children and teachers to be exposed to superior education resources that have been long out of their reach.

Since 2005, we have been running small-scale pilots and evaluations in disadvantaged schools in India using a DVD-based distribution mechanism. DSH won the 2007 ACM Eugene Lawler Award for Humanitarian Contributions within Computer Science and Informatics, and the top prize in the education category of the 2008 Tech Awards by the Tech Museum of Innovation. We believe that the proposed device network will play a critical role in our efforts of further scaling DSH successfully.

**What problem, economic, social or human need are you trying to address?***

In many developing countries, only a small fraction of all the teachers are well-trained and qualified. They teach almost exclusively in the relatively few "good schools" serving middle-class students. The overwhelming majority of the schools, attended by the rural and urban poor, are mostly staffed by poorly paid teachers who lack in both pedagogical and subject matter knowledge; student performance is poor and drop-out rates, high. Even in these "poor schools," however, a very small fraction of the good and dedicated teachers exist. These small number of good teachers, scattered in the different schools, unfortunately, only reach very few students. Less skilled teachers lack a way of improving themselves or their students even if they wanted to. The question is how we could build something that amplifies the good teachers' reach, helps the less trained teachers learn, and bridges the "good" and "poor schools."

**What impact will the solution have? Who will it impact?***

The ultimate beneficiaries are the poor children in the developing countries. For example, of the 200 million plus children (age 6-14) in India, the drop-out rate at lower primary level is 35%, and 53% at upper primary. Over 50% of the Pakistani third graders can't multiply 32 by 4. The network of these inexpensive BitTorrent-like video players will collectively end up housing a "people's video database of everything," covering all subject matters, grades, local languages, state and national syllabus, produced by the people, for the people, freely accessible by everyone. There are several possible ways of using the videos on these devices. Less skilled local teachers may play them in front of their own classes, pausing periodically to interact with their kids; student leaders may use the videos to lead lessons for
their younger peers; NGOs can use them to run their own schools; teachers may study the best videos in teacher-training schools or by themselves.

**Please answer the questions below that are pertinent to your submission**

**Attainability**

What is expected deployment timeline?

The DSH project started in India in the summer of 2005. Today, we are at the stage of small-scale piloting, using DVD players in our schools. On the technology front, we have been developing and enhancing a community video production pipeline and a Netflix-like DVD-based distribution scheme. On the pedagogy front, we have been refining and evaluating a "mediation-based" teaching methodology; the rural and slum school students benefit from a pair of teachers: a "virtual" teacher that knows the subject matter well and practices the best pedagogy under a well-designed lesson plan, plus a "real" local teacher who supplies the crucial human element of interaction.

We are currently in the midst of discussions with partner organizations for the next stage deployment and evaluation of more DSH schools. Should we receive an award, we plan to spend the next one to 1.5 years on developing the software for the proposed device, and to deploy a test-bed device network in approximately 20-30 under-served schools during the fall of next year.

What are the next 3 steps that would be taken if you have a winning solution?

Going forward, we expect that the software development effort of the proposed video player will evolve through these stages in the next 1.5 years: an embedded Linux- and hard drive-based player without connectivity, providing a "video Wiki" interface in local languages for accessing our lesson library; the introduction of wireless connectivity that enables occasional low-bandwidth communication for functions such as remote monitoring, video ranking, and system-wide tests; asynchronous transmission of selected videos from community hubs to the recipient schools; and asynchronous peer-to-peer transmission.

How much will your solution cost?

The short answer is that we expect the hardware deployment cost to be between $750 to about $2000 per school, depending on several factors including how large the school is, how many screens per school we deploy, and the electricity backup or generation solutions required. The following is the longer answer.

Up till now, our base equipment in each school consists of a 19in TV, a DVD player, a 12v x 150Ah battery, an inverter. (The 19in TV is quite clear for a class as large as 50 children---the overwhelming majority of the poor schools in which our system is deployed do not have furniture and children typically sit on floor mats and they sit close to each other.) This base
configuration costs about $500. Replacing the DVD player with a Linux player, we expect to increase the cost of the base configuration by about $250.

We will discuss the electricity issue in greater detail in our answer to a later question, but for the places that are far from the grid, we need to spend a little more on a lower-power configuration that will cost about $900. This entails replacing the 19in TV with a $300 "pico projector" powered by LEDs, and replacing the 12v batteries and the inverter with solar panels and smaller batteries.

Another often-asked question is how many players we need per school. For a typical school of grades 1-5, with a total school population of about 250, three players allow each child to have three half-hour lessons in English, math, and science (the most desired subjects, according to consensus by kids, parents, and teachers) per day. The two additional players need no significant internal storage, and all players can share a wide-area connection and electrical equipment of larger output wattage, limiting the total cost to under $2000 per school. (For example, in a simple scenario, the two additional players can simply be SD card-based "dumb" devices: the teachers will fill the SD cards with the desired content on the single Linux device of the school and carry the SD cards to the classrooms where the dumb devices sit.)

We will discuss the issue of air time cost in our answers to a later question. The per-school hardware cost is the one that, obviously, scales with the number of schools, so it represents perhaps the most visible component of running the whole "eco-system." But the eco-system also includes other components, such as the cost of running community-based video production hubs, and the cost of a small monitoring and trouble-shooting staff that are shared by many schools. At significant scale, these costs should be well amortized, but we shouldn't neglect the fact that it is a whole eco-system that we are running, not just the devices in individual schools.

How many people will the solution reach?

The most immediate beneficiaries are the children and teachers in the proposed "test-bed" of devices deployed in 20-30 under-served schools around our Lucknow hub in India. This test-bed will reach about 5,000 children and 100-150 teachers.

We have been in close discussion with the Uttar Pradesh state government and UNICEF, who have been following and impressed by our preliminary evaluation results demonstrating significant academic improvements and a compelling cost/benefit argument of the DSH approach. Working with such potential partner organizations in the future, we expect the ultimate potential population that can benefit from the system to be large: in the state of Uttar Pradesh alone, one of the most impoverished states of India, where the most accomplished DSH hub operates today, there are more than 100,000 severely under-served government schools, which should all be able to benefit from the DSH system. And as we discuss in our answer to a later question, the system can be replicated in other states of India and other countries.
What is your biggest obstacle you need to overcome in this project?

In the most impoverished regions that we target, many factors over a long period of time have fed on each other to create a culture of low expectations of the existing education system: the isolation felt by people living in rural areas, the lack of access to good education resources, rural families' (correct) perception that the rural schools do not function and their having given up on the system, pervasive perception among some teachers that rural families do not value education and their not taking their jobs seriously, government entities' failure of establishing accountability or a sensible incentive system.

Perhaps the biggest obstacle that we face is often a *culture* of general apathy that is more entrenched than any individual physical elements. One will be naive if he expects that dropping a video device housing a good content library in such a school should have magical effects over night in transforming such a culture that has been built up over generations. However, one will be equally mistaken if he concludes that this problem is intractable and entirely beyond the scope of technology-based solutions.

We highlight three key factors of a solution. First: patience. Although habits and a culture of apathy do not change overnight, the technology-based solution does provide a critical link of a path that can break the vicious cycle where no path existed earlier, and as we have seen in our pilots so far, it can gradually raise the community's expectations, and begin the process of a gradual cultural transformation when people see what is available, what is possible, and what they can accomplish. This change takes longer than what technologists are accustomed to and must be given time to play out.

Second: attention to building an entire "eco-system." We must recognize that the technological components, though critical, is only a small part of a bigger people-based system, and motivating and empowering people is the key to transforming a culture. For example, rural teachers get happier kids when they use the system as an aid to their own work, and the expert teachers are thrilled to see their lessons used by many more children who watch their videos. Harvesting such enthusiasm, working to empower and improve teachers and organizations, not replacing them with technology, is critical.

Third: complementary technology solutions for community building. For example, to overcome a sense of isolation felt by rural teachers and to strengthen the sense of being part of and working with a larger community of teachers elsewhere who care about each others' work, we are currently building a "voice social network" (based on the open-source Asterisk system) for the rural teachers participating in the DSH system, allowing participants to share experiences and encouragements, motivating each other to do better.

Does the solution leverage existing technology, or would new technology needed to be implemented for it to work? What additional resources are needed?

We are leveraging existing technology and building some new pieces. The pieces that we are leveraging include: "Postmanet" (a Netflix-like DVD-based distribution mechanism that we have built and is operating today in our pilots), inexpensive embedded Linux-based video players (the "Tornado M60" produced by SysMaster, a Celeron-class machine, is one of the
devices that we are collaborating with SysMaster on), "3G" cellular connectivity (widely available in India, even in most rural areas, although the available bandwidth is typically low: 10-15KB/s), and peer-to-peer exchange protocols such as BitTorrent.

The pieces that we yet have to build include: an interface, implemented in a local language, for accessing the video database stored locally on the embedded Linux device, adapting a BitTorrent-like peer exchange protocol for our network of devices, (potentially) working on a scheme to dynamically adjust our transmission schedule to adapt to bandwidth arrangements with a carrier (which we explain in greater detail in our answer to a later question), and "low-bandwidth" network-wide features such as ranking and usage statistics collection for analysis by educators.

**What government policies would need to be adopted, if any, for this to be successful?**

We are realistic about the time that it may take to influence government decisions and our project does not necessarily depend on new governmental policies to be enacted right away. Having said that, however, we do believe that certain governmental actions can be helpful. For example, as we have discussed earlier (in the context of "obstacles"), at least in some of the states in India, a better system of accountability and incentivization for government school teachers is very much needed.

This type of reform should complement well the proposed device network: the resources provided by the system (in the form of content, pedagogy, and feedback) provide a tangible path of improvement and remove a potential excuse for inaction; and a policy reform focused on strengthening accountability can help ensure that all the stake-holders get the most out of the investment made in the proposed device network. Other examples of helpful policies may include a government subsidy on the small solar panels used by the schools to power their devices (which we discuss in response to a later question on energy), and tax breaks for corporations that may donate various pieces to the device network, such as off-peak cellular bandwidth, the player and display devices.

**Sustainability**

How is the solution’s business and usage model sustainable long-term? How many months would it take for the solution to become sustainable after initial launch?

We are working on three paths towards financial sustainability: (1) top-down deployment via partnership with governmental entities, (2) bottom-up "viral" adoption by peer organizations, and (3) potentially leveraging the same device infrastructure for for-profit applications. These three paths are not mutually exclusive and some combination of these may make the most sense. We discuss these options below.

We have been including Indian state government entities in the partnership from the beginning of the DSH project, and preliminary evaluation results showing dramatic academic improvement in participating schools have left a strong impression. These governmental entities are fully aware of the desperate lack of skilled teachers in public schools and the fact
that few practical options that can fix it exist today; and they are keenly interested in realistic solutions. The DSH approach of exposing high-quality instruction to under-served communities and training the local teachers in the process, with a fairly low expenditure on infrastructure, represents what we believe is an extremely compelling cost/benefit case of spending limited tax payer funds to achieve a measurable and substantial gain in school performance. Some of our other partners, such as UNICEF, are similarly interested in exploring cost-effective approaches that have large-scale replication potential. We shall continue involving these partners as we systematically conduct larger-scale evaluations of pilot deployments and demonstrate academic gains. In terms of a time-line, we are aiming for a relatively large deployment partnership sponsored by the Uttar Pradesh state government in about two years, after we have gathered sufficient experience and results in our test-bed.

While working with governmental entities can perhaps be described as "top-down," a "bottom-up" "viral" alternative is one under which we work with peer organizations (such as the SEWA and BETI NGOs discussed in our answer to the partner question) and individuals that are interested in adopting the DSH approach in their existing or newly established schools. In this scenario, these partner organizations will spend their own resources to purchase the air time and the player devices to put in their own schools. These player devices will join the larger network, allowing the under-served children and their teachers to experience the community lesson video library.

Once a relatively large network of these peer video exchange devices are deployed, in the future, it may be possible to leverage the same infrastructure for for-profit purposes. We explore this possibility in our answer to the next question.

Describe the income-generation opportunities involved in the solution, if any.

We currently have an exclusive focus on perfecting the DSH system for a disadvantaged student population in urban slum and rural schools. We are determined that kids in these settings should be able to enjoy the DSH system and services for free. However, there may exist the possibility of building a parallel system targeting middle-class students in urban areas, with which we may be able to collect revenue to fund the non-profit arm of DSH. In one possible model, we could strike up partnerships with schools serving a middle-class population, deploy a network of a different class of the lesson video library devices, and share revenue among several parties: the teachers who contribute content, the participating schools, and DSH.

(We must frankly admit, however, that unlike the core DSH mission of serving disadvantaged children, which we have been operating for more than three years and have experiences and results to back it up, this direction of working with middle-class schools discussed here is speculative. And there are existing companies in this space, although we do believe that should we pursue it, we will have competitive advantages: the existing companies are of the more traditional model of hiring a relatively small number of experts to author CD coursewares and such and then massively distributing it, and are not operating under the model of a "market place," the model of an "education eBay," for the lack of a better term, that we intend to operate.)
The two arms (the non-profit and for-profit arms) may complement each other: for example, some (but not all) of the content generated for one arm could be potentially used by the audience of the other arm; and technology built for one arm may be useful for both. We are determined not to create a "segregated system" where the "good stuff" is locked away somehow in a vault and made only available to those who can afford to pay for it: all our content will remain free. However, it may be possible to provide additional services, which teachers and professional tutorial service providers may participate in, that could allow us to share revenue.

An entirely different for-profit possibility is to stick with the under-served population who have no access to the world of the Internet and computers as we know it, and to leverage the same DSH network of peer-exchange devices for non-educational (entertainment) applications. The proposed devices can be made available to the general communities after school hours in the context of something like a "community center"—these are still shared devices, not placed in individual rural households. If we integrate a webcam into the device, for example, and allow recorded clips to be shareable network-wide, we may be able to run applications such as video mails, network-wide singing competitions, and dating applications. To keep the cost down, the communication required to support these applications will still be carried out asynchronously, most likely during off-peak times (as we discuss in our answer to the question on connectivity below). But unlike the lesson videos that are made available to teachers and students for free, a user of these applications may be charged a fee. The carriers may choose to deploy their own applications or host their own content (such as popular songs and videos) that are made available on this network of peer devices; revenues collected for the air time may be used to subsidize the air time consumed by educational activities.

What partners, including governments, play an important role in the development, implementation or long-term management of the solution?

Among the partner organizations that we collaborate with in working with recipient schools (where we deploy DSH content) are UNICEF, SEWA (Self Employed Women's Association, which runs slum schools in Lucknow), BETI (Better Education Through Innovation, which runs a network of informal rural schools in the state of Uttar Pradesh for girls who have dropped out of formal schools), and DIET (District Institute for Educational Training, Lucknow District, which is run by the state government and trains teachers from rural government schools). Among the partner organizations that we work with in managing the process of community-based video production are the Study Hall Educational Foundation in Lucknow, the Madhavi Kapur Foundation in Pune, the Loreto Convent School Sealdah in Calcutta, and St. Mary's Polyclinic in Lucknow (for organizing the production of videos on rural health awareness). The partners that we work with on evaluating the effectiveness of DSH include the Graduate School of Education of University of California at Berkeley, and the College of Education of University of Washington at Seattle.

We have been working with SysMaster, a company that specializes in various embedded solutions. The “Tornado M60" produced by SysMaster is one of the devices that we are considering as a hardware candidate for the proposed effort. We are also examining several
other alternatives. Among the future partnerships that we wish to strike are ones with wireless carriers, who will provide the air time for our devices. We discuss the nature of the potential collaboration with carriers in our answers to the next question on connectivity.

How dependent is this solution on pervasive Internet communication? Is there a workaround for operating in communication-challenged environments?

DSH was specifically conceived and designed for communication-challenged environments: in the past three years of initial piloting, DSH has relied on a Netflix-like DVD-based transport mechanism, not using conventional connectivity at all when "transmitting" videos from the community hubs to the recipient schools. The hubs themselves, located in cities, however, may in some cases communicate with each other via broadband to "sync up" their databases.

The sneaker net approach of using DVDs as a transmission media among the community hubs was pushed even further, so that a layer of asynchronous communication software provides a great deal of transparency: DVDs behave like "network packets;" one just pushes a button to invoke a DVD-handling robot to automatically burn outgoing DVDs from a large hard drive-resident "send buffer;" and an "auto-run" program also allows a stack of incoming DVDs to be processed automatically, depositing incoming data in a large hard drive-resident "receive buffer," upon which application-specific handlers are run. The API is therefore analogous to "asynchronous RPCs."

The sneaker net approach will be retained even as we replace the DVD players with the proposed network of player devices, for places or times where the bandwidth is too low or non-existent. And for the places with low bandwidth that still receive their videos through sneaker net, the weak connection can still be used for less demanding features of the device network, such as ranking and usage statistics collection.

Even for places that have decent cellular coverage, one may question the feasibility of using the wireless connection to exchange our lesson videos. There are three considerations that argue in its favor. First, judging by the 10-15KB/s bandwidth that we have observed and experimented with in most places in India, we estimate that 2-3 lessons of acceptable quality can be exchanged per day, a rate that is satisfactory for DSH purposes (after the initial bootstrap process that populates the internal drives of the deployed devices). Second, the DSH pedagogy model relies on an asynchronous delivery model: the local teachers only play and pause locally stored videos; there is no strict requirement on communicating videos on demand while someone waits anxiously; and we may be able to exploit less expensive airtime (say, during nights). Third, we will implement a peer-to-peer exchange protocol so that the whole network of these devices is not bound by a small number of centralized hub bottlenecks.

Because we only need asynchronous background transfer of video data at any rate that is available to us, we do not necessarily need to compete against the vast majority of "normal" users during peak times; bandwidth during off-peak hours that are otherwise under-utilized may prove sufficient for us. (We could even potentially work out dynamic schemes in which air time allocated to our device network is managed (throttled) dynamically by the carriers.
based on currently detected levels of congestion.) We hope to be able to strike up agreements with carriers who might be willing to provide us with discounted or donated air times during these off-peak hours. Furthermore, regarding other non-educational entertainment applications enabled by this network of devices that could potentially generate revenues for carriers, we hope that we could come to agreements with carriers that will allow us to further offset the air time cost of exchanging educational lesson videos. Perhaps the cost of the devices themselves could be partially subsidized in this way.

**How dependent is this solution on a continuous energy source? Is there a workaround for operating in energy-challenged environments?**

A large fraction of the poor rural schools in India are actually not off the grid; it's just that the electricity is only available intermittently and the quality of the electricity is poor. (For example, it may only come in the middle of the night for 5-8 hours; and voltage and frequency can fluctuate wildly.) A big battery (12v x 150Ah) plus an inverter plus a stabilizer (40v-400v), a configuration that allows batteries to be charged, for example, during the nights when the electricity comes, and used during the day time to run classes, is usually sufficient. The cost of this set of electrical equipment is about $300. We have been using this setup in our pilots in the past three years.

For places that are completely disconnected from the grid (and there are plenty of these too), the 19in TV that we have been using burns too much power for an economical solar-based solution. For such disconnected sites, we will be experimenting with "pico projectors" (a cellphone-sized, LED-based projector that consumes about 6w and sells for about $300 at the time of this writing) in our proposed device network. A small solar panel (probably 20w-35w and under $120) and a smaller battery should suffice.

**Scalability**

**Is the solution widely applicable across different geographies and areas? How so?**

Today, DSH mainly operates in India. The lack of knowledgeable and well-trained teachers in rural areas and slums and the desperate need for better access to basic education, needless to say, is not unique to India. As mentioned earlier, for example, in Pakistan, where we are about to begin a DSH pilot next, over 50% of the third graders can't multiply 32 by 4. We believe the basic idea of filming the best grassroots teachers and distributing them on a network of cheap players is applicable in most, if not all, of the developing countries. India is a big country with diverse cultures and languages; and in the past several years, we believe that we have gained valuable experience in replicating this program (using DVDs) in different parts of the country. In fact, the main thrust of this proposal, the proposal of replacing DVD players with a network of inexpensive wireless hard drive-based players, is based on the lessons that we have learned in these past years' piloting experiences. The availability of main technological ingredients are common across different geographical regions: already widespread and still growing cellular coverage, improving wireless bandwidth (complemented by our sneaker net approach discussed earlier), low energy consumption needs (that can be cheaply solved by solar-based setups mentioned above), and
a shared device model (so a low per-capita investment can generate a compelling bang for the buck).

If the solution is already deployed, in which geographies and areas?

Today, using a DVD-based distribution mechanism, we run pilot "hubs" in Lucknow, Calcutta, Pune, and Dhaka, covering approximately 30 schools in slums and surrounding rural areas. We have accumulated more than 1500 recordings of lessons in English, math, and science, in Hindi, Bengali, Kannada, Marathi, Tamil, and English, and 1500 additional videos of other materials such as stories, special science and history topics, and training sessions. At the time of this writing, we are weeks away of launching a new pilot hub in Pakistan. As discussed earlier, however, we have recognized that problems associated with a purely DVD-based distribution mechanism that could hamper our attempts of scaling up, and this recognition has led to this proposal of replacing it.

How have you tailored your solution to be locally relevant?

As we have discussed, DSH has been operating in India in the past three years, and from day one, it was designed to be a locally appropriate solution. We list some of the elements. First, technology. Some examples are the use of a Netflix-like DVD-based transmission mechanism as opposed to relying on broadband, shared TVs (driven by other player devices) in classrooms that deliver clear visuals and sound to a whole classroom as opposed to expensive per-person devices, low-wattage electricity provision solutions that can be practically implemented on a per-school basis as opposed to, say, being put into disadvantaged individual households at a large scale.

Second, content produced at grassroots level. Our lesson videos are based on syllabus decreed by the state governments, taught by the best local teachers in a local language, who speak about local culture and customs. For the health awareness videos disseminated among rural adults, again, we address local customs and habits that may be far from obvious for outsiders. For example, local villagers in some areas of Uttar Pradesh have a custom of reserving the job of cutting the umbilical cord after birth to lower-caste people and waiting for as long as 24-48 hours before they can find the right person to do it, a custom that significantly worsens infection rates, a custom that is not known to most outside "experts," but well-known to the local doctors and nurses featured in our grassroots videos.

Third, local participation and local capacity building. Technology employed by DSH is not meant to replace people in anyway; instead, it empowers people. The "producers," or the better teachers who appear in the videos, see themselves reaching a larger audience; the "consumers," or the less skilled teachers, "mediate" the videos so that they themselves get trained in the process and are encouraged to do away with the video crutches in the long run; the organizations, including schools and NGOs that aspire to do better outreach work, when they adopt the DSH program, get to realize what they have always wanted to do on a larger scale with the system than without.
Fourth, continued adaptation. We continue to tweak our approach in an iterative process of field trials, feedback, and change to adapt to the local environment. For example, in the earliest days of DSH, we used a cheap laptop to drive the TV. We observed quite a few problems: 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. And then, we start to observe new problems with DVD players too, and it's precisely this adaptation process that has led to this proposal of replacing the DVD players with a better specialized player device, a device that should be without most of the faults of the general-purpose laptops but providing features not possible on the DVD players being used today (features that we have discussed earlier).

In the longer run, our vision of successfully reaching a vast under-served population is a "core and fringe model." The "light-tech fringe" is populated by simple, cheap, and practical devices like TVs, conventional FM radio receivers, dumb phones, and now, under this proposal, specialized video players, while the "high-tech core," embedded inside community hubs and run by partner organizations, with "ingredients" such as higher-powered servers, databases, more sophisticated software, DVD-burning robots, better skilled staff, contains the logic and data to drive these fringe devices distributed among a vast under-served population, uniting them into a coherent and intelligent whole, providing functionality and services above and beyond what these dumb fringe devices are capable of in isolation today. One may think of this vision as an extreme version of "thin clients" plus "the cloud," tailored for a severely resource-constrained developing country environment.

What is the ROI and how is it realized?

The ultimate "ROI" of the proposed system is not in monetary terms: it's about producing academic results with a relatively low investment in infrastructure development.

For example, In a recently published preliminary evaluation of a small-scale deployment, 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 matters as well as pedagogical skills, and the classrooms showed significantly increased student participation. A paper on this preliminary evaluation results presented at the annual meeting of the American Educational Research Association of 2008 can be found at:


Having said that our main mission is not revenue-generation, we have also discussed (in our response to an earlier question) several speculative scenarios of "income-generating possibilities" that could potentially add extra paths to sustainability. One is constructing a "parallel system," targeting middle-class students, and sharing revenue in partnerships involving participating schools, contributing teachers and tutors, and DSH. Another is leveraging the same device network deployed in under-served areas to attract users from the community in fee-charging entertainment applications, potentially in partnership with carriers who profit from air time revenue.
Innovativeness

In addressing unmet needs, is the proposed solution an improvement over an existing solution or a completely new approach?

Perhaps the best way of characterizing DSH is taking a number of known models and technologies (such as Netflix, YouTube, and BitTorrent), combining them, and applying the result to solve the problem of improving education for under-served populations. We believe this is a new approach.

We discuss some related approaches and models and how ours is different. EduComp is perhaps a typical example of a class of education content production companies in India. They hire a relatively small number of "education experts" to author education content, in the form of, for example, flashware, and the resulting product is marketed to middle-class schools. The difference between DSH and EduComp can be thought of as being similar to the difference between YouTube and just plain "tube," or broadcast TV---the latter is a more traditional mass media exercise: a very small number of producers producing studio-quality content for a massive audience; while the former represents the new grassroots media production model: harvesting a large grassroots movement to produce content for peers.

The grassroots production model has a number of advantages: (1) Extreme local relevancy. For example, despite the fact that the entire state of Uttar Pradesh speaks some form of Hindi, there are many different dialects. The city dwellers speak a very different version than villagers, and the city-variant can be difficult for rural folks to understand. The grassroots content production model can churn out extremely tailored content for narrow-casting to relatively small audiences. (2) Quick turn-around to adapt to feedback from the field. A video is played in the field; feedback is received by a field staff or through a phone system; a change is made to an existing video, or a new video is produced in response. This whole process can happen in the span of just a few days. (3) Large content repository produced very rapidly and shared at extremely low cost. In the three years of existence of DSH, with a shoe string budget, in a largely "research mode" of operation, we have produced more than 1500 videos of high-quality lessons in various local languages. We believe that the ambition of producing an encyclopedic "library of everything" that covers all subject matters, all grades, all languages, and all syllabus is only feasible under the grassroots production model. (4) Serving the "right" target audience. EduComp caters to an upper-middle-class client base: its basic fee is $1500 per classroom per month, with a slight discount for additional classrooms, an amount that is far above what the under-served schools can afford, and there have been many questions raised over the years about whether any of this expensive content actually raises student performance.

Another related area of efforts is rural kiosks. One of the major challenges of kiosks is for their advocaters to come up with compelling content and applications that change reality on the ground; more often than not, this challenge has not be successfully met. The proposed DSH system is not a device solution---it's a whole "eco-system" that includes many technical and non-technical elements: teachers, schools, organizations, community-based content production, dissemination, pedagogy, feedback and evaluation. Technology is an important
part of this eco-system but the whole eco-system is much larger; technology development in this context, therefore, never originates in the vacuum: it always starts with educational tasks or problems; the team then attempts to work out solutions, some of which may turn out to be technical. And we continue to monitor, evaluate, and iterate. As a small example of technology serving the needs of the educational tasks, the need of gathering usage logs of the DSH videos played in recipient schools is identified by the education team, a feature that has not been possible with the DVD players currently used, and one of the features that we intend to build into the proposed device.

There have been many attempts of using video as an education tool ever since the invention of TV. One of the perhaps more interesting such attempts dated back to the 1970s when researchers at Stanford got a group of master's students to learn from taped lessons in a peer-mediated setting, and concluded that students were able to excel as long as a number of ingredients were present, chief among which was the appointment of an active mediator who supplied the crucial live interactive elements. This experience, known as TVI, or Tutored Video Instruction, was one of the main inspirations for DSH. To the best of our knowledge, however, we know of no attempts of applying this technique to learning environments of much younger children, or to developing country settings, or by exploiting the community-generated video approach.

There have also been many attempts using satellite-based distance learning systems. Satellites are a good broadcast medium, but ill-suited for customized point-to-point and high-bandwidth communication, which is what a YouTube-like Web 2.0 application requires. In addition to being a technical mismatch, satellites are also a poor pedagogy match. Satellite-based communication was originally intended for synchronous real-time applications such as live teleconferencing. What we have observed is that teleconferencing is a poor metaphor for enabling distance learning in our setting: when an experienced remote teacher attempts to "teach" to a large number of rural sites over a live teleconferencing-style link, the many students at the many target schools cannot "pause" the remote teacher or participate in any meaningful interaction across distance on a large scale. The synchronous nature of the communication, paid for at a hefty price, ends up being a liability. The asynchronous nature of the DSH communication, in terms of inexpensive and "high-bandwidth" DVDs that allow local teachers to take full control, to play and pause the content at will, at times and paces of their own choosing, to engage in meaningful dialogs with their local students, to train themselves after school hours, turns out to be a blessing.

The Google book scanning project is another inspiration. In spirit, we share its goal of creating a digital database of "everything." Unlike the book scanning project, however, DSH is community-based and video-centric; and all the DSH content is free for use or modification by the public. Being video-centric is also what distinguishes DSH from Wikipedia. DSH also shares obvious commonalities with YouTube. Among the twists that we add to the YouTube model, from a technical standpoint, are a Netflix-like practical solution of transmitting content where connectivity is problematic, and a BitTorrent-like peer transfer model to eliminate the need of paying for prohibitively expensive centralized distributors.

What are the key technology components in the solution? What Intel technology is used?
The most visible technology components are the embedded Linux-based video player devices distributed to the under-served schools. They will be Celeron- or Atom-class devices.

Less prominently visible are the video editing and database equipment housed at the community video production and dissemination hubs. They will be based on high-powered Intel processors.

**Length of Impact**

How long does the solution's impact last in its initial phase?

Our intent is that the DSH program and its impact will last indefinitely.

The community-based lesson video production effort will continue; the equipment placed in the participating school will remain indefinitely; the growing lesson video repository will remain available to any schools, NGOs, individual teachers and students who desire to access it; and the DSH staff will continue to monitor and evaluate the academic progress of participating schools and adjust the system.

The initial phase proposed here will see the deployment of a device network test-bed in 20-30 under-served schools. Again, we intend the devices in these schools to remain indefinitely, serving the children and teachers for the foreseeable future. The deployment of the test-bed will start about 1.5 years from now, should we be fortunate enough to receive an award.

What criteria must be met for the solution to have long-term impact?

The two most important criteria are: (1) our continuing to demonstrate evaluation results at progressively larger scale that show significant student academic performance improvement and teachers' progress, and (2) obtaining funding in working with our partners (and possibly, profit-generating spin-offs, as discussed earlier), so that we can expand to a progressively larger set of schools, while continuing to work with existing participating schools and maintaining their quality.