The Digital StudyHall

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1977

A long time ago in a galaxy far, far away….

“Tutored Video Instruction”

• Stanford \(\rightarrow\) Santa Rosa plant of HP
• Minimally edited videos of unrehearsed lectures
  – Easy to make

“Tutored Video Instruction”

• “Tutor” job:
  – Initiate and encourage stopping the videotape for discussions
  – Rely on dynamic interaction to stimulate intrinsic interest
  – Interfacing with on-campus instructor
VVI results

Caveat: data does not yet permit a rigorous statistical test

TVI students start with worse qualifications
They come out ahead regular students

Lessons

- Although not sufficient by themselves, captured lectures are a good foundation
- Instigating interaction can significantly enhance effectiveness
- Successful instigation can be effected with relatively simple means
- Group learning can play a key role

Outline

- The “TVI prelude”
- India education background
- Introduction to the Digital StudyHall
- Connectivity: Postmanet and phttp
- Content capture
- EdTV
- Homework
- Pedagogy
- Other applications
- Conclusions
What to focus on?

• Peter Bell (president of CARE):
  – Three top priorities of combating extreme poverty…

• Basic education, clean water, fighting AIDs

India

• Adult literacy rate: 61%
• 34% of adult illiterates in 9 most populous countries

• An average Indian spends about 2 years in school

Poor state of public/private education

- “Free” public schools of extremely poor quality
- Serious teacher shortage and absenteeism
- Exponential growth of unregulated private “teaching shops,” especially in rural areas

StudyHall

- Urban private school in Lucknow
- Founder and principal: Dr. Urvashi Sahni

StudyHall

- Well-staffed
- Well-furnished
- Lots of facilities: sports facilities, science labs, music rooms, computer labs
Study Hall

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The Affiliated Village Schools

- About 250 students per school
- 2-6 teachers
- Little training
- Difficult subjects: English, math, science
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The Digital StudyHall

The Affiliated Village Schools

- Chintat-Ganeshpur Primary
- Itunja Primary
- Manzil
- Mahipat Mau Primary
- Kanaar Upper Primary
- Sarojini Nagar Primary
- Madantoosi Upper Primary

The Digital StudyHall (Lucknow)

Homework
Lectures
Sharing
The Digital StudyHall

- Narrow the gaps between:
  - Urban and rural
  - Private and public schools
  - The rich and the poor

- "Out-sourcing" model
  - Make shared resources available to those who can't afford piecemeal instances of their own
  - Economy of scale: encourages specialization, fosters efficiency
  - Uniform standards and quality

In the longer run...

- Scale up
  - More villages
  - More students
  - Start schools where there's none today
  - More staff/volunteers
  - Including volunteers overseas (mirror at UW-Seattle running)

- Allows distributed participants to "plug themselves in"
- Matches supply and demand
- Service offerers: both volunteers and professionals
- Flexible time and location commitments by participants
- "Open source" model
Principle 1: cost realism

- Schools in Bihar, Madhya Pradesh, Uttar Pradesh, and Rajasthan:
  - 63% leaking roofs
  - 58% no drinking water
  - 89% no functioning toilet
  - 27% no blackboard
  - 8% none of the above

- Weigh the cost of ICT against the above
- Cost realism crucial for scalability


Principle 1: cost realism

- Cost of “wiring” a village school < $1500
- Cost of “wiring” a child < $6
- (Not included: operational cost)

- Compare this against:
  - Average daily income per person: $1 - $2
  - Not uncommon: a rural family spends 1/5 of income sending one kid to school
  - A village teacher’s daily income: $1 - $4
  - A text book in the village: $0.3

- Cost of “wiring” a village school < $1500
- Cost of “wiring” a child < $6
- (Not included: operational cost)

- Compare this against:
  - A GSM base station
  - Erecting a tower for a directional 802.11 antenna
  - Launching EDUSAT
  - Adding an extra telephone line to a house in the US
  - Wiring a household in the Salt Lake Area with fiber

Slides convention:
Principle 2: build “systems” that solve education problems

- A lot more than connectivity
- “workflows” and pedagogy
- Work with people:
  - Headquarters staff
  - Village teachers
  - Students as students
  - Students as teachers

Recurring themes

- Any-to-any communication, customization, sharing, high bandwidth, cheap, solve education problems
- Enable collaborative learning among kids

Some hard questions

- How do you provide connectivity?
- How do you quickly populate your database with good teaching content?
- How do you address the “display problem”?
- How do you collect homework and provide feedback?
- How do you teach effectively with such a system?

Work in Progress: Icons

- ✔️ Deployed as planned
- ⬆️ Modified during deployment
- ▶️ Tried in lab, or ongoing work
- ►► Future work (not tried yet)
The Affiliated Village Schools

- Madantoosi Upper Primary
- Barojini Nagar Primary
- Kanaar Upper Primary
- Mahipat Mau Primary
- Itaunja Primary
- Chinhat-Ganeshpur Rahman Primary
- Manzil

StudyHall (Lucknow)

75km 25km 30km 5km 22km

The “big picture”

- Components: repository, phttp, EdTV
- “Workflows:” content capture, homework feedback
- Pedagogy research

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What Is A Postmanet Router?

- Start with a conventional router
- Users oblivious of “routers”
- Routers are general and transparent
What Is A Postmanet Router?

At the end of the day, it spits out a DVD

Picked up by a postman

The postman may also drop off an incoming DVD
A Postmanet Router

- Basic idea of using DVDs not new
- What is new: general and transparent
- General:
  - Support for multiple applications
  - Generic infrastructure (public transit system)
  - 2-way communication
  - Multiplexing/demultiplexing onto/from minimum disks
- Transparent:
  - No manual inspection of DVD content
  - No manual staging, copying
  - No manual handling of acks, losses, duplicates, …
  - Just insert/remove DVDs from the box

Advantages

- Wide reach: a truly global “network”
- Great bandwidth potential, technology trends:
  - “Sneaker nets” becoming more powerful
  - Storage density growth > Moore’s Law
  - Wide area bandwidth growth bound by digging ditches, launching satellites, erecting WiMax towers…
- Low cost
- Incremental deployment:
  - Classic chicken & egg problem: infrastructure, applications, users
- Good scalability

DVD Capacity

- HD-DVD: 15-20GB per layer, maximum of 40GB dual-layer discs
- Blu-Ray: 27GB per layer, 54GB dual-layer discs
- Sony plans to commercialize 4-layer 100GB Blu-Ray discs in 2007
- Sony has demonstrated 8-layer 200GB Blu-Ray discs in October of 2004
- Torok of Imperial College London
  - Asymmetric pits encode more than one bit per pit
  - Expects 4-layer 1TB discs 2010-2015

Sources:
- Scientific American, February 2005.

phttp: Postmanet-enabled http

- Network packets carried by DVDs in the postal system
- Transparency:
  - Minimum manual involvement beyond postal workers’ leg work
  - Crucial for scale-up
### Difference from offline browser

- **Offline browsers**
  - Eventual connection
  - no support for server scripts

- **Phttp**
  - May never be connected
  - Explicit migration of server script fragments

### DVD Robot

- Why DVDs? Capacity, cost, weight, …
- Robot automation
• Robotic entry—minimum manual intervention

• Data automatically copied from incoming DVD onto local disk
• No manual intervention beyond DVD insertion

• Village staff has access to two views
  – What’s available at the headquarters
  – What’s available locally
• Can “interact” with the site: browse, make download and upload requests

• Requests and data buffered on local disk automatically burned onto outgoing DVD
• No manual intervention beyond removing DVD from the box and handing it to the postman
phttp: (e) data arrives at headquarters

- Robot automatically fulfills upload and download requests from the villages

The key is transparency

- Transparency and efficiency needed for:
  - Scale up
  - Handling “exceptions:” lost or damaged DVDs
  - Splitting server scripts for asynchronous interactions
Complement with low-latency network

- Catalog of metadata
- Small requests, acks, NAKs, retransmission requests, etc.
- A UI for the cell phone?

Complementing low-latency low-bandwidth link

- Our current choice: packet radio (ham radio)
- Pro: range, cost; Con: low bandwidth
- (India cell phone tele-density: 2.5% as of 2003)

Other potential phttp services

- Asynchronous services
- With possible synchronous refinements (Google)
- Some service-specific scripts executed at both ends
- Lots of service-neutral infrastructure shared

Recurring theme: any-to-any communication

- Customized content, customized schedule
- High-bandwidth
- Cheap
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Main content sources and their mixture

1. Recording of live lectures
2. Authoring by remote volunteers
3. Redistribute existing content
Lecture capture

- Replaying captured lectures, by itself, will not suffice, but
- It can be an important part of a bigger solution
- (We will talk about other parts of the solution)

Real-time MPEG4 encoders

- 720x480 (DVD quality), DivX codec
- 30fps generates 1GB/hour
- 10fps generates 0.3GB/hour

- 250GB
- $160

- $300

- 720x480 (DVD quality), DivX codec
- 30fps generates 1GB/hour
- 10fps generates 0.3GB/hour

- 250GB
- $110

- $470
Screen Capture Movie

- 1024x768, DivX codec
- 5fps, 100kbps, 50MB/hour

Still camera: periodic shutter release

- 2048x1360
- 6 seconds per frame, 180MB/hour

Processing

- Passive capturing
- Modest post-processing
  - Breaking down into coarse-grained snippets
  - Subtitles, Annotation
  - Potential aid by lecturer during lecturing
- Staging lectures for captures
  - In Hindi
  - Volunteers from the teacher training institute

Mix and match snippets

- Simple editor that makes “super objects” out of sub-segments of existing objects
Other content

• Homework and feedback (more later)
• Asynchronous question and answer sessions
• Student-authored content

• Contributions from other teaching centers
  – Multiple centers of content accumulation
  – A peer-to-peer architecture of the repository

Recurring Theme:
any-to-any communication

• Customized content, customized schedule
• High bandwidth
• Build “systems,” not just providing connectivity
• Cheap

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The display problem

• Additional computer displays?
• Projectors?
• Expense and power consumption
EdTV

- Multiple TVs serve as displays
- Cheap and low power
- Plus cheap “input” devices

EdTV components (“output”)

- Graphics card with RCA/S-Video output
- Small TV signal transmitter
- A 12-inch TV set burns 20W

EdTV components (“output”)

- Scan converter (VGA to RCA/AV)
- AV-to-RF converter
- A 12-inch TV set burns 20W

EdTV

- Multiple TVs serve as displays
- Cheap and low power
- Plus cheap “input” devices
EdTV

- Multiple TVs serve as displays
- Cheap and low power
- Plus cheap “input” devices
EdTV (“output”)

- Extra graphics cards, sound cards, and transmitters for extra channels

EdTV (“output”)

EdTV leaving the classroom

- Kids work during the day
- (50% attendance during mango-picking season)
- Customize EdTV schedule: catch up at nights

EdTV leaving the classroom
EdTV: more profound potential

- EdTV is not regular TV:
  - Personal media vs. mass media
  - E.g.: “village idol”, same-language-subtitling
- EdTV is not WebTV:
  - Shared infrastructure, shared backend connectivity, cheap
- EdTVs are not kiosks
  - Brings a face into each household
  - Shared (multi-user) experience

Extending EdTV range

- Used VCRs, balloons, directional 802.11, …

EdTV “input” devices

- A ham “remote”: a simple transmitter that emits several command signals:
- Same ham receiver at base-station that handles both:
  - Input from ham remote, and
  - Input from long-distance communication with headquarters
- TV and radio control signals: ways of bridging the last mile

EdTV “input” devices

- Walkie talkies, microphone, voice recognition
- Use Hindi
- Paid $10 apiece but can do better
EdTV “input” devices

- Walkie talkies, microphone, voice recognition
- Use Hindi
- Paid $10 apiece but can do much better

Walkie talkies, microphone, voice recognition

$10

EdRadio

- Radios even more pervasive
- Customized local content: songs sung in schools, teaching English, recordings of “town hall meetings,” kids being “DJs for the day,” text-to-voice of content relevant to locals, …

Recurring theme:
any-to-any communication

- Customized content, customized schedule
- High bandwidth
- Build “systems,” not just providing connectivity
- Cheap

Electricity

- Intermittent power
- Battery/inverter unit
- Laptop battery: no UPS required
- Low-power TVs and laptops
- 10-20 hours operating time? (haven’t tested draining battery)
Electricity

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- Low-power TVs and laptops
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  (haven't tested draining battery)

Operator training

- Training for village and headquarters operators
- Capture the training sessions and use the system to propagate training videos
- Village operator training videos done in Hindi

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Village computer monitoring and administration

- Village computer log collection: distance monitoring and diagnosis
- Various levels of system restore in case of trouble
- Quick replacement with spares

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Goal: start schools where there’s none

- Assume minimum staff expertise beyond operating equipment
- Homework graded by outside staff

The obvious solution too expensive

- Village
  - Scan homework in
  - Transmit to headquarters
- Headquarters
  - Print it out
  - Grade it on paper
  - Scan it
  - Transmit back to villages
- Village
  - Print it out
- Problems
  - Expensive computer papers
  - Expensive printer cartridges
  - Some printing ok, but not massive amount of printing

The homework workflow (1): digitizing

- Camera instead of scanner: speed, versatility, portability, simple power requirements
- Microphone: digitize voice questions
- Webcam: video for a personal touch, not strictly necessary

The homework workflow (3): grading

- Step 3B: Batch image editing software + tablet pen
The homework workflow (3): grading

Step 3B: Batch image editing software + tablet pen

Step 3C: produce a feedback video with screen capture

The homework workflow (4): feedback

- Collective feedback played to all students on EdTV in classroom
- Use it to instigate group learning
- Individualized feedback “scheduled” at convenient times on EdTV
  - In-classroom, or even during evenings
  - Pause, rewind, zoom, etc.
  - Review graded raw images if necessary
- Showcases customized content/control of EdTV

Implications (1): better experience

- Not only comparable to what urban kids receive,
- But also better than existing homework feedback experience: more personal, rich media
- Same workflow useful for less structured question/answer sessions
Implications (2): content reuse

- Permanent storage, reuse, and sharing of prior interactions

What can an experienced staff do?
- Mix and match feedback snippets from the repository
- Contribute good content back to the repository for use by other villages
- Get higher-grade “genius” students to grade for other students

Implications (3): peer-to-peer help

Experienced staff

- What can an experienced staff do?
  - Mix and match feedback snippets from the repository
  - Contribute good content back to the repository for use by other villages
  - Get higher-grade “genius” students to grade for other students

Recurring theme:
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Two different questions

- Given a reasonably competent teacher, can any technology better a blackboard?
- Where there’s no teacher at all, how do you make the most out of what you have?
- Our focus is the second question

A Tale of three schools

- StudyHall morning sessions
- StudyHall after-school program for slum girls (Prerna)
- Madantoosi (village) school
  - Prerna as an “in-house testbed” of village schools

A Tale of three schools

- Teacher qualification difference
- Language difference
- Student background (environment) difference
- Different text books
- Systemic difficulty of bridging the education gaps

A Tale of three schools

- Morning lessons -> villages?
- Afternoon lessons -> villages?
- Morning lessons -> afternoon classes?
A Tale of three schools

- Teacher qualification difference
- Language difference
- Student background (environment) difference
- Different text books
- Systemic difficulty of bridging the education gaps

Try 1: Morning -> Afternoon

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- Language difference
- Student background (environment) difference
- Different text books
- Systemic difficulty of bridging the education gaps
Try 1: Morning -> Afternoon

Mediation

- Recorded material provides a framework
- Teacher “facilitates” instigate interaction
- Training for less experienced teachers
- (Model lessons stored in database for future training)

**Mediation:**
- Questions by teacher
- Dialogue between teacher and students
- Student exercises
- Student-to-student interaction
- Role plays
- Songs, poems, stories, drawings
- Tests
Teachers Learn to Mediate

- Learn communication/interaction skills
- Study recorded material ahead of time
  - Familiarize with material
  - Plan
- Flexibility:
  - How much to depend on recorded material
  - How much to improvise
Try 2: Replicate experience in villages

- Model lesson in front of village teacher
- Followed by village teacher’s running the class
Replicate in villages
Try 3: Staged model lessons in afternoon school

- Stage sequences of model lessons
- By best teachers from morning school
- Conducted in front of after-school girls
- Recorded for reuse by both:
  - Village schools, and
  - Future afternoon classes

Receiving ends: promising so far

- Village 1 (private)
  - 5 hours of daily use
  - English lessons for all grades
  - Science lessons for grades 5-8
  - Want a lot more (math lessons)

- Village 2 (public)
  - Working well but less well
  - Worse power outages
  - Software bugs
  - Elections/festivals
  - Sufficient teacher motivation?

Try 3: Staged model lessons in afternoon school

- Entire English curriculums for classes 3-5
- Based on government text books
- 90% English, 10% Hindi
- “Bonus:” for the 1st time, the best teachers teach in the afternoon!
- The girls seem to be doing very well
Evaluation

- Design rigorous tests for evaluation
- Turn the Digital StudyHall into a learning science testbed

Build a participatory and immersive environment

- Role-plays
- Distributed development of digital plays: involving both urban kids and rural kids
- After-hour cartoon shows
  - Consciously cultivate an English-speaking environment
  - Edited, with extra voice over

Preparations for scale-up

- Involve various levels of government
- Design teacher training sessions for scale-up
- Devise cheaper village hardware “classes:”
  - a spectrum that starts with DivX players + TVs
- Methodic scale-up that builds a network of excellence

A model for urban slums: “Prerna 2”

- Use existing school premises after regular hours: low cost
- Hire a small dedicated staff:
  - Trained in mediation
  - Armed with a high-quality digital content feed
- About $10K per year for 200 children
- Cost-effective way of reaching dense urban slum populations
- Reach out to existing urban schools and special ed kids
A model for rural areas: “Prerna 3”

- Use existing school premises after regular hours: low cost
- Hire a small dedicated staff:
  - Trained in mediation
  - Armed with a high-quality digital content feed
- Higher grade classes: target high dropout rates of girls

Deviations

- Number of deployed village schools:
  - 2 + 1 instead of 6
  - Goal of maintaining quality: build a network of excellence
- Different types of distance interactions
  - Fun exchanges
  - Remote classroom monitoring
  - “Distributed play-making” planned
- One large TV per classroom instead of multiple small TVs

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1. Google on phttp

- Request and refinements over low-latency link
- Search results plus crawls of top ranked sites over high-bandwidth link
2. “Copies of the web”

- Villages: a “top-ranked” fraction of the web
- Lucknow headquarters:
  - A somewhat bigger selected fraction of the web
  - “Refreshes” villages in customized ways
- Google:
  - A huge fraction of the web
  - “Refreshes” the headquarters periodically

3. Local searches

- Village and headquarters databases: large and growing collection of multimedia content
- In particular: video!
4. “User-contributed content management”

- Blogs, pictures, video, music, wikis, …
- Web-based applications that allow ordinary people to contribute and share: grass-roots media hybrid
- “Content-management” tools for publishing, browse, classification, indexing, polls, forums, downloads, collaboration, user/group management, administration, …

4. The Digital StudyHall: an example of user-contributed content management

- Philosophically:
  - Not just bring the web to the poor
  - But allow the poor to contribute
  - Peer content creation: heart of our approach
- Technically:
  - Rich media: connectivity and bandwidth demand: a big hurdle
  - The Postmanet and EdTV may provide an important piece of the solution for reaching the poor.
  - (Google could provide the rest 😊)

Other applications

- Other speculative applications:
  - A “healthcare eBay”
  - Turning your TV into a phone (voice mail)
  - Commercial transactions
- Infrastructural features:
  - Postmanet: pervasive, cheap, high bandwidth, asynchronous
  - EdTV: getting new services into each household
  - EdTV and repository: shared multi-user experience

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The “big picture”

- Components: repository, phttp, EdTV
- “Workflows:” content capture, homework feedback
- Pedagogy research

Synergy: phttp + repository

- A simple distributed file system analogy
- Generic abstraction that can support all manners of shared applications (without a conventional network)
Synergy: `phttp + repository`

- A simple distributed file system analogy
- A network analogy: a "network with memory"
- Why not direct peer-to-peer transfer between villages?

Synergy: `phttp + EdTV`

- A natural two-hop "network"
- The `phttp` "hop:" pervasive, high-bandwidth, cheap, asynchronous
- The `EdTV` "hop:" cheap end devices, bridging last mile

Synergy: `repository + EdTV`

- The repository abstraction makes it easy to build shared `EdTV` applications, like voice mail
Synergy: repository + EdTV

- The repository abstraction makes it easy to build shared EdTV applications, like voice mail

Recurring themes

- Any-to-any communication, customization, sharing, high bandwidth, cheap, solve education problems
- Enable collaborative learning among kids

Message in a bottle

- How is this fundamentally different from a cassette in the mail?
- Sending a message to the database == sending a message to the world
- It’s about interconnecting to the world

Implications

- Implications for StudyHall: raise bar of excellence for all teachers
- Implications on breaking down class barriers
Implications

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Implications

- Implications for StudyHall: raise bar of excellence for all teachers
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High-level things I learned

- Be a generalist, not a "computer scientist"
- Work with and respect locals
- Importance of long-term commitment
  - Expect delays
- The most fun and rewarding work ever!!
High-level things I learned

- The most fun and rewarding work ever!!

Interested in helping?

- $
- Smuggle equipment to India
- Non-technical help: e.g., “teach” virtually
- Technical help
- Data? Software? Time?
- You get to determine the agenda!

Thank you!

- Google for: digital studyhall
  - http://pnet.cs.washington.edu
- Donations: email rywang@cs.princeton.edu