The Digital StudyHall

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1977

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

“Tutored Video Instruction”

• Stanford -> Santa Rosa plant of HP
• Minimally edited videos of unrehearsed lectures
  – Easy to make

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

Stanford Engineering Graduate Students

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

Caveat: data does not yet permit a rigorous statistical test

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
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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 Affiliated Village Schools

- Itaunja
- Primary
- Chinhat-Ganeshpur
- Rahman Primary
- Madantoosi Upper
- Primary
- Sarojini Nagar
- Primary
- Kanaar Upper
- Primary
- Mahipat Mau
- Primary
- Manzil
- StudyHall (Lucknow)
- 45km
- 15km
- 75km
- 25km
- 30km
- 5km
- 22km
- 25km
- 30km
- 22km
- 45km

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

• “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)

In the longer run...

• 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

- 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

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

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

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

• Picked up by a postman
What Is A Postmanet Router?

- 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

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
• Why DVDs? Capacity, cost, weight, …
• Robot automation

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• Robotically operated---minimum manual intervention
**phttp: (b) data reaches a village**

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

**phttp: (c) village interaction**

- 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

**phttp: (d) data leaves village**

- 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.

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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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
- 5fps generates 250MB/hour
Real-time MPEG4 encoders

720x480 (DVD quality), DivX codec
30fps generates 1GB/hour
5fps generates 250MB/hour

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
  - 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 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

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EdTV (“output”)

• Extra graphics cards, sound cards, and transmitters for extra channels
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 much better

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)

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
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

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

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Goal: start schools where there’s none

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

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

$15

$15

$120

The homework workflow (3): grading

- Step 3B: Batch image editing software + tablet pen

$30

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

Implications (3): peer-to-peer help

- 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: any-to-any communication

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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

- 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

Mediation

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

- Model lesson in front of village teacher
- Followed by village teacher's running the class
Replicate in villages

Replicate in villages

Replicate in villages

Replicate in villages
Replicate in villages

Stage sequences of model lessons
By best teachers from morning school
Conducted in front of after-school girls
Entire year-long English curriculums for classes 3-5 based on government text books
90% English, 10% Hindi

Ongoing

- 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
Ongoing

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

Tasks next

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

An Urban model: “Prerna 2, 3, …?”

- Potential model of catering to more children from urban slums
- Use existing school premises after regular hours
- A (small) staff:
  - Trained in mediation
  - Dedicated
  - Armed with a digital content feed
- A budget of about $10K per year for 200 children
- Reach out to other urban schools
- Experiment with special-ed classes

Implications

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

Deviations
- Number of deployed village schools:
  - 3 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
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

Lucknow
Headquarters

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)

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
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

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!!