The Digital StudyHall

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“Tutored Video Instruction”

- Stanford → Santa Rosa plant of HP
- Minimally edited videos of unrehearsed lectures
  - Easy to make

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

1977

“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
TVI results

Stanford Engineering Graduate Students

- 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
- Principal: Dr. Urvashi Sahni

StudyHall

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

After-school program

- Targets girls from the urban slums
- Would not have had access to education otherwise
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

- Lectures
- Homework
- Graded Homework
- Sharing
• 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

• 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 < $1000
- Cost of “wiring” a child < $5
- (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 < $1000
- Cost of “wiring” a child < $5
- (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

- phttp: low-cost network
- EdTV: low-cost networked displays
- Workflows: e.g.: minimize printing
- Cost of “wiring” a village school < $1000
- Cost of “wiring” a child < $5
- (Not included: operational cost)
- Slides convention:
  - Village $500
  - Headquarters $1100
  - Both $15

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Principle 2: build “systems” that solve education problems

- A lot more than connectivity
- “workflows” and pedagogy
- Work with people:
  - Headquarters staff
  - Teacher training institute volunteers
  - 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
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
What Is A Postmanet Router?

- 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

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
**DVD Robot**

- Why DVDs? Capacity, cost, weight, …
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**phttp: (a) publish**

- Robotic operation—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

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- 30fps generates 1GB/hour
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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

- 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 ("output")

EdTV leaving the classroom

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EdTV: more profound potential

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

- 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
Used VCRs, balloons, directional 802.11, …

Extending EdTV range

- A “repeater”

EdTV “input” devices

- A ham “remote”: a simple transmitter that emits several command signals:
  - 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

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  - 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

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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

The homework workflow (3): grading

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

- 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

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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?
TVI and StudyHall

- **Challenges:**
  - Different audience
  - Different subjects
  - Unstructured “discussion” may not work
- **Resources:**
  - Digital technologies beyond pause-and-resume
  - Skilled and cooperative headquarters staff
  - A digital repository that “remembers everything”
  - Village staff of varying levels of skills

TVI equivalents for the StudyHall

- **A 5-minute in-class quiz/exercise**
  - Conducted in headquarters lectures
  - Graded and feedback provided on the spot
  - All captured and replayed
  - Same quiz administered in villages
- **Homework feedback integrated into regular lectures**
- **Village staff as “pattern recognizers” in a “program”**

Interactions in StudyHall

- Encourage students to help students
- Harvest “leaders”
  - But be careful not to produce consistently passive followers
- Harvest upperclassmen
- Communication between urban and rural students
- Foster positive group dynamic
- Encourage social, artistic, entertainment exchanges

Ultimate scalability

- What’s the ultimate scalability bottleneck of the Digital StudyHall?
  - Not computers
  - Not bandwidth
  - Probably not even money (to some extent)
  - It’s the skilled man power!
- **Ultimate scalability promise:**
  - To turn every kid into both a teacher and a student
A Learning Science Test Bed

- Currently:
  - Disconnect between research and practice
  - Research: not always in realistic settings
  - Practice: teachers, parents, administrators, policy-setters, have their own obligations

- The Digital StudyHall:
  - A learning science test bed
  - Tightly combine research and practice
  - Short-circuit the research-to-adoption cycle

Funding and sustainability

- Initial stage: “angel funding:” grants and donations
- An “open source” volunteer model
- Turning over the operation to local entities
- “Cross-subsidize” with synergistic for-profit applications

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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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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 + 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

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Interested in helping?

- Why stop at “do no evil?” 😊

Interested in helping?

- Why stop at “do no evil?”
- Do some good too 😊
Interested in helping?

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

www.cs.princeton.edu/~rywang/distance