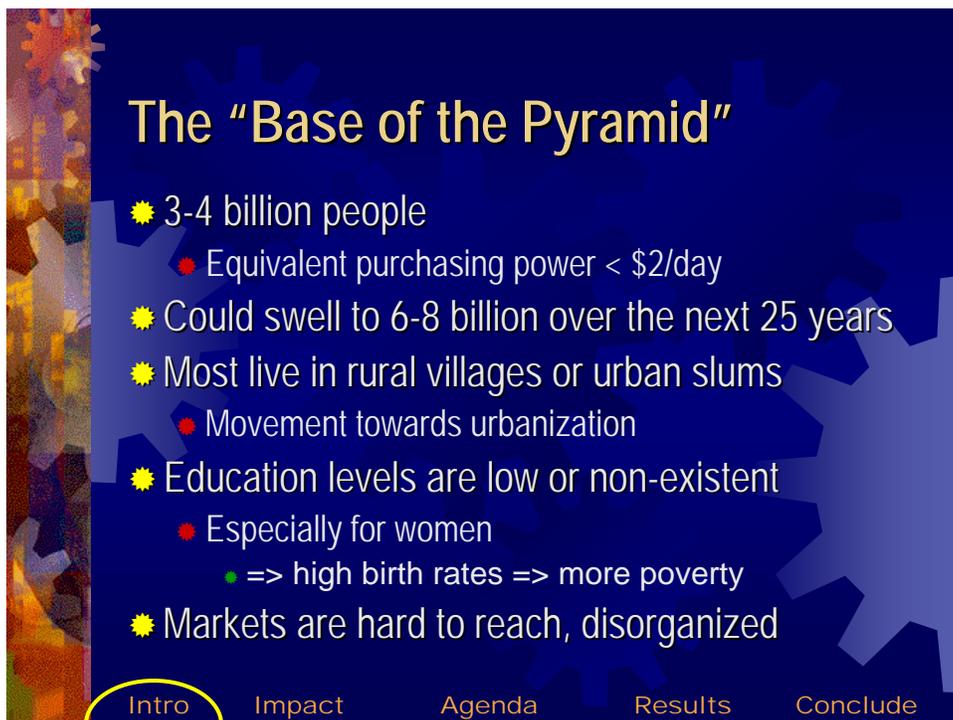




# Technology for Developing Regions

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EECS, UC Berkeley  
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**VLDB Keynote, Vienna**  
September 26, 2007



# The "Base of the Pyramid"

- ☀ 3-4 billion people
  - Equivalent purchasing power < \$2/day
- ☀ Could swell to 6-8 billion over the next 25 years
- ☀ Most live in rural villages or urban slums
  - Movement towards urbanization
- ☀ Education levels are low or non-existent
  - Especially for women
    - => high birth rates => more poverty
- ☀ Markets are hard to reach, disorganized

Intro Impact Agenda Results Conclude

## Sustainable Impact

- ☀ Public goods (via taxes)
  - E.g. fire department, disaster relief, primary education
  - Ideally: save money and improve service
  - Transparency to limit impact of corruption
- ☀ Private projects
  - Must be “non-loss” companies
  - Increase income or reduce costs
  - E.g. Vocational education/training, entertainment
  - Needs capital, OK to kick-start with charity

Intro Impact Agenda Results Conclude

## Public good example: River Blindness

- ☀ ICT used to help eradicate blackfly that carries river blindness in West Africa
- ☀ Network of real-time hydrological sensors, satellites, and forecasting software determined best time to spray larvicide
- ☀ Protects 30 million people from infection
- ☀ Freed up 100,000 square miles of land – capable of feeding 17 million people

Intro Impact Agenda Results Conclude

## Private example: Grameen Bank—Bangladesh

- ☀ Owned entirely by the poor
  - Began in one village in 1976
  - 2.6 million borrowers (95% women), over 1,000 branches in over 42,000 villages. 12,000 staff.
- ☀ Has loaned more than US\$3.9B since inception
  - Over US\$3.5B repaid with interest (98.75% recovery rate); \$290M loaned in the last 12 months.
- ☀ Has never accepted any charity
  - has always been a profitable social enterprise
- ☀ 46.5% of borrowers have crossed the poverty line

Intro **Impact** Agenda Results Conclude

## Grameen Telecom

### A Disruptive Societal-Scale Business Model



- ☀ 'Village Phone' is a unique idea that provides modern telecommunication services to the poor people of Bangladesh.
- ☀ So far over 95,000 loans of average US\$200 have been given to buy mobile phones.
- ☀ Covers 50,000 of the 68,000 villages
  - 60M users
  - => Scales!
- ☀ Phone Lady income goes up by >2x
  - Maintains the system
  - => Works!
  - Example of new rural income

Intro **Impact** Agenda Results Conclude

## TIER: Technology and Infrastructure for Developing Regions

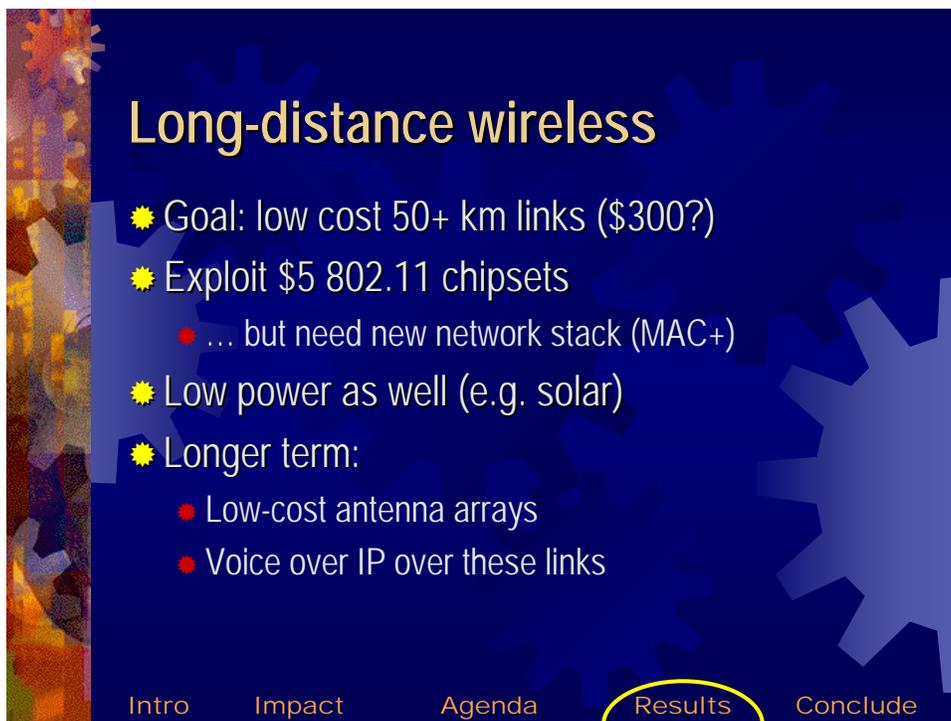
- ☀ Great Partners
  - NSF 5-year grant, Intel
  - Microsoft, Grameen Bank, UNDP, Inveneo
- ☀ Working with social scientists at Berkeley
- ☀ Co-design, co-deploy with NGOs in India
  - Small deployments every 6 months
  - Must establish trust, relationships!
- ☀ Cambodia, Ghana, Mexico, Sri Lanka, Rwanda, Uganda ...

Intro   Impact   Agenda   Results   Conclude

## Early Research Agenda

- ☀ Rural network coverage
  - Long-distance low-cost links
  - Intermittent connectivity
- ☀ Telemedicine: Real Patients
- ☀ Education, Literacy and UI issues
  - Interactive and semi-interactive education
  - Non-English speech recognition
- ☀ Power issues
  - Low-power networking/computing
  - Low-cost \*quality\* power

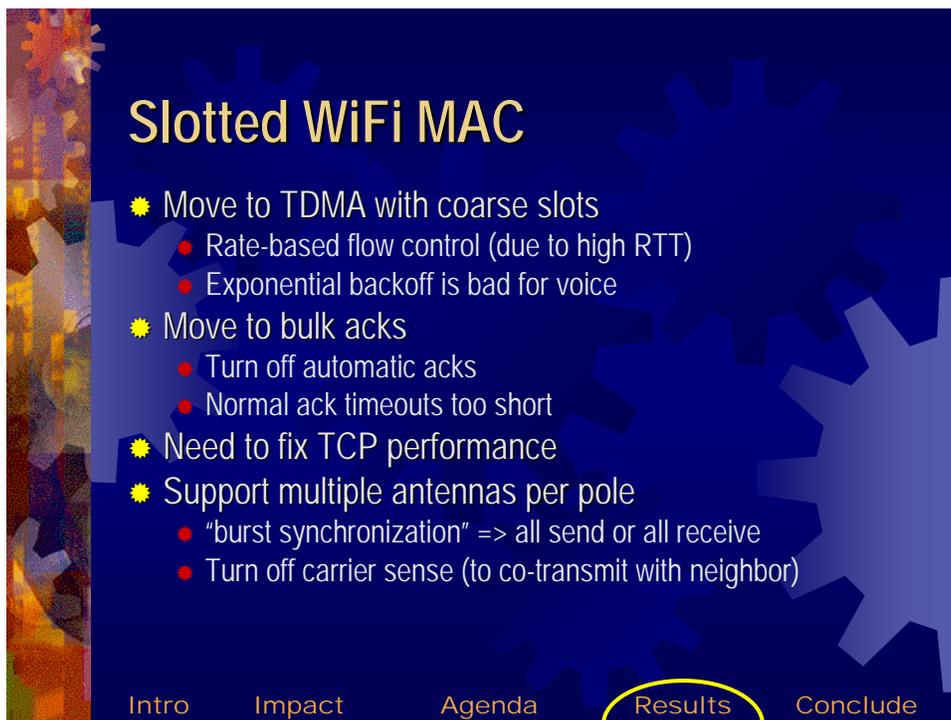
Intro   Impact   Agenda   Results   Conclude



## Long-distance wireless

- ☀ Goal: low cost 50+ km links (\$300?)
- ☀ Exploit \$5 802.11 chipsets
  - ... but need new network stack (MAC+)
- ☀ Low power as well (e.g. solar)
- ☀ Longer term:
  - Low-cost antenna arrays
  - Voice over IP over these links

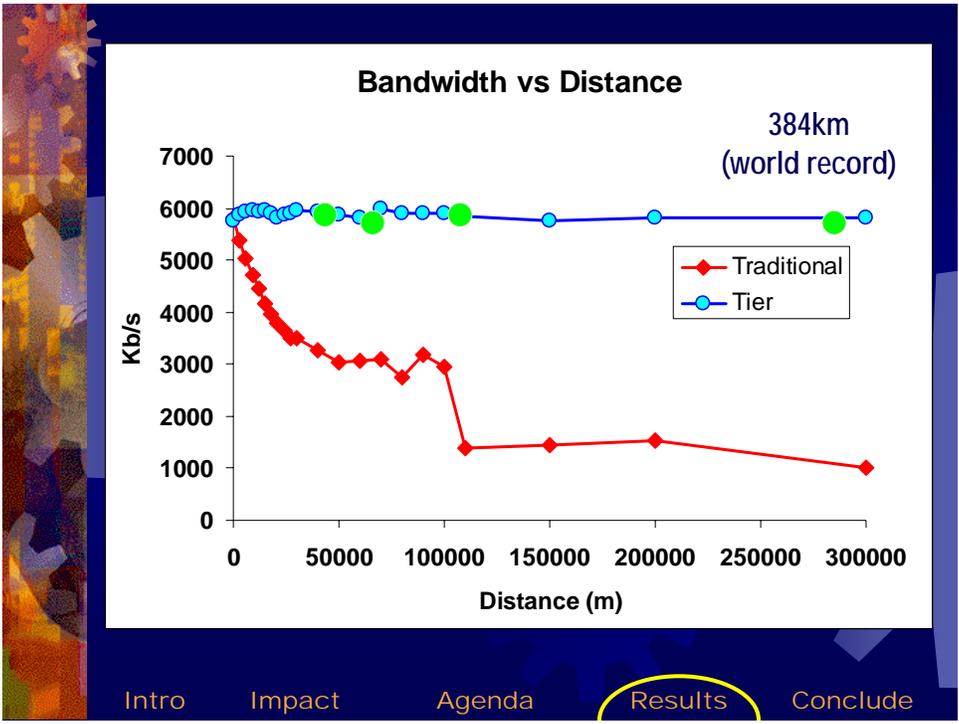
Intro   Impact   Agenda   **Results**   Conclude



## Slotted WiFi MAC

- ☀ Move to TDMA with coarse slots
  - Rate-based flow control (due to high RTT)
  - Exponential backoff is bad for voice
- ☀ Move to bulk acks
  - Turn off automatic acks
  - Normal ack timeouts too short
- ☀ Need to fix TCP performance
- ☀ Support multiple antennas per pole
  - "burst synchronization" => all send or all receive
  - Turn off carrier sense (to co-transmit with neighbor)

Intro   Impact   Agenda   **Results**   Conclude

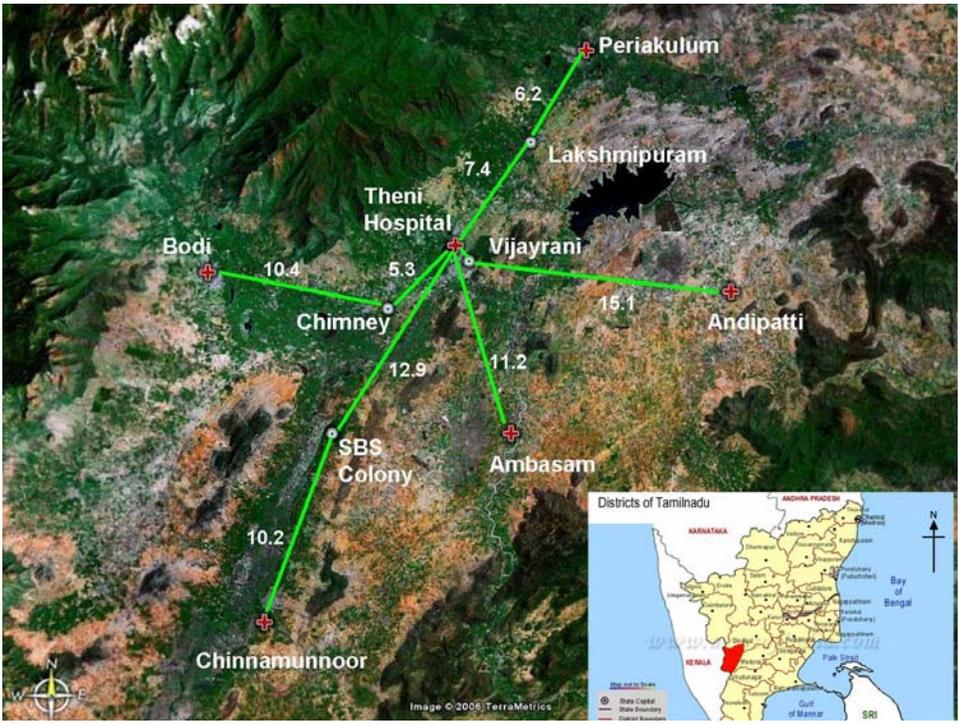


## Rural Telemedicine

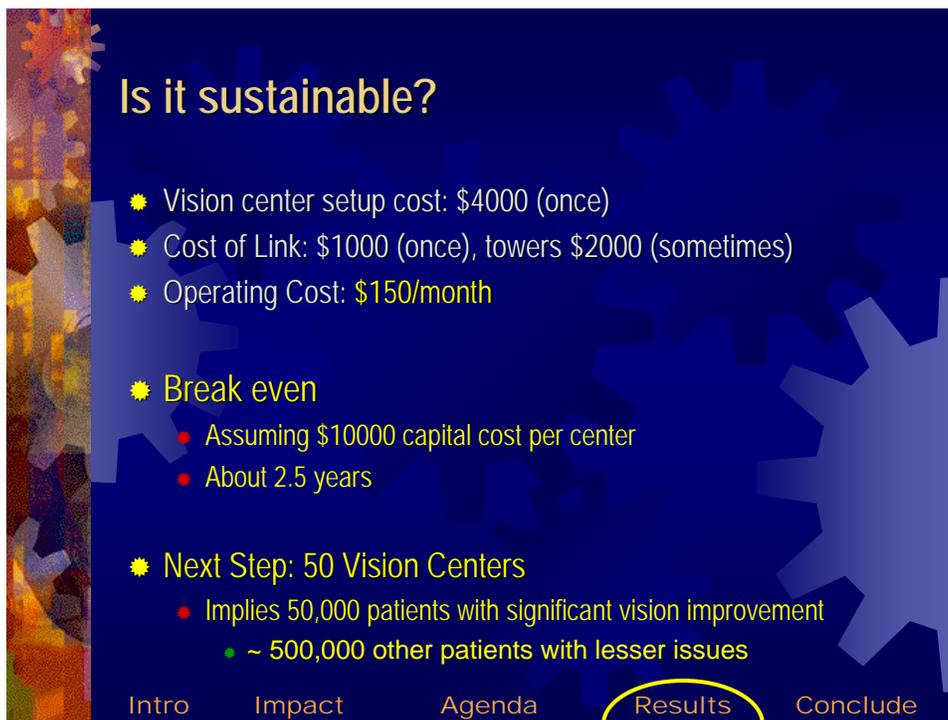
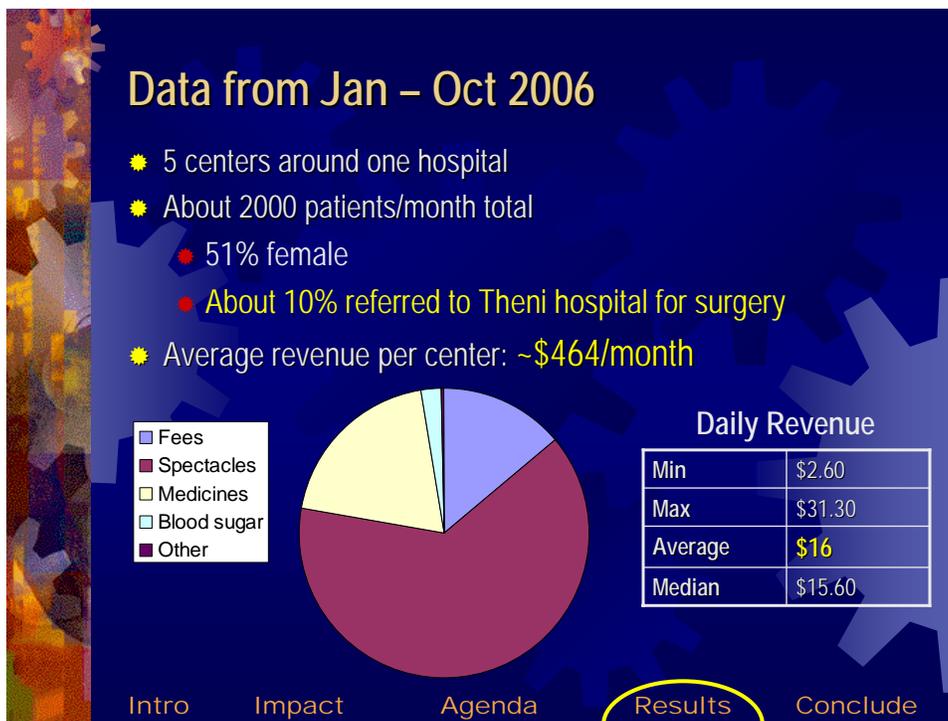


- Aravind Eye Hospitals
  - Tamil Nadu, India
  - 5 hospitals
  - But too far for most to walk
- Need:
  - 15M blind in India
  - 70% of blindness treatable
  - 7% in rural areas get care
- Goals:
  - 50 rural vision centers
  - Diagnosis and prevention

Intro   Impact   Agenda   **Results**   Conclude



The collage consists of four photographs: top-left shows a laboratory with a large plant; top-right shows a laboratory room with a microscope; bottom-left shows a woman in an orange sari at a computer workstation; bottom-right shows two women, one in an orange sari and one in a red sari, looking through a microscope. Below the photos is a navigation bar with the following labels: Intro, Impact, Agenda, Results (circled in yellow), and Conclude.





## Education: multiple mice per PC

**Common Content**  
The upper part of the screen is used for common narrative content for all the users of the system - the space below is three separate threads assuming three users

- Most PCs are used by 5-8 kids
- Educational value?
      - Appears to reduce attrition
- Give each child their own mouse:
  - Joint with MSR India
  - Single mouse: forced rotations of mouse operator improves learning
  - Multiple mice:
    - Significant impact on boys
    - ... but not for competitive games
    - Most effective game: all users must pick correct answer

Intro
Impact
Agenda
Results
Conclude

## Education: English

- ☀ English as a second language is very valuable
  - Arguably defines "middle class" in India
- ☀ Goal: teach English via cell phone games
  - Cell phones are a better platform than PCs
  - Games can be effective with limited teachers
  - Must localize the content
  - Also developing continuous speech recognition on the phone



Intro Impact Agenda **Results** Conclude

## Learning Assessment (Preliminary)

- ☀ Substantial vocabulary gains:
  - Mean score (pre-test): 3.7 out of 12
  - Mean score (post-test) : 8 out of 12
  - p-value < 0.001
  - std. dev. = 3.7



Matthew Kam  
Divya Ramachandran  
John Canny

Intro Impact Agenda **Results** Conclude

## What about databases?

- ☀ Primary need: disconnected databases
  - Medical/loan records on phones
  - Sync over very poor networks
    - Including “sneaker net” (DTN)
  - Focus on availability, eventual consistency (not ACID)
- ☀ New financial systems:
  - Phone minutes as currency
  - Move away from cash

Intro   Impact   Agenda   Results   Conclude

## Claims revisited:

- ☀ Technology has made a difference
  - ... for health, education, government, commerce – the real problems
  - Telemedicine: 2500 patients/month
    - 10% achieve **much** better vision
- ☀ There is room for EECS research!
  - .. But need to be on the ground.... with partners
  - Progress:
    - More players: IITM, IITB, Waterloo, UW, Microsoft, Intel
    - Strong papers: SIGCOMM, CHI, NSDI, ICTD (new)

Intro   Impact   Agenda   Results   Conclude



For more details....

- ☀ Companion article to this talk:  
"The Case for Technology for Developing Regions" – E. Brewer *et al.*
- ☀ IEEE *Computer*, June 2005
- ☀ [Tier.cs.berkeley.edu](http://Tier.cs.berkeley.edu)

Intro   Impact   Agenda   Results   Conclude