Long-distance Wireless
The Hope, the Hype and The Highway

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(with input from the TIER group!)
“The technology life cycle has three stages – hype, disillusionment and application.”
-- Bob Lewis, Volkswagen

The TIER take on long-distance wireless:
“Disillusionment is not the truth”
-- Mason Cooley, aphorist
The Hope
Basic Network Setting

City/Internet → Peering Point → T1/T3 → Backhaul network → Access Network → Rural distribution Network

Kiosk

POPS
Directional antenna

- Focus signal in a specific direction
- Directional links can provide roughly a few Mbps bandwidth over 50-100 kms
The necessity for adoption

• For a technology to be adopted in the large-scale, it should:
  – Offer something new
  – Have a significant economic advantage to competing technologies

• Long-distance wireless can provide both!
  – What’s new?
    • Build a wireless backhaul network offering good bandwidth over 100-200km regions
  – Economic advantages
    • Cheap, low initial deployment cost
The potential market...

• Cheap networking infrastructure to rural regions in developing countries

• Challenges
  – No power
  – No infrastructure
  – low purchasing power

• Requirements
  – Low cost
  – Low power
  – Reasonable bandwidth
Why long-distance wireless?

- **Wireless vs Fiber**
  - Fiber provides much more bandwidth but has high setup cost
  - Fiber ill suited for low population densities

- **Intranet vs Internet**
  - Local Intranet applications like health-care, e-governance can be established!

- **Fixed wireless vs Mobile wireless**
  - Point-to-point vs Omni-directional
    - Need lower power for directional links
  - Longer range
  - Better performance
Types of Technologies

• **Key: Use affordable technologies**
  – *mass-produced standardized technologies are generally affordable!*

• Computer networking industry
  – WiFi (802.11)
  – WiMax (802.16)
  – Other commercial technologies
    • WipLL, CorDect

• Telecommunications industry
  – CDMA 450
    • CDMA 1xEVDO – data protocol for CDMA
  – GPRS - Part of the GSM standard
  – Satellite Networks
The Hype
Performance problems

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Throughput</th>
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<tbody>
<tr>
<td>UDP</td>
<td>4.5 Mbps</td>
</tr>
<tr>
<td>TCP</td>
<td>362 Kbps</td>
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</tbody>
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• Bad TCP performance over a single 802.11 link from Berkeley->SFO!
  – Frequent timeouts due to bursty loss patterns
• Performance variability
  – Link characteristics are variable!
Other problems

- **Reliability**
  - Unlike fiber, difficult to provide 99+% availability!

- **Maintenance**
  - Link-repairs
  - Labor charges (operating expenses can be high!)

- **Limits of Multi-hop networks**
  - Performance degradation

- **Deployment hassles**
  - Line of sight, terrain (water), antenna alignment
The Highway (the road ahead)
Questions…

• How to achieve good performance?
  – MAC issues
  – Multi-hop issues
  – Understanding the wireless channel behavior

• How to ease deployment?
  – Addressing line of sight challenges

• Are these technologies economically viable?
  – Need for economic analysis

• What applications do they enable?
**Rural Telemedicine**

*A specific example application*

- Lack of doctors in rural regions
  - 1 rural clinic for every 50,000 people in Africa!
  - Need to travel long distances
  - Specialists are only present in big cities

- Time is ripe now…
  - Nearest town is less than 200 kms away!
    - Long-distance wireless can be an enabler
  - Availability of cheap medical diagnostic devices
  - Direct video interaction is possible
    - Feasible bandwidth
  - Mobile hospitals
Real-time telemedicine

• Requirements
  – Good audio+video-conferencing capabilities
  – Real-time medical data transmission + feedback

• The Remote Ultrasound Challenge
  – Challenge #1: *Data size*
    • Data compression/ transmission
  – Challenge #2: *Real-time feedback on image quality*
  – Challenge #3: *Remote 3D reconstruction*
    • Need to ensure 2D images are good quality
## Networking Challenges

<table>
<thead>
<tr>
<th>Telemedicine application</th>
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<tr>
<td>Video +Image coding issues</td>
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<tr>
<td>Statistical guarantees</td>
</tr>
<tr>
<td>MAC issues with long-distance wireless</td>
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<tr>
<td>Channel Characterization</td>
</tr>
</tbody>
</table>
Rest of the session

• Case study
  – “Aravind: Long-distance WiFi for telemedicine” – Sonesh Surana

• Technologies
  – “802.11: MAC challenges and System Design Issues” – Rabin Patra and Michael Rosenblum
  – “Performance analysis of CDMA 450 Backhaul Networks” – Sergiu Nedevschi
  – “Optimal Antenna Steering” – Omar Bakr

• Economic Aspects
  – “Economic Analysis of Long-haul Wireless Networks” – Shridhar Mubaraq Mishra
Long-distance wireless: an example

Closest city

Internet Cloud

POP

Directional links

POP

SubPOP (village)