



# Interconnecting Villages: Cost Effective Internet Access with WiFi



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# Many Types of Wireless Networking

- Mobile Telephony: GSM and CDMA
- Mobile-based Internet: 3G, HSPDA, LTE, etc.
- WiMax: 802.16d, 802.16e
- WiFi Wireless LANS
- WiFi Internet Access (Outdoor Networks)





# Connectivity without Mobility\*

- Best rural solutions are NOT mobile
- Improves:
  - Range (using antennas and lower frequencies)
  - Bandwidth (particularly for local the uplink and very local connectivity)
  - Power (bigger antennas mean less power)
  - Robustness (via mesh networking)
- Mobile cellular and non-mobile data networks should co-exist
- Use higher frequencies for mobility and cities
- ‘Nomadic’ is easier and better than Mobile
  - Intermittent connectivity
- ***Point-to-point links between islands of service***

\* (Prof. Eric Brewer, UC Berkeley)



# Comparison of WiMax and WiFi



**WiMAX**



**WiFi**

# WiMax: 802.16d and 802.16e

- 802.16d: “Fixed WiMax” - for Fixed Wireless Internet Access

Deployments typically require outdoor CPE antenna

‘Truck Roll’ expensive in the West

Now relatively mature, but investment has shifted to 802.16e

- 802.16e “Mobile WiMax”

Changes to support moving stations

Long term play by cell phone manufacturers and operators:

Low-royalty IETF/IEEE VoIP/WiMax vs. ITU Mobile Cellular

ITU Mobile Cellular networks are single vendor

Qualcomm Royalties

More robust path loss budget, to allow more installations without outdoor antenna

Lower cost installation; Installation cost dominates in the West

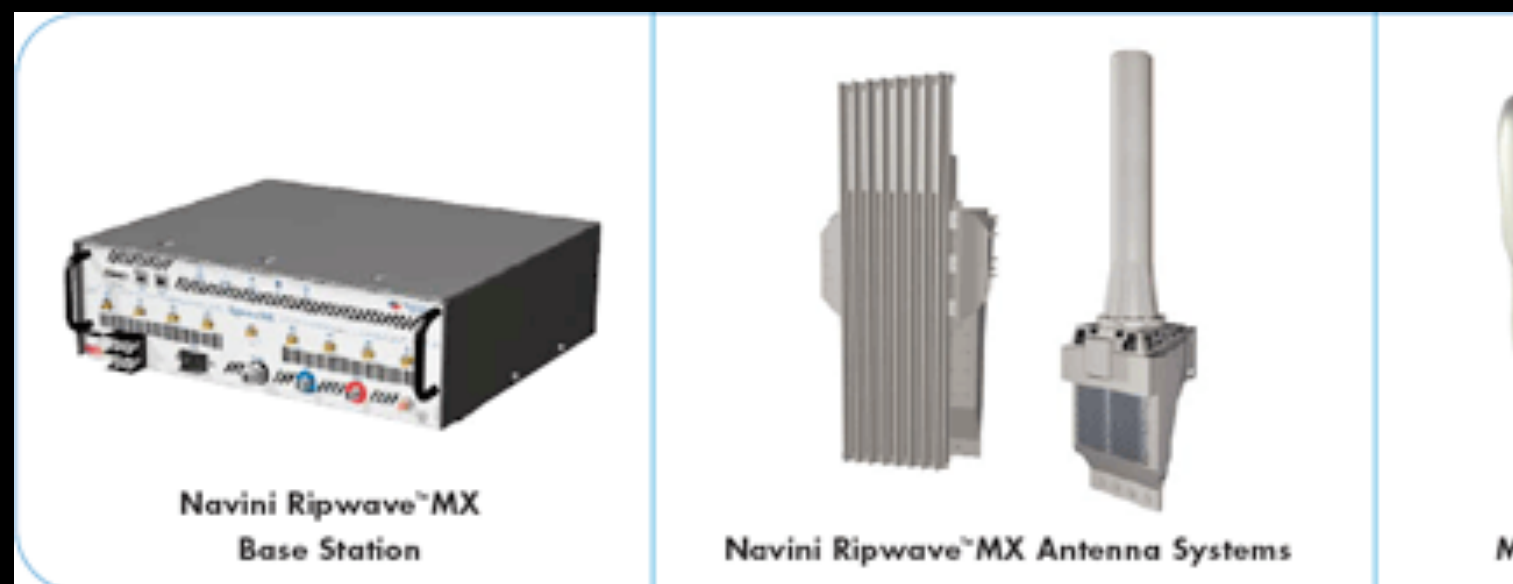
Only starting to mature; still no multi-vendor installations





# WiMax Economics

- Roughly follows Cell Phone deployment model:
  - Fewer, more powerful, base stations
  - “Blanket Coverage”: ~90% of locations can receive signal once deployed
- Typical base station \$25K - \$50K for electronics
  - Options: one sector or multi-sector, beam-forming, etc
- “Civil Works” typically doubles base station expense to \$50K - \$100K
  - 50M tower
  - Diesel generator
- \$10-20K / month revenue required to pay for CAPEX
  - 200 subscribers @ \$50 / month or equivalent
  - All sharing ~ 10 - 20 Mbps



# WiFi Advances

- Extremely active - 500-1000 people attending 802.11 meetings
- 802.11n - more bandwidth, some multi-path rejection via MIMO
- 802.11s Mesh
- 'WiFi' on different frequencies - not just 2.4/5.8
  - 4.9 Licensed - Safety and Public Services in the US
  - 3.5, 2.5 Licensed (WiMax uses these)
  - 900Mhz ISM (license free in many places)
  - 700Mhz
- WiFi Long Distance (WILD - UC Berkeley), WiRE (WiFi Rural Extension, IIT)
- Two channel / Double Bandwidth
- Vibrant Open Source SW - openwrt.org and others
- Outdoor-ready routers - Ubiquity PS2/PS5, NS2/NS5, etc. US\$80
  - 12V DC supply - easy for solar power, no inverter
  - 12V Power over Ethernet

# WiFi Challenges

- Fantastic chip technology for \$5-10, very good free SW, but networks require organization, planning, debugging
  - You can't debug what you don't understand
- Interference and Congestion (only a problem in cities)
  - Other frequencies can help
  - 5G band has 21-42 non-overlapping 20Mhz channels
- Line of sight++ required
  - 900/700 Mhz - very good for long links, goes through trees and walls better than 2.4G
- Work with government to expand unlicensed bands
- A small network is easy, a big network is harder
- Bridging is OK for small nets, but not for large networks
  - 'Noise' traffic builds up
  - Customer PC mis-configurations and malware affects more links, more PCs
- Need QoS, Port Blocking, Debugging Tools, Monitoring, etc.



# Comparison with WiMax and WiFi



**WiMAX**

- Powerful
- Specialty equipment
- Needs many customers
- Blanket coverage
- Fine for Cities
- Expensive for Villages
- Licensed spectrum -> few players



**WiFi**

- Low cost for small villages
- Common equipment
- Connecting Islands (villages), no coverage in between
- Products not built for 1000's of users
- Unlicensed spectrum - anyone can do it

# Rural Networking Challenges

- Maintaining PCs
- Power - low power gear save money over the long run
  - Less batteries
  - 12V network and 12V computers easily solar powered
  - Nepal and some places have good hydro, but in most places power will become even more expensive
  - Batteries and UPS's don't follow Moore's law
- Local Skill Sets
  - Training programs - Installer/Maintainer, Trouble Shooter, Designers
- Sustainability (business model)
- Cost of equipment

# Business Model Variations:

- Private for-profit Company
- Government financed and operated
- Community-group based
- Hybrids: Government subsidized
- Franchise Model



# Formal and Informal Economy

- Formal economy is based on contracts, registered companies, assets that are known and may be taxed by the government. Assets and contracts secured by rule of law. Individual and business identities are stable and can be referenced from afar
- Informal economy is cash, barter, and sweat-equity based. Assets and contracts secured by a circle of friends. Identity is only local
- Hernando de Soto in “The Mystery of Capitalism” observed that in many developing countries 75% of assets are in the Informal Economy
- If we can use and leverage the informal economy we have more assets
- Mobile phones succeeded because Pre-Pay is accessible to the informal economy
- **Community Wireless Networks and small WISPs can use assets in the informal economy**

# What is success?

- Delighted Customers!
- If you don't cover costs or make a profit then you go out of business or depend on begging
- If you have delighted customers and Free Cash Flow then you can use financing for growth
- **Growth no longer matters how much money you have, but what you know**

# What's Needed to Do More?

- **Training - Increase the skills set / people capital**
- **Organize - Groups do more than individuals**
- **Talk to - Government, Policy, and Finance**
- **Help others - You are professionals network engineers**

**Thank You!**

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# References

- List of 802.11 Channels: [http://en.wikipedia.org/wiki/List\\_of\\_WLAN\\_channels](http://en.wikipedia.org/wiki/List_of_WLAN_channels)

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