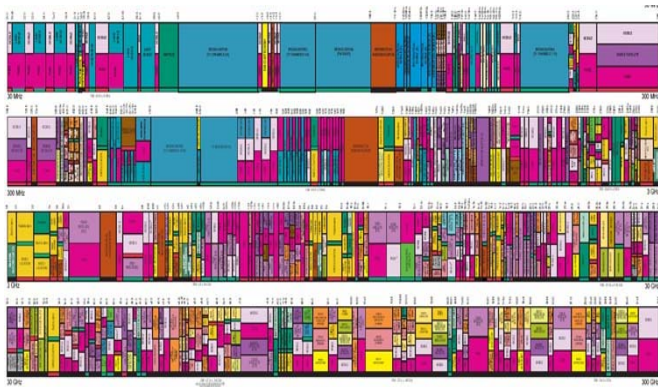
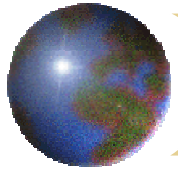


'Openness' and the Public Airwaves



Victor Bahl
Microsoft Research



Do we have a problem?

Number of wireless data devices is **increasing**

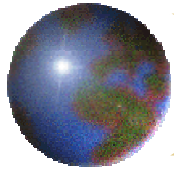
Demand and **expectation** from wireless connectivity is increasing

Unlicensed bands are **not sufficient** to meet these demands

Intense lobbying by Microsoft & others to FCC for additional unlicensed spectrum

Success! November 2003

- FCC opens up 255 MHz (5.470-5.725 GHz) for RLAN and U-NII (with DFS and TPC)



In the meantime..WiFi is everywhere...

Wi-Fi Hits the Hinterlands, *BusinessWeek Online*, July 5, 2004

"Who needs DSL or cable? New "mesh" technology is turning entire small towns into broadband hot spots"

Rio Rancho N.M., population 60,000, 500 routers covering 103 miles²

NYC wireless network will be unprecedented, *Computerworld*, June 18, 2004

"New York City plans to build a public safety wireless network of unprecedented scale and scope, with a capacity to provide tens of thousands of mobile users"

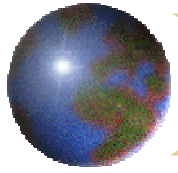
Rural Areas need Internet too! *Newsweek*, June 7, 2004 Issue

"EZ Wireless built the country's largest regional wireless broadband network, a 600-square-mile Wi-Fi blanket, and activated it this February"

Hermiston, Oregon, population 13,200, 35 routers with 75 antennas covering 600 miles²

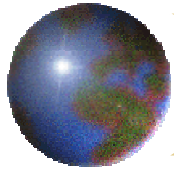
Mesh Casts Its Net, *Unstrung*, January 23, 2004

"Providing 57 miles² of wireless coverage for public safety personnel in Garland Texas"



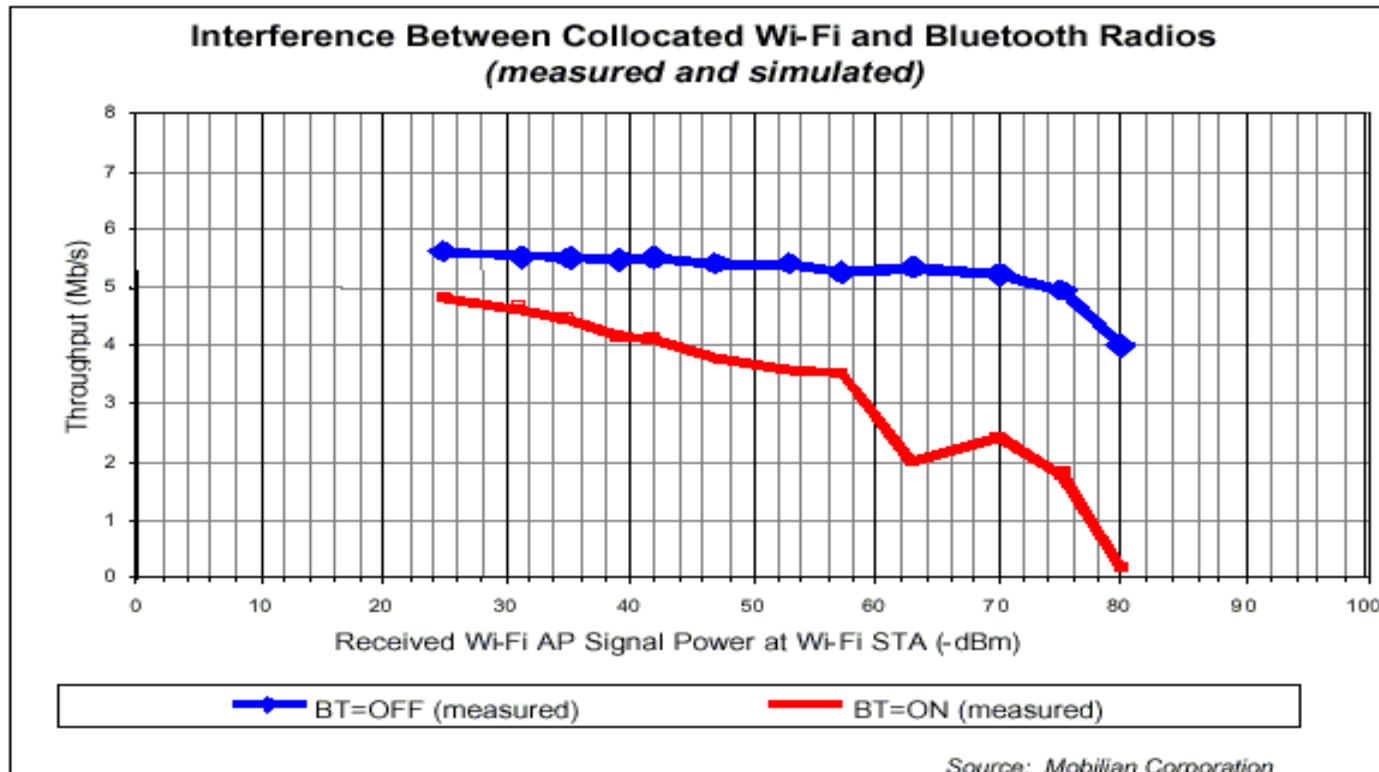
Question is....

Can you build robust wireless networks in unlicensed bands?

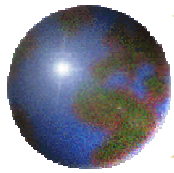


Unlicensed Bands: Colliding standards

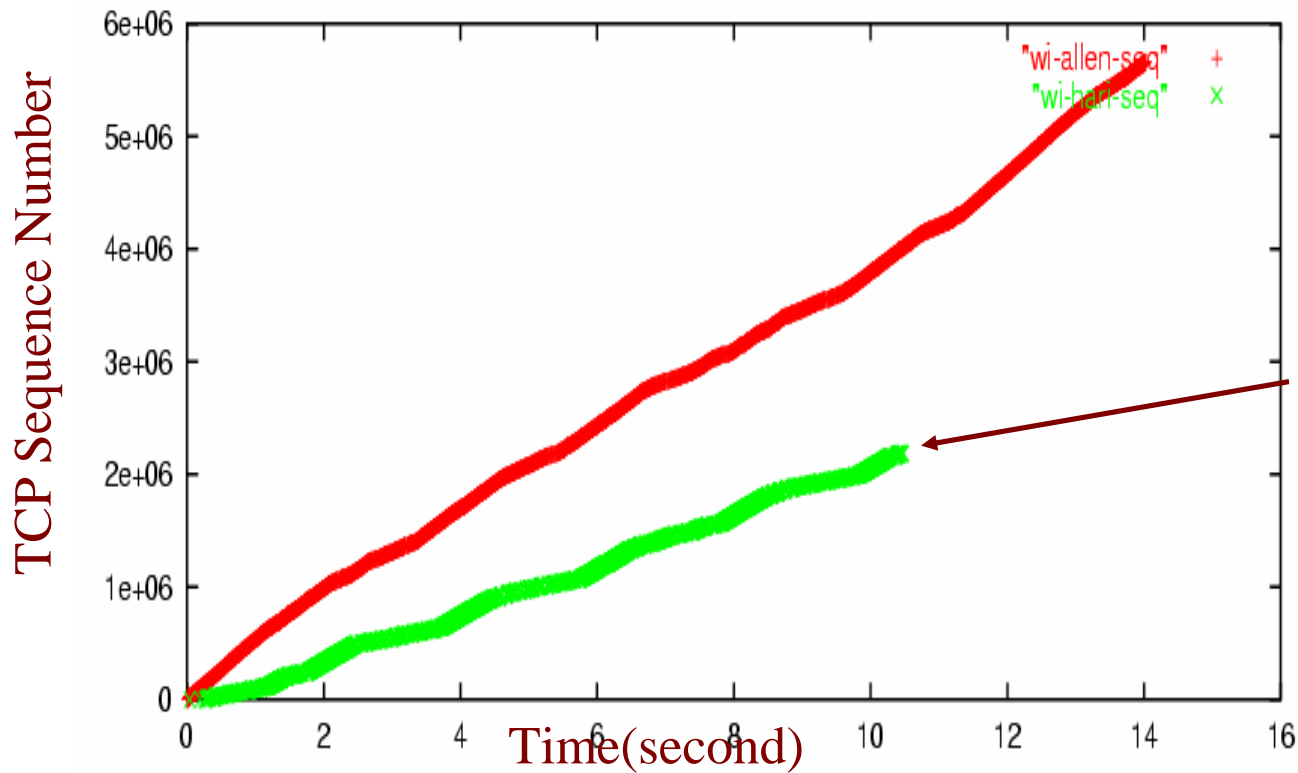
Courtesy: Mobilian Corp.



Performance worsens when there are large number of short-range radios in the vicinity

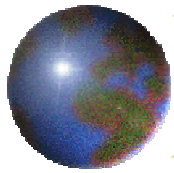


Following rules and regulations but....



Adding BT to the mix

Two TCP Downloads From a 802.11 Access Point

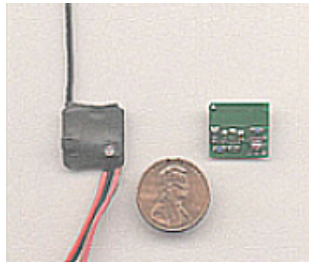


The world is full of non-802.11 Devices

LUV-200MV



SDX-1



I-920X009



I-520X007



2.4 GHz FM Video Transmitters

<http://www.rf-video.com/>

2.4 GHz Spread Spectrum Data Transmitters

<http://www.freewave.com/>

WaveTV 100



Transmitter



Receiver



Remote Control

VT2461
2.4 AGHZ

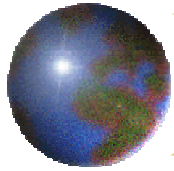


Baby Monitor



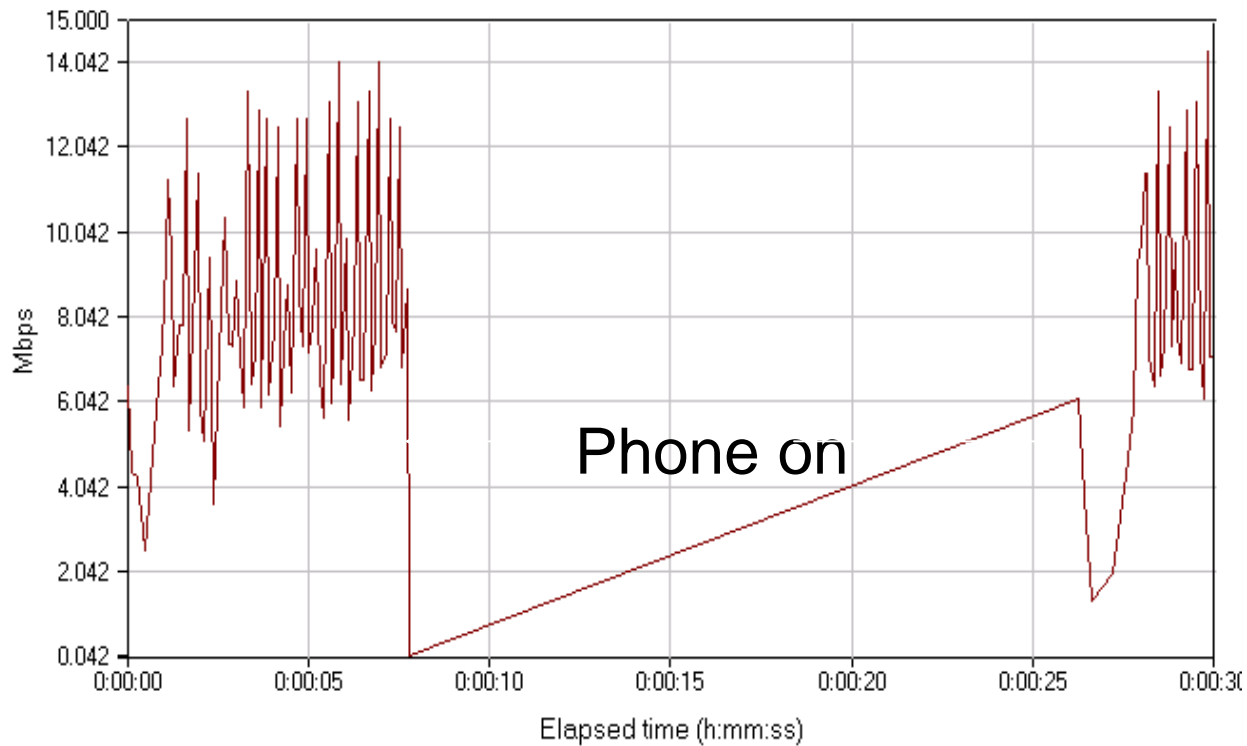
WAVECOM Jr.



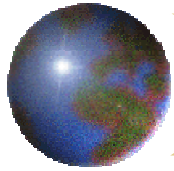


In the presence of other 2.4 GHz devices

Throughput



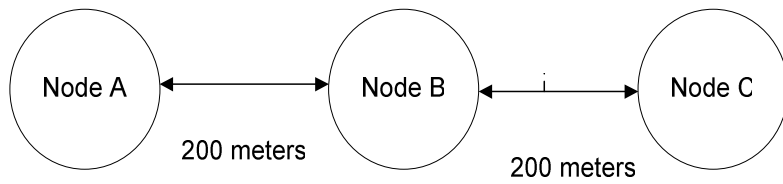
Panasonic 2.4GHz Spread Spectrum
Phone 5 m and 1 wall from receiver



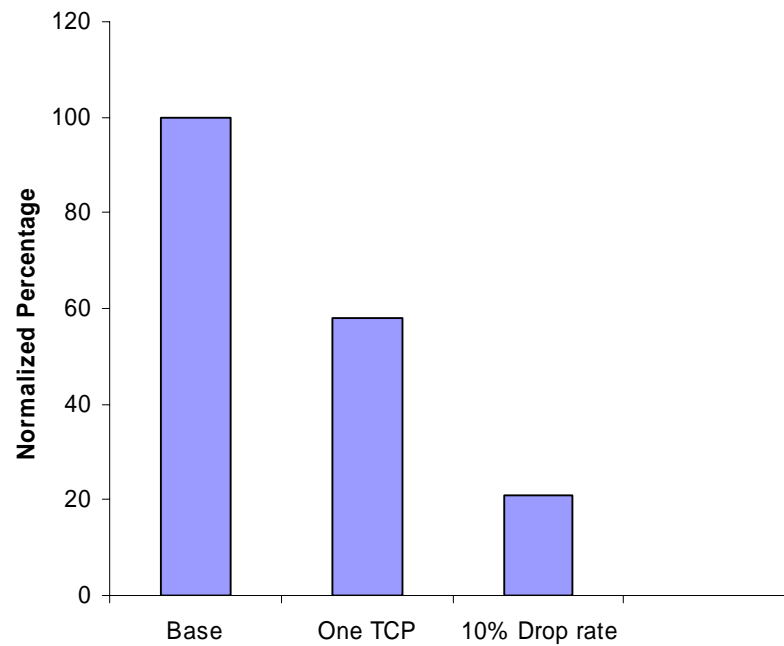
Local behavior affects Global Performance!

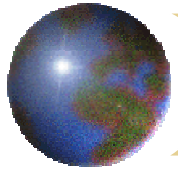


Doesn't care



Packets get dropped!



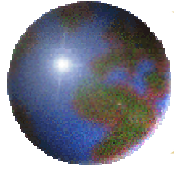


Do we need Etiquettes?

Every “common” needs rules that apply to everyone
(Voluntary standards aren't sufficient)

Etiquettes do not completely eliminate device interference

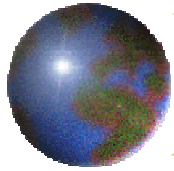
Etiquettes do not address the inevitable reduction of throughput with increase in node density



Design Criteria for Regulations

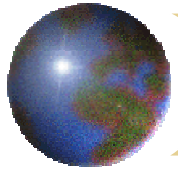
1. Allow continued innovation in the Physical (PHY) and Medium Access Control (MAC) layers
2. Minimize mutual interference between transmitters
3. Allow all devices to contend and gain access to the channel
4. Maximize spectrum utilization and capacity
Note: goals 2 & 4 are related.

Promote harmonization of rules and regulations for spectrum management around the world



Constraints (my opinion only)

1. Make no assumptions about receivers or their existence
 - Consider transmitters only
2. Make no assumptions about the channel
 - Channel may be symmetric or asymmetric
3. Make no assumptions about formats
 - Do not think in terms of bits, bytes, or frames – this is for higher layer protocols (e.g. TCP/IP)
 - Work with **time**, **frequency**, and **power**



Now go figure it out 😊

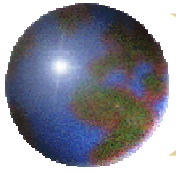
But wait...what about connectivity?



5 GHz:

- Bandwidth is good,
- Published 802.11a ranges (Yellow circles) decent
- Measured range (red circle) poor
- Range is not sufficient to bootstrap mesh until installed % is quite high (in this diagram ~50%)

0 20 40 60 80 100 120 140 160



But....

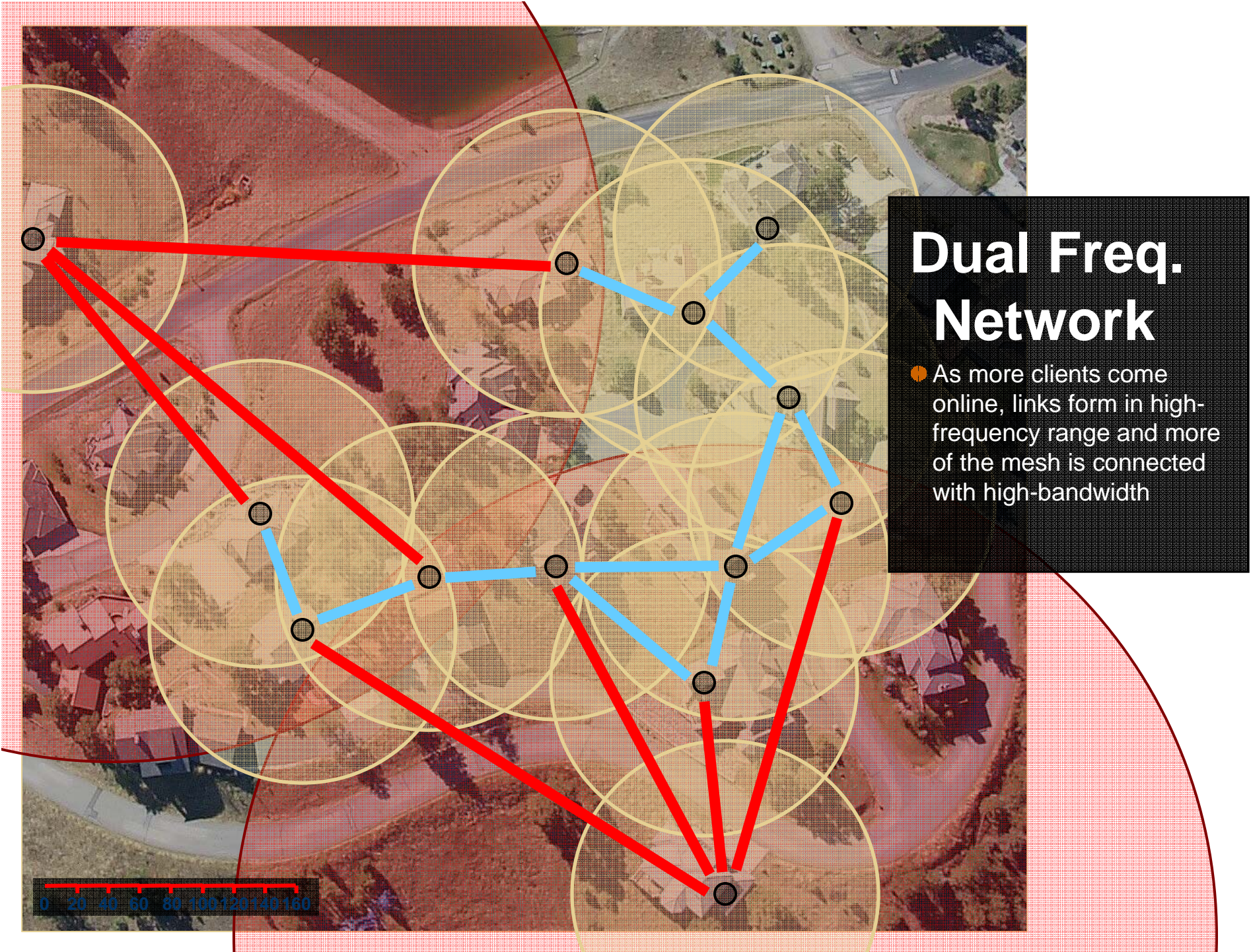
What about lower frequencies?....

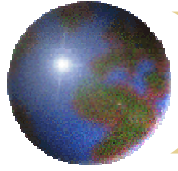


700 MHz:

- Much better range: about 7 times further than 5 GHz at equal power settings
- Three 2 MHz channels can bootstrap a neighbourhood with ~3-5 Mbps

0 20 40 60 80 100 120 140 160





Government is trying to help...

May 2004 FCC issues NPRM (Notice of Proposed Rule Making):

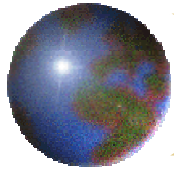
- Proposal to allow operation of **unlicensed device** operation in **broadcast television spectrum** (ET Docket No. 04-186)
- Establishes a **Wireless Broadband Task Force** to investigate technological development, review wireless broadband policies and research applications of technology

February 2005 Task force issues 8 key findings

...

- Expedite transition of DTV spectrum for Wireless Broadband and Public Safety
- Best industry practice among unlicensed users to facilitate efficient spectrum use

...



Broadband WiFi Debate

...there are always two sides to the coin

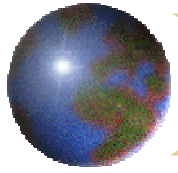


Proponents

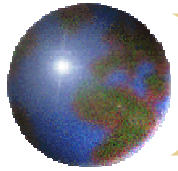
- Local and state government should provide WiFi access free everywhere
- Propel US from its 13th position among developed nations
 - Lower cost, faster deployment (specially in rural areas)
 - Stimulate competition by raising service standards

Detractors

- Unfair to ask private sector to compete with local government who have tax dollars
- Not a utility, highly competitive enterprise
- Continuously changing due to innovation

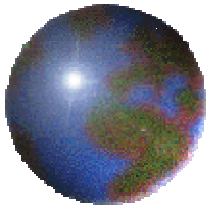


Now go get involved.....



Where do I stand?

- Want to enable wireless broadband Internet access
- Like both licensed and unlicensed spectrum (particularly below 1 GHz)
- For Unlicensed spectrum:
 - Researching co-existence etiquettes (it's a challenge)
 - Regulations will be necessary; industry standards are not sufficient)
- For Licensed spectrum:
 - Researching **leasing options** in licensed bands



Thanks!

For prior work & updates, check out:
<http://research.microsoft.com/netres/>