Rethinking Wireless Access for the All-Wireless Home

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UW-MSR Institute '09

Wide Spread Adoption of Wi-Fi in the Home

- Wi-Fi being rapidly integrated into a everyday consumer electronic devices in the home
- Enabling a range of novel applications and services being the home

Macworld » Mac IT

May 1, 2009 10:18 am | 0 Comments | + 5 Recommendations | Digg submit | ShareThis

Is it time to cut the Ethernet access cable?

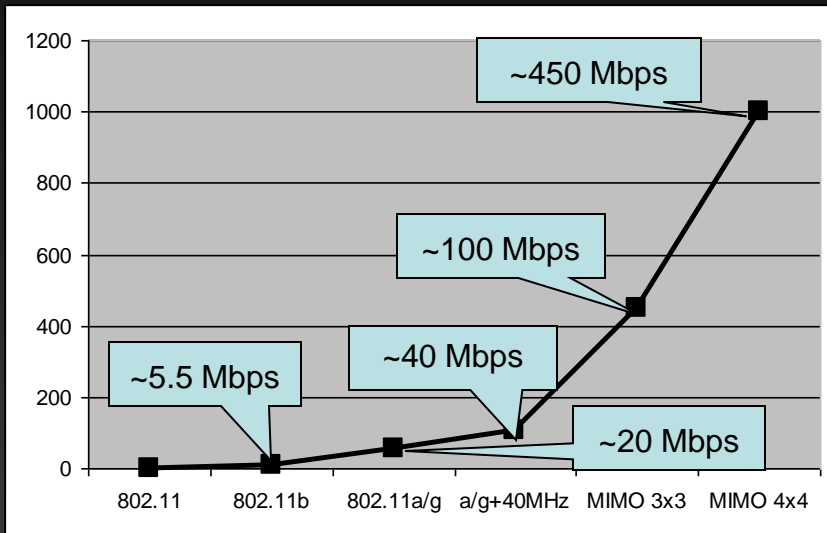« Apple Boosts 802.11n Speed to 140 Mbps (Asterisk)

SEPTEMBER 12, 2007

The End of Ethernet Because of N?

BY GLENN FLEISHMAN

At first, I thought this was link bait, but
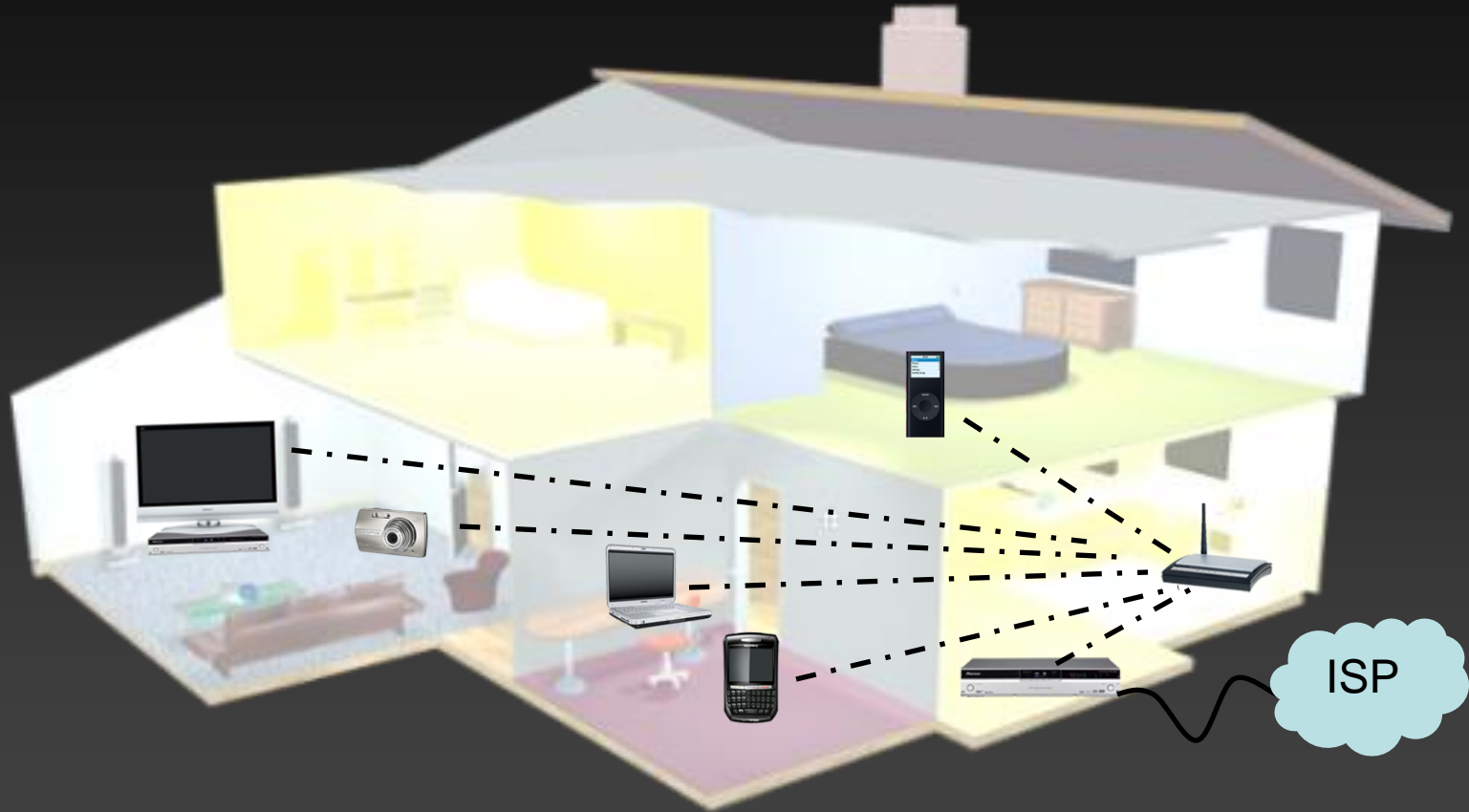
Superior Performance and Ease of Use

Wireless HD streaming	**15 Mbps**
Telepresence: Super HD (H.264, MPEG4)	**50Mbps**
Immersive 3D spaces	**126 Mbps**

Network Magic

WPS Push-N-Connect

Apple's Airport Extreme

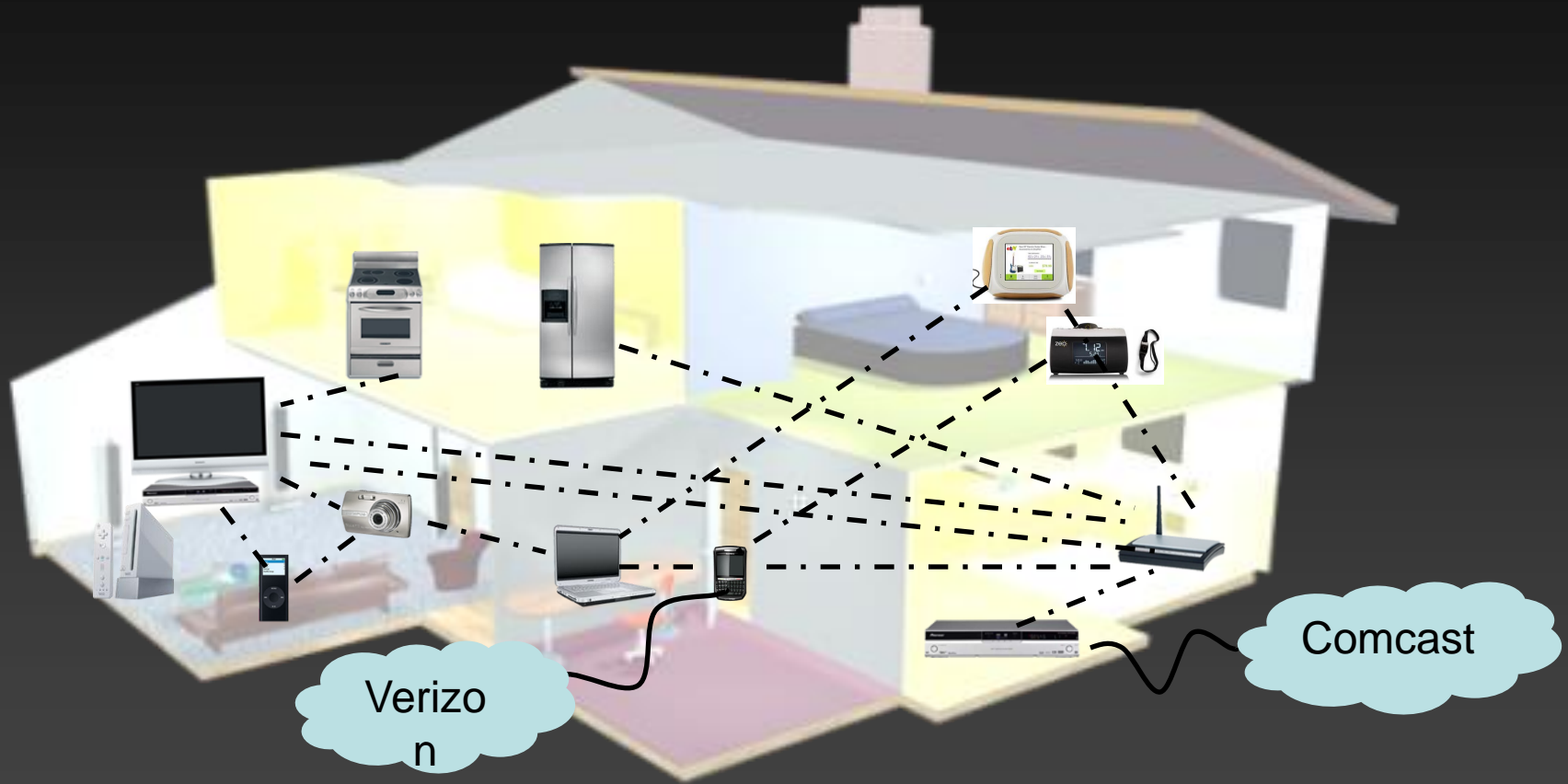**Wi-Fi performance has crossed an inflection point**

Easier to create, manage and secure Wi-Fi networks

Typical Wireless Home of Today

Sparse, medium range, low-bandwidth, noise limited and centrally controlled

All-Wireless Home of the Future

Verizon

Comcast

Dense, short range, very high bandwidth, interference limited and not centrally managed

Problems

- How do we provide users meaningful control over the Wi-Fi service areas?
  - "Provide Wi-Fi service to all devices located within my home"
  - "Provide Wi-Fi service to only the common areas of the house"
  - "Dock my laptop over wireless with the devices located on my desk"

- How do we manage interference to scale Wi-Fi performance across densely packed devices in the home?
  - Supporting simultaneous HD video streams
 - Multiple game consoles in the same area

Broadcast nature of the wireless medium makes it difficult to reason about coverage areas and interference

Beamforming Based Directional Antennas

- Multiple antenna based radio systems provide the ability to:
  - steer the Wi-Fi signal
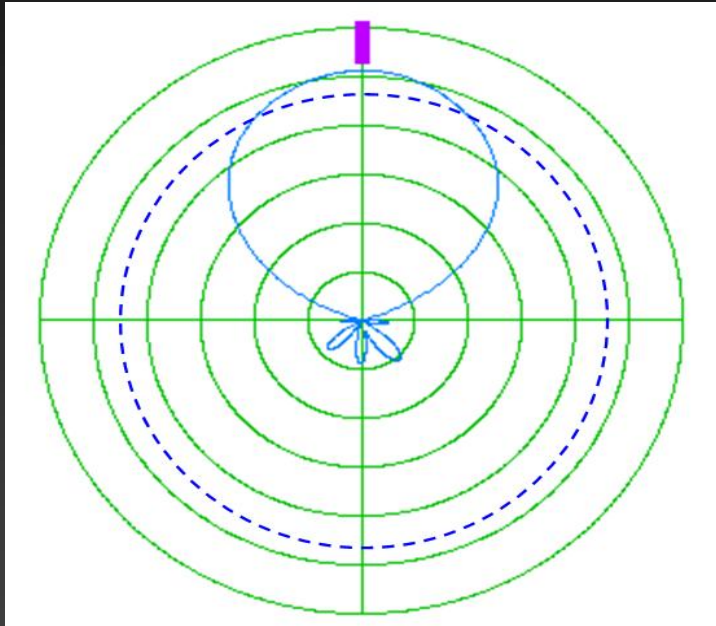 - control the signal spillage in unwanted regions
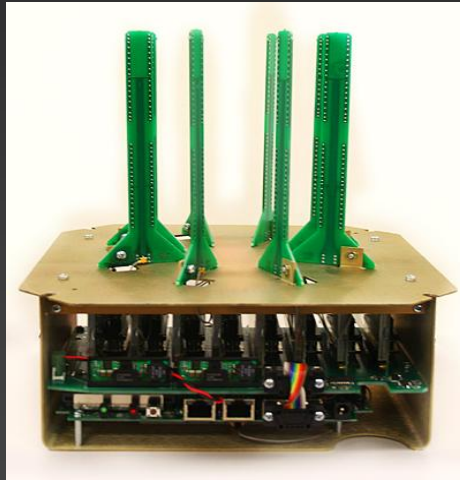
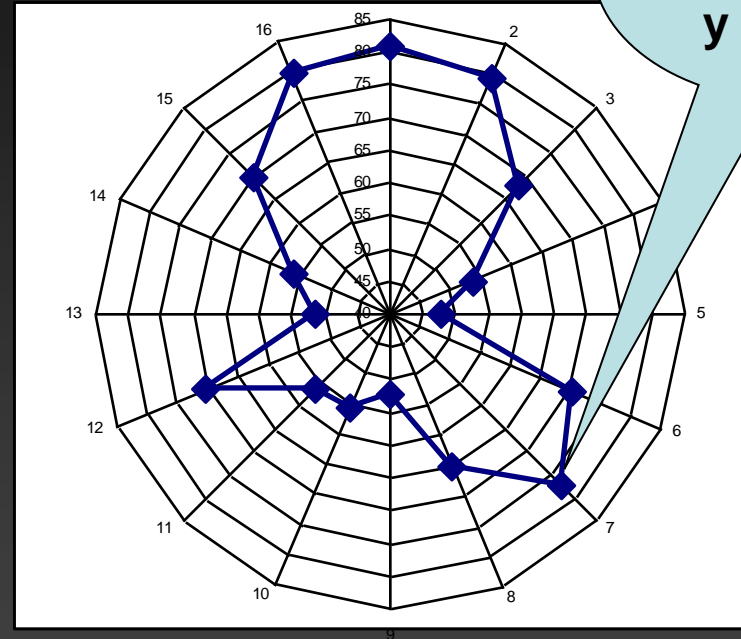**Phased-array antenna with 8 antenna elements**
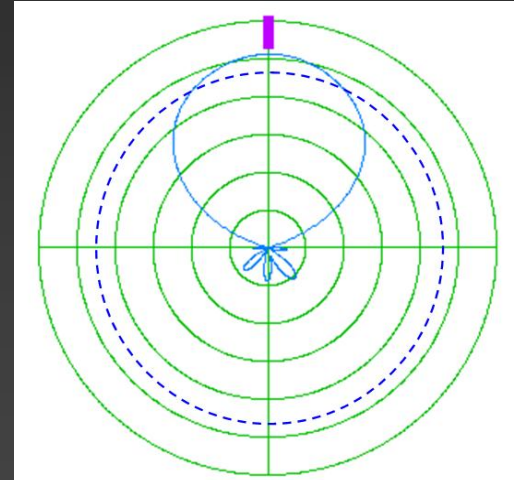
Antenna can be steered at angular displacement of 22.5 based on analog beamforming

Are these antennas still useful in indoor environments?

Directional Antennas in Indoor Environments

Large Secondary Lobes

Pattern in multipath-free environment.

Measured pattern in a cluttered indoor environment

The irregular patterns create *secondary paths* that provide an *opportunity* to control the signal level across the devices in the home.

Geo-fencing: Confine Wi-Fi Service Areas to Meaningful Physical Boundaries
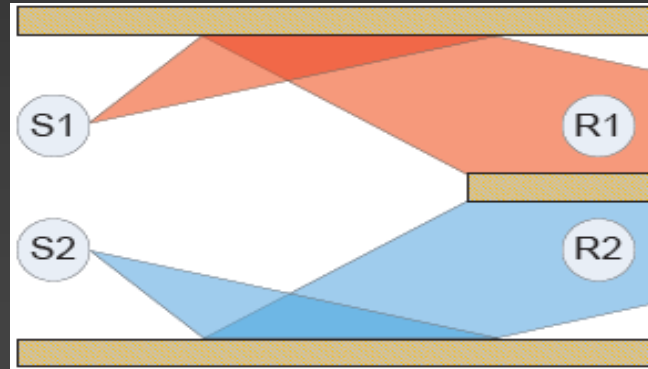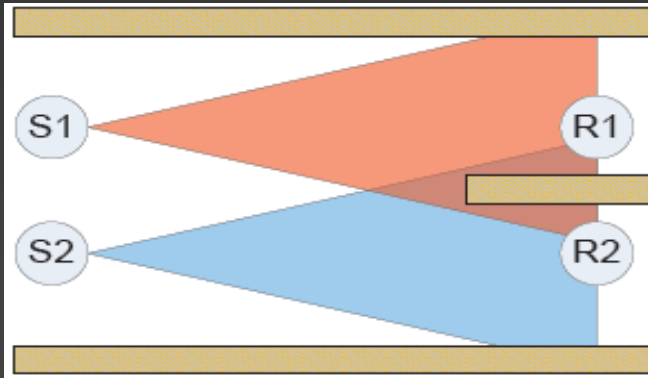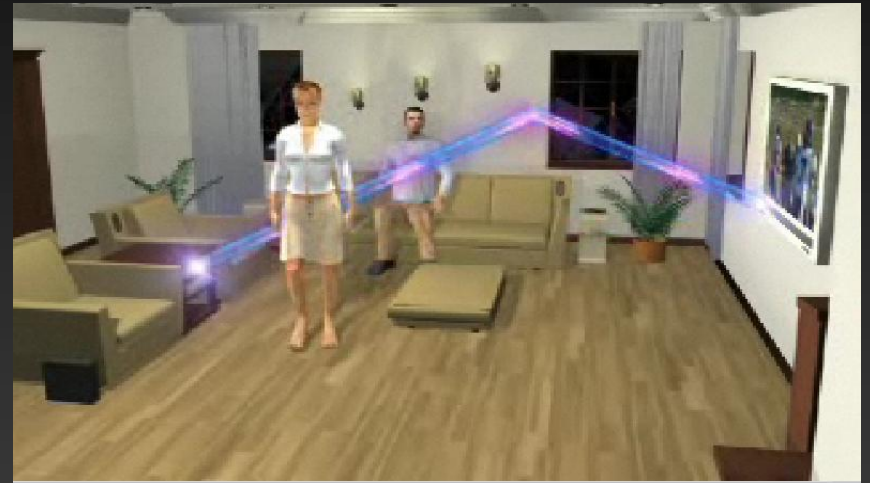
- Create controlled overlap between multiple directional antenna patterns
- Tie connectivity to the intersection of these overlapping patterns
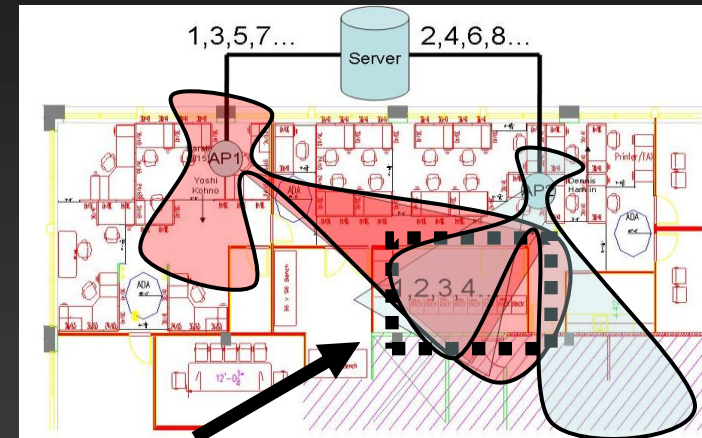
Wi-Fi service confined to target region

**Simplifies access control and Strengthens privacy**

Mitigating Wi-Fi Interference by Leveraging Spatial Reuse

Scaling wireless capacity by the spatial reuse of "disjoint" secondary RF paths.

Discovering and Using Alternate Spatial Paths

- Assumptions:
  - Rely on measurement based feedback from the distributed devices in the home.
  - A centralized controller to coordinate the distributed devices in the home.
- Challenges
  - Heuristics for orienting the antenna
  - Minimizing the search space
  - Dealing with mobility and changes in the environment
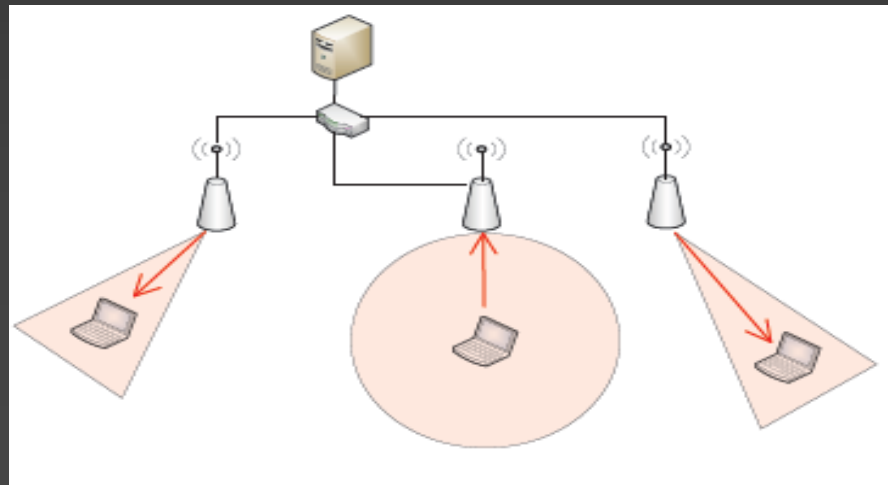
Initial Results

- Geo-fencing [Pervasive '09]
  - Able to selectively provide service between adjacent nodes located ~ 5 ft. away from each other.
  - Able to form regions of varying shapes and sizes (single office desk to a large room sized region)

- Mitigating Wi-Fi Interference [Sigcomm '09]
  - Record signal strength across distributed devices.
  - Encode interfering antenna orientations in a conflict map
  - Schedule concurrent transmissions across interference-free antenna orientations
  - 100% improvement for UDP and ~45% for bidirectional TCP.

Max capacity

2x Imp.
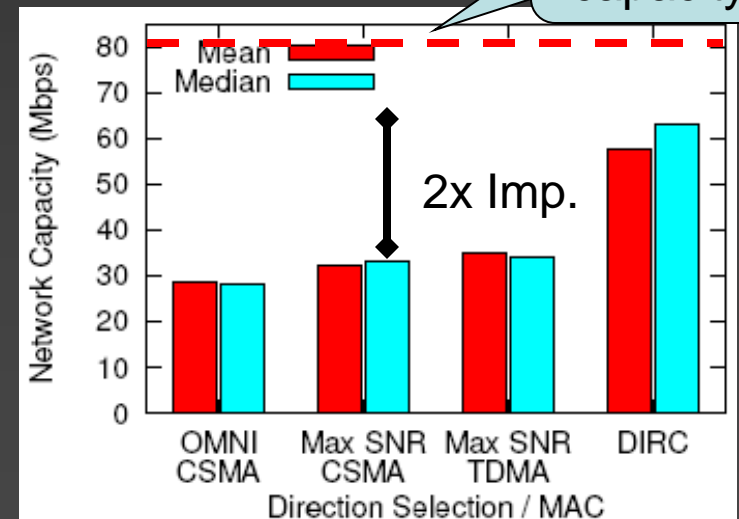
Conclusion

- Broadcast nature of the wireless medium makes it hard to reason about the extent of wireless coverage areas
- Multiple antenna based radio systems provide significant control over wireless coverage areas
  - Enable users to control the Wi-Fi service areas to meaningful physical boundaries
  - Provide rich experiences by scaling wireless performance
- Early stage, simple experiments are promising
  - Assessing feasibility of using 802.11n MIMO based digital beamforming.

Thank you!!

Questions?