

Talking Points

FCC Field Broadband Hearing **Mobile Applications and Spectrum**

San Diego, CA

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Observations

- 56% of Americans have accessed Internet via wireless networks (Pew Internet & American Life Project, April 2009)
 - 39% of adults access it through wireless laptop
 - 1/3rd of all Americans through cell phones & SmartPhones
 - 1/5th of Americans access Internet everyday via a mobile device
- # of users is going up, consumption of data per user is going up
 - Lots of data out there that already shows this
 - Social networking (e.g. micro-blogging), multimedia networking (e.g. Hulu, YouTube), 3D gaming, real-time scientific visualization, augmented reality etc.
 - Human attention is constant, latency & bandwidth matters (low latency impacts battery consumption)
- 3G WAN throughput and Latency are not enough for next generation applications
 - Augmented Reality (face recognition), 3D gaming etc.
 - On-going world-wide study of 3G network performance (with UMichigan)

Capacity is Finite!

- Shannon's law sets a limit to what is achievable
 - Limit set by thermal noise (~ 20 dB) ; SNR is a function of B
- Engineering innovations help but the limit still exist and it is not enough
 - Coding schemes (Turbo coding is within a few dBs of the Shannon limit)
 - MIMO (*increase number of channels*) & Cooperative MIMO (network-wide MIMO with device-to-device cooperation)
 - Antennas placement & size is an issue AND even with MIMO Shannon limit holds
 - Processing power has implications on battery power (battery is not following Moore's law)
 - Network coding
 - Traffic patterns are important, cannot always exploit benefits
 - Receiver sensitivity (already quite good, also expensive)
 - MAC and transport protocols (TCP) are already wireless aware, not much improvement to be made
 - Reducing cell size? Increasing BS density & spatial reuse
 - Network management headaches (think interference, channel collisions etc.)
 - Expensive

What can we do?

- Fatten the pipes - open up additional spectrum
 - A mix of licensed and unlicensed spectrum
- Set policies & rules that do not make unlicensed a non-starter (e.g. don't protect illegal microphones)
- Secondary market place (SKIP)
 - No MS position but an interesting research problem
 - Engineering problems include
 - Protocols & mechanisms for leasing spectrum on a timely basis (think IP leasing via DHCP protocol and then design spectrum leasing via DSCP)
 - Spectrum leasing in {space, time, power}
 - Agnostic of communications protocol, Future-proof
 - Enforcement Problems
 - Research papers published by MSR, Bell Labs, Intel etc.

Power of Unlicensed Spectrum

- Novel usage scenarios
 - Inside homes (home networks), offices, buildings, communities
 - Machine-to-machine
 - Think sensor networks
 - Inside data centers (as a cost reduction measure, which then reduces cost for customers)
- Rapid Deployment
 - In hard to get to areas (rural, sparsely populated)
- Significant Innovations (which helped licensed holders)
 - Allowed academics & researchers to build proof-of-concept systems
 - Network stack became open - a HUGE STEP forward for research community
 - Examples of past innovations
 - PHY Layer, OFDM & MIMO -- IEEE 802.11 standards first to incorporate)
 - Data-driven networking that is helping understand & improve TCP performance in WANs (think ECN bit & adaptive window size)
 - Signal strength based location determination
 - Examples of future innovations
 - Network coding
 - SDR's and Cognitive Radios – allow optimum use of spectrum by including techniques to mitigate interferences, allow opportunistic access,
 - Network management, diagnosis

Unlicensed Spectrum (Cont.)

- Allow Licensed Operators to Offload Traffic
 - Provide more services while simultaneously relieving pressure on licensed band (Recent NY Times article on iPhones over AT&T networks)
 - Research work coming out of Bell Labs talks on how a Femto cell architecture can benefit from unlicensed use
 - Provide location based services with much better granularity
- Decentralized operation can be more resilient in the aftermath of disaster
- Consumer Networks (not just WAN)
 - Body Area and Personal Area networks
 - Sensor networking applications (e.g. Health, education etc.)
 - Device to device networks in the home etc.
 - Standards like Bluetooth, Zigbee have helped etc.
 - Local Area Networks
 - Enough said already

Economic Value of Unlicensed Spectrum

- Thanki recently published a study which found:
 - Wi-Fi broadband access in homes, delivering voice-services and wireless access in hospitals and RID inventory tracking in retail stores could generate anywhere from **\$16 to \$37 Billion / year for next 15 years** (only 15% of the total projected market for unlicensed chipsets)
- Wi-Fi Alliance said 387 million chips were sold and they are on target to sell 1 Billion before 2012
- Telcos
 - AT&T offers 20,000 Wi-Fi host-spots in the US
 - Sprint-Nextel announced that they will feature Wi-Fi in all its devices
 - Verizon offers “MiFi” and has made statements similar to above
- WS’s could generate an additional **\$3.9 billion to \$7.3 Billion / year for the next 15 years (~ \$109 billion total)**

White Space Networking

- Revisit effective scenarios
 - Community meshes
 - Dual frequency meshes
 - Only 5-10% penetration needed
 - Dual frequency meshes (Wi-Fi and WS can work together)
- Extend coverage (Universal coverage)
 - Blanket city-wide coverage in hot-spots
 - Enterprise Networks (inside and around buildings (covering holes))
 - Inside homes and around homes (multimedia transfers, device to device)
- Microsoft has a very active research program in this area.
 - Focus is on networking WSDs
 - Opportunistic access & Cognitive network (DSA + intension aware networking)
 - Reuse existing technology (e.g. Wi-Fi Substrate)
 - Co -existence between multiple unlicensed networks
 - Databases
 - How much white spaces are there
 - Impact of client location resolution
 - Impact of propagation models, Building a network that does not require sensing,
 - Funding Universities
 - SDR (SORA Academic Program), WS research with rice University (mesh networks viability), UCL (Directional antennas study and viability in London) etc.
 - In-house: Deploying WS networks – in the lab and campus-wide
 - FCC granted us license for experimental use

Conclusions/Recommendations

- The FCC got it right in making Spectrum a centerpiece of our NB plan (compliments to the Chairman, Commissioner Baker and their team)
 - The world is watching, the opportunity to lead is now
- Additional spectrum is needed if US is to maintain leadership
 - Capacity is limited & consumer needs are going up, technology with small pies will not be able to keep-up and enable next-gen applications
- History has shown that a mix of licensed and unlicensed works best
 - Provides great economic value, enables innovations, rapid deployment etc.
- To ensure success, rules should not be stifling
 - E.g. w.r.t WS networks move away with sensing
 - Don't like unlicensed microphones
 - Reduce sensitivity of -114 dBm
 - WS are not just for rural (need to win urban for the economics to work out)
- Microsoft has lots of skin in the game
 - Working hand-in-hand with policy makers, building proof-of-concept systems, funding & providing software/hardware tools to academics, funding programs such as Digital Inclusion, sharing our learning's openly