2016 WISPAPALOOZA

And In The Long Run… What's coming over the next 5-10 years?

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WISP technology has advanced rapidly

- The radio technology used by WISPs has gone through several generations within the past 15 years
  - Comparable to how PCs advanced between 1986 (i386 and MS-DOS 3.1) and 2002 (Pentium 4 and Windows XP)
  - It isn't slowing down yet, even as we are creeping up on Shannon limits
- Where we have been – multiple generations in a short time:
  - 2001: Canopy FSK; 802.11b-based modules
  - 2006: Orthogon; StarOS, early UBNT, based on 802.11a; still with Wi-Fi MAC
  - 2011: UBNT M-series dominates; polled MAC with 802.11n-derived 2x2 MIMO
  - 2016: Several 802.11ac and n derivatives; 24 GHz PtP; 60 GHz; some beamforming
- Like PCs, radios are economically obsolete before they are worn out
- So what are the key technologies to watch?

Beam steering is becoming practical

- The idea of beam forming, beam steering and phased antennas is not new
  - AM broadcast stations have been doing beam forming since the 1920s
- The hard part is *dynamic* beam steering, where beams can be computed and changed on the fly, steering as required
  - Included in LTE specifications but not widely implemented
- Beam forming gain does not exceed sum of gains of component antennas
  - E.g., four 7 dB omnis can potentially steer up to 13 dB gain
  - Not a huge deal on transmit, then, where in any case EIRP may be limited by regulation
- Beam steering can do wonders to create nulls, though
  - Compute a pattern that reduces unwanted signals to improve signal to noise ratio
- New beam steering products coming on at high end of market now (e.g., Cambium 450m Medusa, with 14x14 “massive MIMO”)
  - Like other new technologies, prices will fall and it will enter the mainstream

Flexible high-order MIMO

- Multiple In/Multiple-Out (MIMO) technology can be deployed in various ways
  - Wi-Fi and 802.11-derived devices use it to increase capacity on a channel.
  - WiMAX an LTE have a “Matrix A” option that uses it for path diversity; higher-order MIMO could further improve NLOS performance through clutter (trees, buildings)
- Multi-User MIMO allows simultaneous communication with different destinations, with different beam patterns (space division multiple access)
  - Not in today’s 802.11-based systems but likely to become less costly
  - Potential single-array AP: 360° coverage from 8 or more omnis using MU-MIMO to direct signal in each user’s direction.
- This all takes advantage of cheap digital signal processing

Software-defined radio

- Speaking of cheap DSP... SDR has been around for some years but continues to improve. It is likely to have more impact on the WISP space.
- How about a cheap SDR ($<1000) that can be an LTE base station? (Already demoed by Lime Microsystems, so products based on the technology can follow.)
- How about a base station or CPE that can operate on multiple bands on demand?
- Big risk factor to SDR: Regulatory! The FCC doesn't want products on the market that can be hacked too easily to transmit illegally
  - But the key to SDR is open source, not locked products
  - A solution to this may well take a few years to iron out

Millimeter waves gain importance

- Millimeter waves (above 30 GHz) have well known limitations
  - Highly susceptible to rain fade
  - 60 GHz band is absorbed by oxygen in even dry air (up to 14 dB/km)
  - Very precise antenna alignment usually required
  - Intolerant of clutter in the path
  - So largely an urban play, but with some rural short-haul uses
- But spectrum crowding is making people look harder at them
  - “5G” mobile will probably use some mmWaves
  - Short-range backhauls and “small cell” backhaul can use them
  - VERY high unlicensed EIRP limit on 60 GHz PtP, if you can generate the power
- WiGig (802.11ad) creates a standard for low-cost 60 GHz chips
  - IgniteNet is the first to turn them into a PtP product *and* a 15° outdoor sector
  - Remember how Wi-Fi chips were repurposed on 5 GHz?

Shared spectrum

- The FCC is just starting to rethink its exclusive licensing policies
  - Make more efficient use, in real-time, of available spectrum
- Two major initiatives: TVWS and CBRS
- TV White Space Devices consult database to determine which channels are available
  - TV Band 802.11af standard just starting to see silicon, so it could take off over the next few years
  - TV channel Incentive Auction under way, transferring channels to CMRS use
    - Unlike earlier TV repacking, auctioned channels *remain white space* until they are used; TVWS devices can still use the channels elsewhere on a non-interfering basis
- But *very* strict certification rules have held back equipment – NAB fights TVWS all the way
- While CBRS (3550 MHz) is on the short-term horizon, it is likely to be seen as a trial run for future spectrum sharing.
  - 3-tiered licensing (incumbent, Priority Access, General Authorized Access)

Future spectrum sharing possibilities?

- A lot of licensed spectrum is not widely used, and might become available to WISPs if spectrum sharing becomes the norm
  - CMRS bands, like 1900 MHz PCS and 1700 MHz AWS-1. Licensees sometimes “bank” these.
  - Wouldn’t you love some 700 MHz spectrum? This might have some rural space.
- Will the FCC allow the 2500-2690 BRS/EBS bands to be banked? Sprint uses some of it, but a lot is banked.
- Could the 10 GHz band be opened on a shared basis?
- Additional federal spectrum is now used for radar and other applications that don’t cover the whole country. A trusted spectrum-sharing system could open more bands up in limited areas.
  - A nice alternative to more auctions

IoT Opportunities & Challenges

- Internet of Things is a huge buzzword today
  - Network-connected lights, thermostats, refrigerators...
- IoT devices generally need low bandwidth but also low power consumption
  - The opposite of the “4KTV unicast to every phone” 5G mainstream push
- Missing from the equation: Security!
  - Do you want a kid in Moldova to hack your pacemaker via IPv6?
  - IoT devices do not usually get security updates
  - IoT devices already were hijacked to perpetrate Biggest DDoS Attack Evah
  - Will ISPs be held (even partially) responsible for IoT DDoS from their networks?
- Think beyond the current Internet architecture box
  - IoT needs more *privacy*, not *connectivity*. This is *not* TCP/IP’s strength.
  - Could ISPs provide more private networks alongside the big bad Internet?
  - Could new protocols, like RINA, be more suitable?

What is “5G” mobile?

- The commercial mobile industry has successfully deployed “4G” LTE, its fourth generation technology
- Whatever they do next is therefore “5G”, because 5 comes after 4.
- To date, a basket of technologies get tossed around under the 5G umbrella
  - Millimeter wave point-to-multipoint, at least for fixed use
  - Bonding across multiple bands (e.g., mix 700 MHz with CBRS with LAA)
  - A more unified API for applications
- Watch for encroachments on unlicensed bands
- Watch for hype!

The big boys are on to us...

- The fixed wireless model used by WISPs is a proven winner
- The big ILEC/Cellcos are starting to emulate us, looking at fixed wireless as a cheaper way to replace their decrepit copper plant
  - They promised fiber in exchange for deregulation, took the money...
- Google is looking to build a WISP instead of just pulling Google Fiber here and there
- Verizon has largely halted FiOS expansion
  - It will “densify” wireless coverage as “5G”, blurring the boundary between its wireline and wireless subsidiaries and networks
  - Fiber to the block, not the home, not open to competitors’ use
  - Millimeter wave and 3-6 GHz (CBRS, LAA) last-block delivery
- AT&T is moving beyond U-Verse DSL
  - Project AirGig: Millimeter wave dielectric-body “pole toppers” for feeders
  - CBRS and “5G” for last-block delivery
- Can elephants learn to dance?
  - Maybe they should fear us mice after all!