802.11n

Brian S. Walden

NYCwireless Presentation

February 28, 2007

http://802.11n.cuzuco.com/

Non Sequitur History

- On February 15th 2007 Dr. Robert Adler passed away, he has been credited as the inventor of the remote control.
- In 1950 Zenith's founder-president Eugene F. McDonald, Jr. requested a remote control to mute the volume during commercials. He hated commercials and believed that advertiser supported TV was doomed and subscription TV was the future.
- This first remote was wired and was called "Lazy Bones" but McDonald wanted better.
- In 1955 the Zenith Flash-Matic was invented by Eugene Polley. It was basically a flashlight. It had 4 functions: On/Off, Channel Up, Channel Down, and Mute/Unmute determined by which corner of the set you pointed it. Demand outstripped supply, and sold 30,000 that year. However TVs in direct sunlight seemed possessed.

Remote Control

- In 1956 Zenith's Space Commander invented by Robert Adler. Ultrasonic and needed no batteries. Same 4 functions. Increased set costs by $100 (30%). Sold 9 million units until 1982 when infrared took over.
- Since all the content is paid for by advertisers, they were worried that it would destroy the business by turning viewers in to ad avoiding "clickers."
- It did, but advertisers kept on paying – but for better content, amount of ads and the timing of them

Advertisers respond

- Commercials between shows eventually disappeared.
- Today: 18 minutes of ads/prime time hour
- 1992: 13 minutes of ads/prime time hour
- 1965: 9 minutes of ads/prime time hour

802.11

Designation	Freq.	Data Rate: Typical/Max	Indoor Range
a	5GHz	25/54Mbs	100ft
b	2.4GHz	6/11Mbs	100ft
g	2.4GHz	24/54Mbs	100ft
n	2.4 or 5GHz	200/540Mbs	160ft

IEEE Task Group

- In 2004 the IEEE 802.11 Task Group n (TGn) was formed to get 100Mbs throughput
- There were two main competing groups: TGnSync and WWiSE (World-Wide Spectrum Efficiency)
- Both used MIMO (Multiple-Input Multiple Output) to achieve this.
- They merged in 2005.

My 802.11g is all ready 100mbs

- Many commercial “g” APs are speed enhanced, via proprietary means
  - **Broadcom**: 125Mbs using frame-bursting and compression. You know this as Linksys “SpeedBooster” but also Belkin, Dell, Gateway and HP used it too.
  - **Atheros**: Super G, frame-bursting, compression and channel-bonding. 108Mbs used by D-Link, Netgear, Sony and Toshiba.
- This is <u>not</u> using MIMO

MIMO

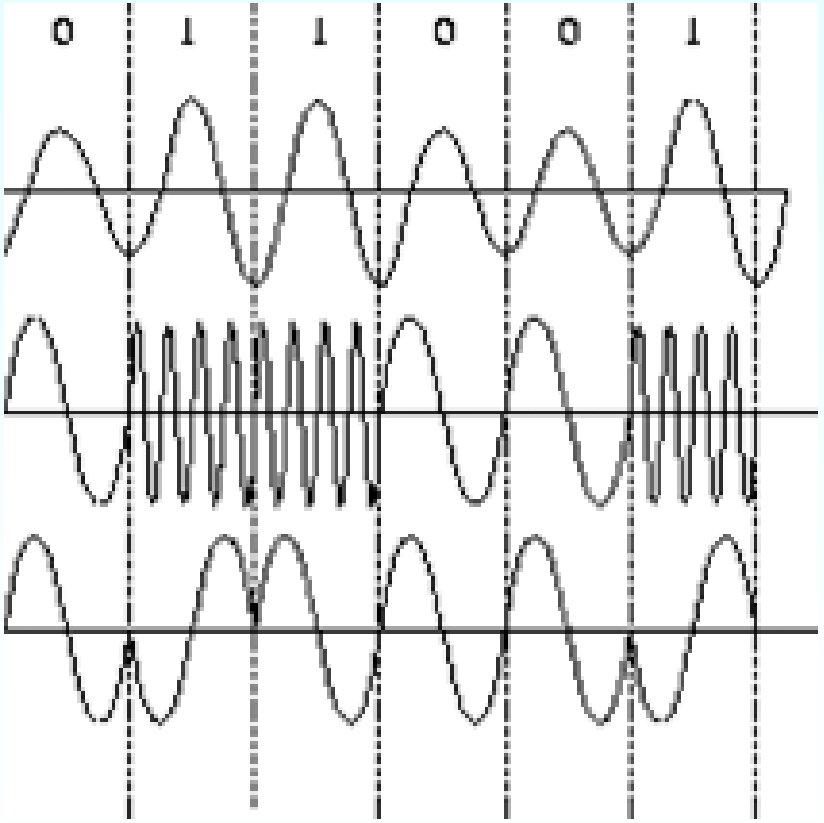
- The use of multiple input/output streams to boost throughput. This will use more than one antenna for a spatial dimension. A single frame can now be broken up and multiplexed across multiple spatial streams.
- My old “b” AP all ready has two antennas. Yes, but this was for diversity – only the best antenna was chosen at a single time.

More throughput AND more range

- That seems counter-intuitive.
- But the more throughput is only up close and the range is greater, but will down-shift to slower modes.
- This is accomplished by providing a better quality signal.
- To see how signal quality affects quality, you need a little background

Digital Modulation Primer

- Amplitude Shift Keying (ASK) – AM signaling: different amplitude for “0” and “1”
- Frequency Shift Keying (FSK) – FM, different frequencies for “0” & “1”
- Biphase Shift Keying (BPSK) – two phases 0° for “0” and 180° for “1”



Note: the word “keying” is from the telegraph operator key

Digital Modulation Primer

- Quadrature Phase Shift Keying (QPSK) – 4 phases

Phase	Data
45°	00
135°	01
225°	11
315°	10

- Quadrature Differential Phase Shift Keying (QDPSK) – 4 phases but the phase is relative to previous phase (prevents synch problems)

Digital Modulation Primer

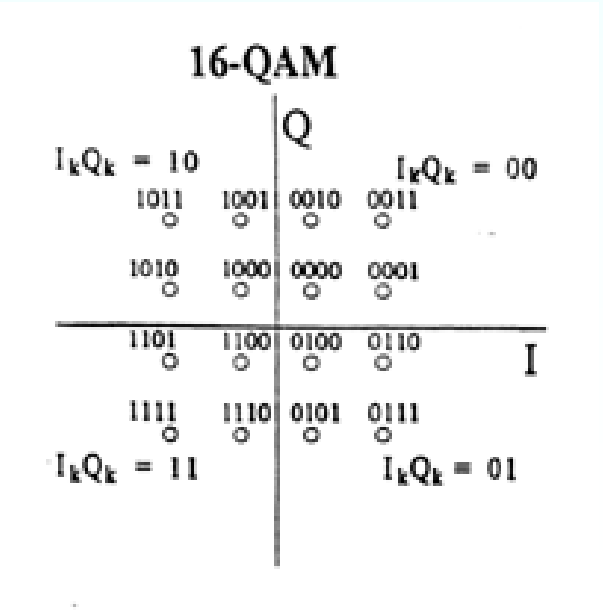
- Eight Phase Shift Key (8PSK)

Phase	**Data**
0°	000
45°	001
90°	011
135°	010
180°	110
225°	111
270°	101
315°	100

Digital Modulation Primer

- Combine 4 levels of Amplitude and QPSK – you get **16QAM**
- Caveat: this needs a better signal to noise ratio than plain QPSK

	0°	**90°**	**180°**	**270°**
+3	0010	0110	1110	1010
+1	0011	0111	1111	1011
-1	0001	0101	1101	1001
-3	0000	0100	1100	1000



Digital Modulation Primer

- Combine 8 level amplitude and 8PSK – you get **64QAM**
- Combine 16 level amplitude and 16PSK – you get **256QAM**
- Combine 32 level amplitude and 32PSK – you get **1024QAM**
- 256QAM can only be used in a low noise environment (e.g. cable)

Typical 802.11g

Speed	Modulation	Rec'v Sensitivity
54Mbps	64QAM	-73dBm
48Mbps	64QAM	-75dBm
36Mbps	16QAM	-80dBm
24Mbps	16QAM	-84dBm
18Mbps	QPSK	-87dBm
11Mbps	CCK	-88dBm
5.5Mbsp	CCK	-91dBm
1.2Mbs	BPSK	-94dBm

802.11n speed boost techniques

- Cutting guard band time in half
- Reducing the number of pilot carriers, more for data
- Aggregating frames and bursting
- Using a 40MHz channel instead of a 20MHz channel (or bonding two 20s)
- Use of beamforming
- 256 QAM?

Backwards compatible

- An 802.11n AP will be able to handle a, b, g and n simultaneously.
- If there are other non-N APs in range, even if your are all “n” your throughput will suffer as it avoids interference.
- You'll see the term “greenfield” for areas that have only n access.

Interoperability

- Atheros and Broadcom stated their chipsets are compatible at N speeds (over 100mbs)
- Chipset: Vendor
  - **Atheros**: Belkin, D-Link
  - **Broadcom**: Linksys, Apple, Netgear, Buffalo
  - **Airgo**: Netgear
  - **Marvell**: Netgear

Interoperability

- Several test have been performed by various groups.
  - You are only guaranteed N throughput within a single vendors recommended product group matrix
  - Almost all the times when N cannot not be obtained it down shifts to G
  - Rarely no connection could be made at all, but does happen

Maximum Throughout

- If we get 540Mbs what interfaces can keep up?
- NICs will need to be 1000base-T
- CardBus in 32 bit double word burst mode: 132Mbytes/sec
- USB 2.0: 480Mbps
- Standard 32 bit 33MHz PCI: 133MB/sec
- PCI 2.1 32-bit@66MHz: 266MB/sec
- PCI 2.1 64-bit@33MHz: 532MB/sec