The Wi-Fi Boom

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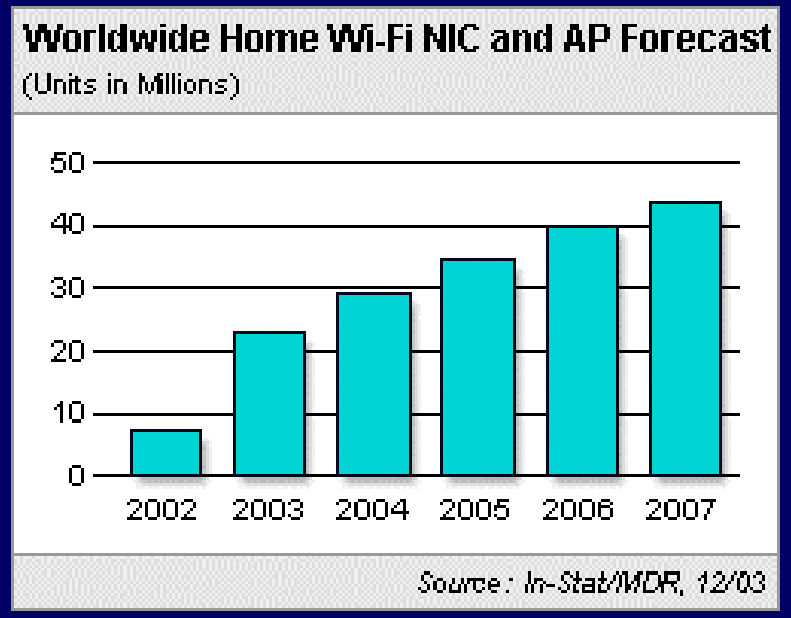
Outline

- Wi-Fi has gone mainstream
- Background of Wi-Fi/802.11
- Technical Details of Wi-Fi
  - Physical Layer(s)
  - MAC Layer
  - Security
  - Wi-Fi in different environments
- The Future of Wi-Fi
- Trends

Wi-Fi is Everywhere

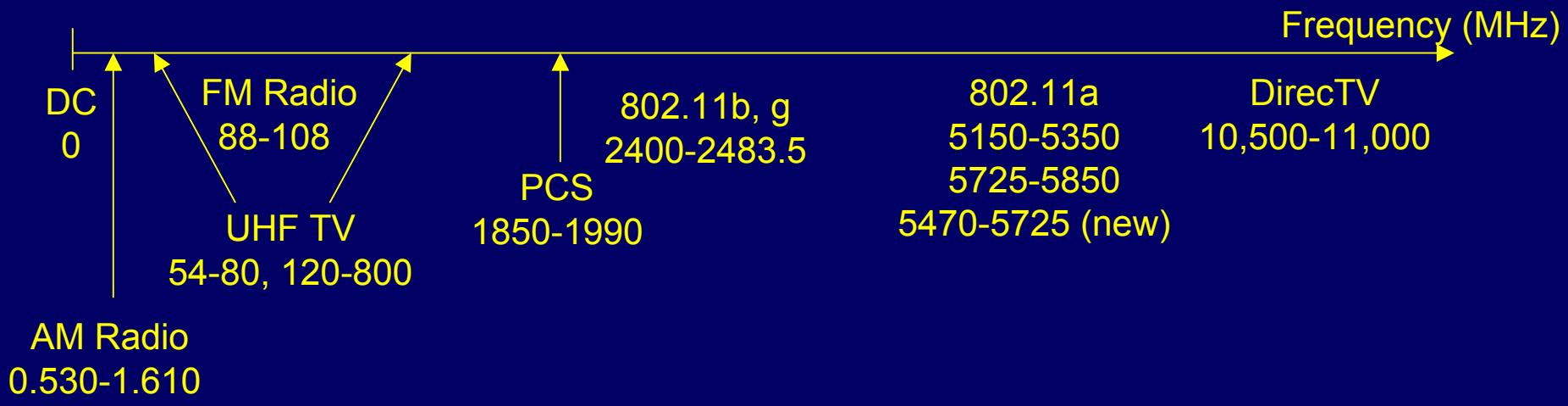
- In the early 90s, the hockey stick curve for WLAN growth was in every publication
- Took until late 90s and early this decade
  - Completion of 802.11 standard
  - Industry alliances (Wi-Fi Alliance, HomeRF)
  - Interoperability
  - The name “Wi-Fi”
  - Component costs
  - End-user need/demand
- Warchalking
- Centrino



Wi-Fi everywhere

- Every major news/business magazine seems to talk about Wi-Fi
  - USA Today Feb. 19, 2004 – once you've used it you'll never go back
- Even with some warts, Wi-Fi is here to stay
  - It's cheap
  - It's easy
  - It's mass-market
  - Everyone loves it
  - It's got room to grow

Electromagnetic Spectrum (not to scale) (not complete)

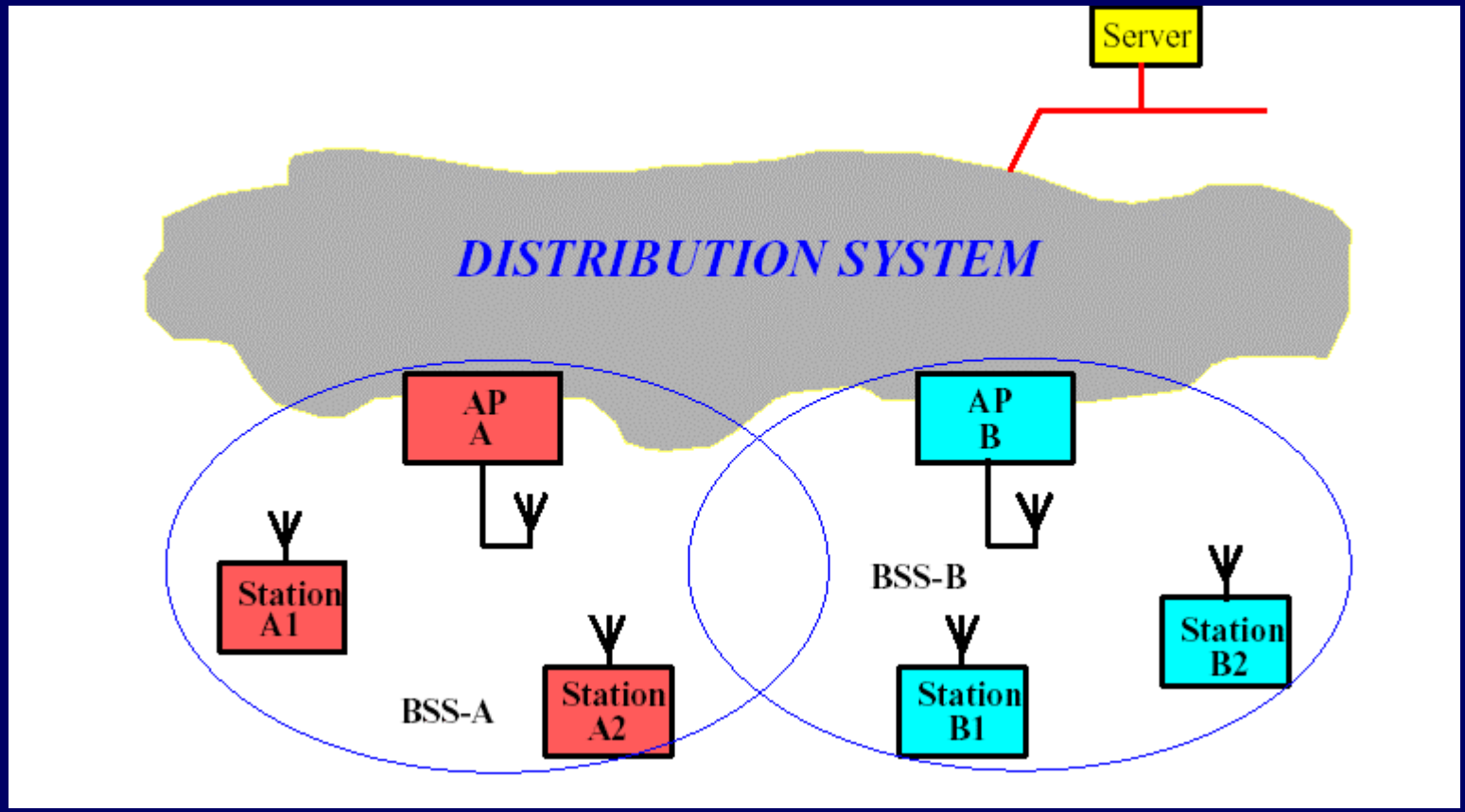


Interference

- Rules of unlicensed band say you cannot CREATE interference beyond legal limits
  - Maximum power allowed differs throughout the world
- But you must ACCEPT any interference that exists in the band
- Examples
  - Other 802.11 traffic
  - Microwave ovens (2.4 GHz)
  - Cordless phones
  - Point-to-point links

Basic Network Topology

- Access Point (AP) and client (a.k.a. end-user, station)



Background of 802.11

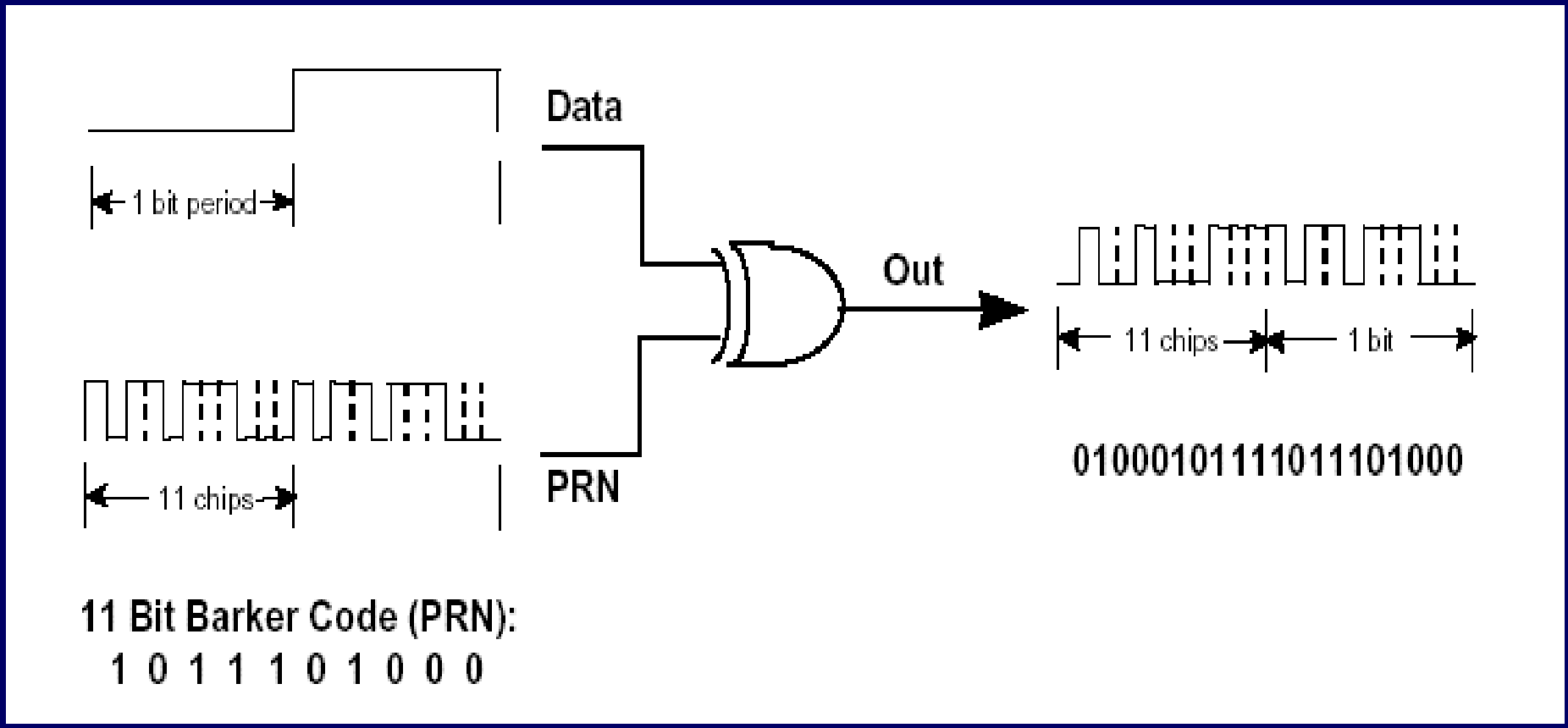
- IEEE standardizes layer 1 and 2 of OSI model
- Creating the first 802.11 standard out of IEEE took 9 years
- Original [“base”] standard 802.11-1999 had the MAC and *two* spread spectrum physical layers with data rates of 1 Mb/s and 2 Mb/s
- Use the same spectrum for transmit and receive
- Amendments since 1999 have added new physical layers, internationalization, operational recommendations

802.11 Physical Layer #1

- Frequency-hopping spread spectrum
  - 1 Mb/s and 2 Mb/s data rate (NOT throughput)
  - Signal hops through 26 of 78 possible 1 MHz wide carriers in a pre-determined algorithm throughout the band

802.11 Physical Layer #2

- **Direct-sequence spread-spectrum**
  - **1 Mb/s and 2 Mb/s data rate (NOT throughput)**



802.11b (Today's Majority)

- Also finalized in 1999
- Direct sequence spread-spectrum with data rates of 11, 5.5 Mb/s over 22 MHz channel bandwidth
- Three total non-overlapping channels in 83.5 MHz

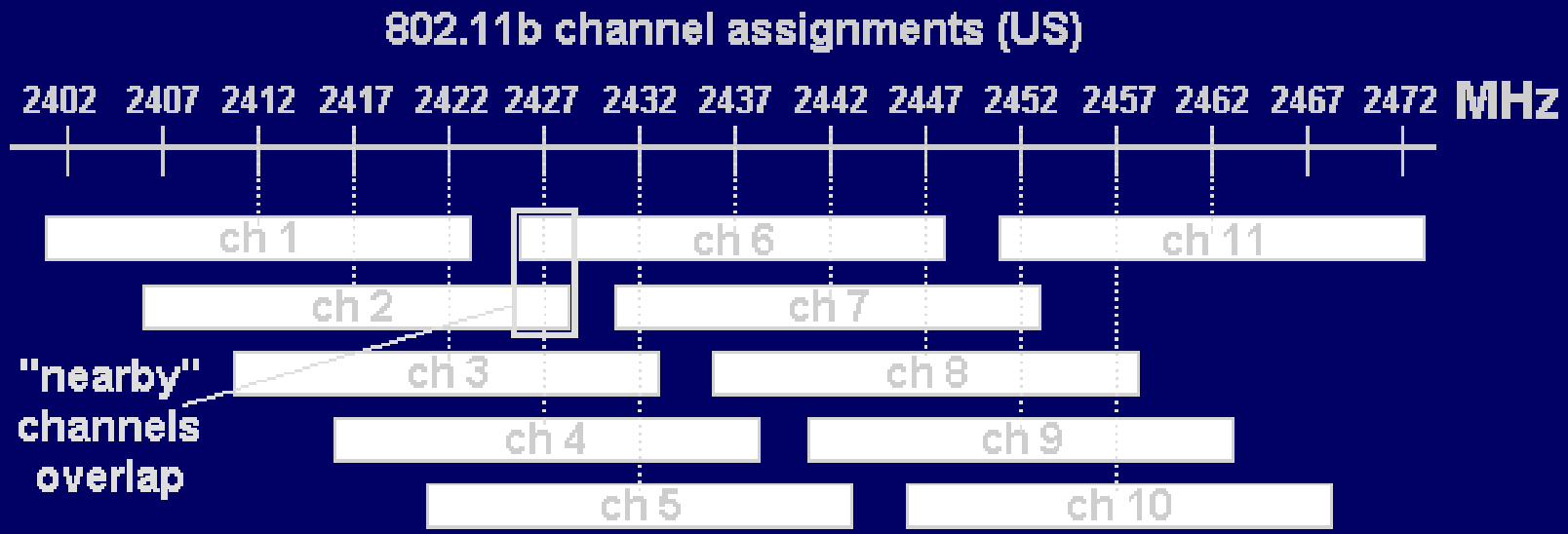


Diagram from: http://www.unixwiz.net/images/80211bchannels.gif

Other Physical Layers

- 802.11a
  - 1999
  - Uses Orthogonal Frequency Division Multiplexing (OFDM)
  - 5 GHz spectrum, can vary widely around the world
  - Channel bandwidth of 20 MHz
  - Data rates of 54, 48, 36, 24, 18, 12, 9, 6 Mb/s
  - Has not achieved popularity of 802.11b
    - Propagation difference
    - Cost
    - 802.11b is good enough for many applications today
  - Advantageous in business applications

802.11g

- Finalized in June 2003
- Same spectrum (2.4 GHz) and channels as DSSS and 802.11b
- Uses OFDM to achieve improved throughput
- Fully backward compatible w/ 11b
- Shared networks are allowed
  - Interleaved operation
  - Major throughput impact --- a single 11b client cuts 11g throughput by 50%

802.11 Media Access Layer (MAC)

- Carrier Sense Multiple Access with Collision Avoidance
  - Collision detect not possible
- Access point or client senses the medium before transmission
- If collision, device waits a random amount of time within an exponential time window before retransmitting
- "Hidden Node" problem when clients cannot hear each other
- No idea of prioritization for quality of service

Security

- Most prevalent negative issue in popular media
- Makes corporations nervous about using Wi-Fi
- But the troubles are overblown (my opinion)

What's the problem?

- The original 802.11 security protocol was called Wired Equivalent Privacy (WEP)
- Consists of a 10- or 26-byte password ("key") attached to a 6-byte initialization vector through an encryption algorithm
- Unfortunately, these keys were easy for a listener to decode
- Numerous freeware tools can sniff out the keys
- Many users (e.g., homes) did not even bother setting the WEP key anyway
- Sounds pretty bad….

What's the fix?

- Rotate the WEP keys
  - Takes time to figure out the WEP key
  - Even if someone hacks your key, you change it fast enough – takes effort
  - Snooper will move on and look for a wide open AP
  - Business needs to add extra layer of defense
- Wi-Fi Protected Access (WPA)
  - Generated by the Wi-Fi Alliance as a framework of dynamic keys and 802.1X authentication
- Advanced Encryption Standard (AES)
  - Based on government encryption standard DES
  - So far, has not been cracked

802.11 alphabet soup

- 802.11d: Internationalization [completed]
- 802.11e: Quality of Service (voice) [ongoing]
- 802.11f: inter-access point protocol [completed]
- 802.11h: 5 GHz for Europe [completed]
- 802.11i: Improved over-the-air security [ongoing]
- 802.11j: 4.9 GHz for Japan [ongoing]
- 802.11k: Radio Resource Measurement [ongoing]

Wi-Fi at home

- Generally a single AP <$200
- Basic firewall and WEP key is good enough security
- Even with wide-open AP, person in street can get access but that's it
- 802.11g is a good candidate for new install or upgrade, best propagation, unlikely to be concerned with mixed 11g/11b network

Wi-Fi Hotspot

- Examples: Starbucks, Hotels
- Provides access to individuals who bring 802.11 enabled device to the (generally) small area
- Often run w/ no security (no WEP)
- Users are directed to a captive portal to subscribe to a service plan

Citywide Wi-Fi

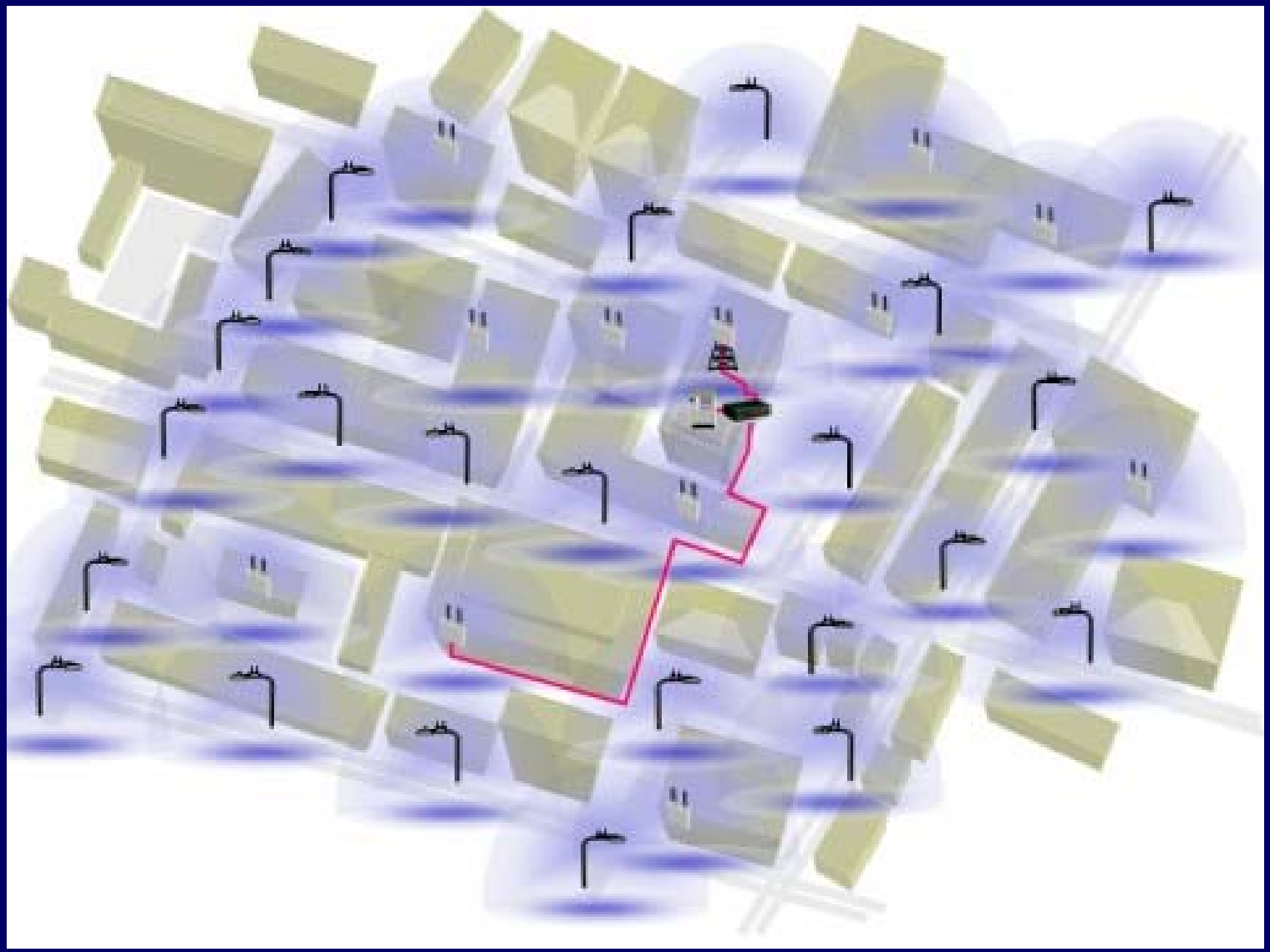


Diagram from http://www.tropos.com

WLAN at the office

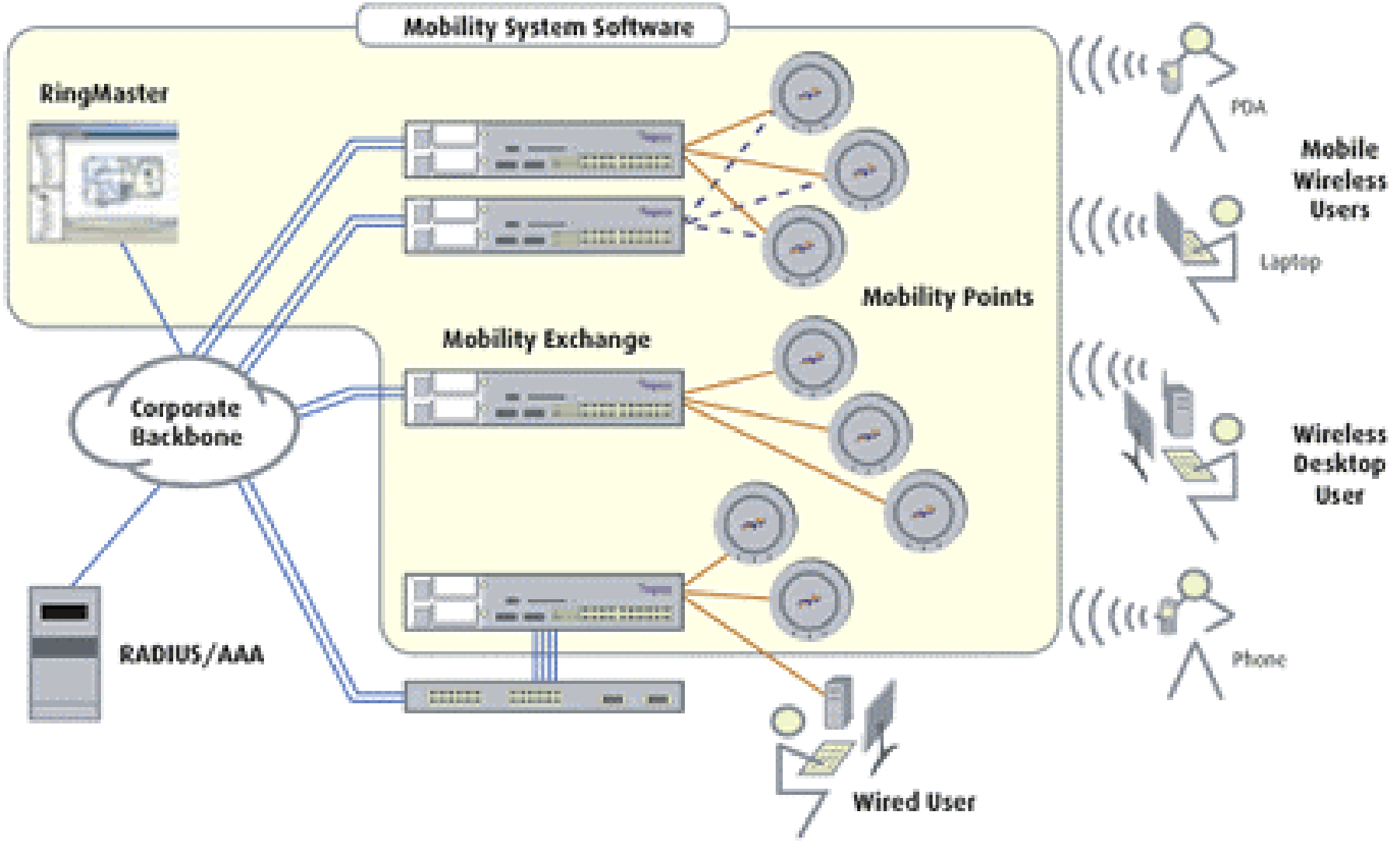
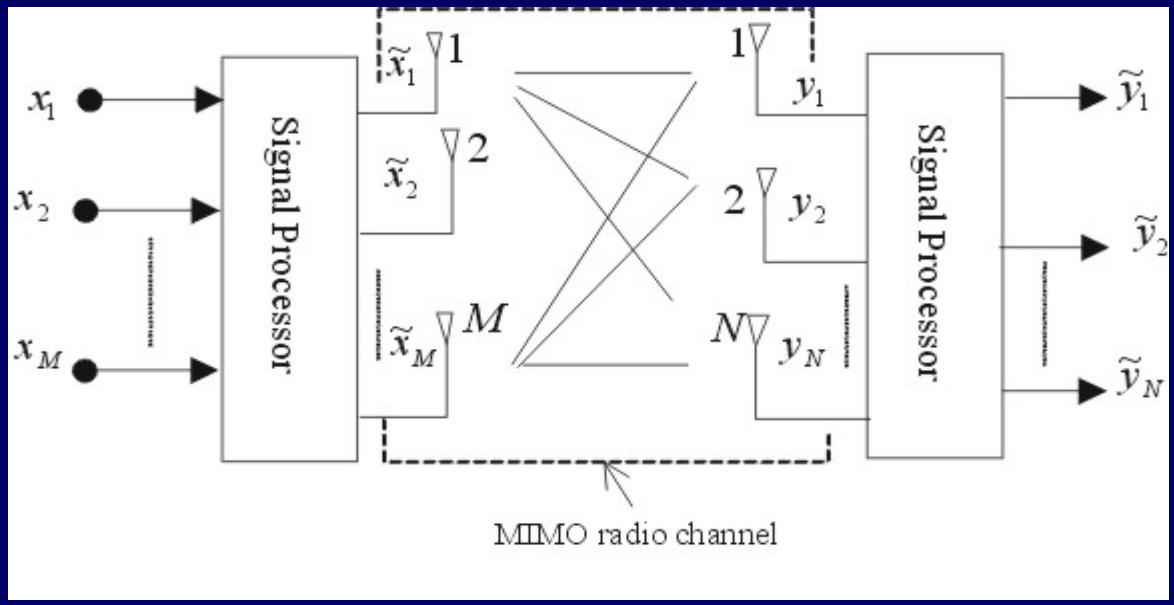


Diagram from http://www.trpz.com

Future of Wi-Fi technology

- 802.11n: higher throughput, make 802.11 better suited for even wider applicability



- 802.11p: Wireless Performance Prediction
- 802.11r: Short-Range Communications
- 802.11s: Mesh Networking

- Diagram from http://kom.aau.dk/~beza/mimo.html

Future Trends

- Wi-Fi has seen phenomenal growth and is here to stay
- Wi-Fi is pervasive
- However, this is just the beginning:
  - Much more room for PHY innovations
  - Much more room for MAC innovations
  - Billions more worldwide WLAN devices will be used
- Enormous opportunity

References

- *802.11 Wireless Networks* by Matthew Gast
- IEEE 802.11 website http://ieee802.org/11
- Wi-Fi Alliance website http://www.wi-fi.org
- Websites of companies in the industry
  - Chipsets: Intel, Broadcom, Atheros, TI
  - Business Wi-Fi: Airespace, Aruba, Trapeze, Legra, Cisco
  - Mesh Networking: Tropos, BelAir, MeshNetworks
  - Hotspots: Boingo, T-Mobile
  - Home Access Points: D-Link, Linksys, Proxim