

“Wireless“ Overview

History
Situation
Standards
Regulatory

Wireless Products

- **WLAN is *integrated***
 - ◆ Centrino chipsets
- **Very high data rates**
 - ◆ Towards modern Ethernet speeds
- **Good solutions to mitigate security problems**
- **Data and realtime (voice) services**
- **Ongoing penetration in consumer market**
 - ◆ TV/Radio-links, Wireless HiFi, other gadgets, ...



802.11 Evolution



- 1980s: Early developments - 215, 344, 860 kbit/s @ 900 MHz
- 1997: 802.11 aka 802.11
 - ♦ 1 or 2 Mbit/s, FHSS or DSSS
 - ♦ 902-928 MHz, problems with EU & Asia
- 1999: 802.11b
 - ♦ 1, 2, 5.5, 11 Mbit/s, only DSSS
 - ♦ ISM 2,4000-2,4835 GHz, nearly world-wide available
 - ♦ USA: 11 channels, Europe 13, Japan 14
 - ♦ 3 non-overlapping (1,6,11 with 22 MHz per channel)
- 1999: 802.11a (*shipped* in 2001)
 - ♦ 6,9,12,18,24,36,48,54 Mbit/s, OFDM
 - ♦ 5.150-5.350 GHz, 8-12(-24) non-overlapping channels
 - ♦ 20 MHz per channel
- 2003: 802.11g
 - ♦ 1,2,5.5,11,12,18,24,36,48,54, DSSS and OFDM
 - ♦ ISM 2,4 GHz => same channels as 802.11b
- 2004: 802.11i (Security) finished
 - ♦ Heading towards >100 Mbit/s and QoS

IEEE WLAN Standards Overview



- 802.11a – 5 GHz- Ratified in 1999 (shipping 2001)
- 802.11b – 11Mbit/s 2.4GHz, ratified in 1999
- 802.11c – MAC-layer bridging (802.1d)
- 802.11d – Additional regulatory domains (world mode)
- 802.11e – Quality of Service
- 802.11f – Inter-Access Point Protocol (IAPP)
- 802.11g – Higher Datarate (>20MBit/s, actually 54 MBit/s) 2.4GHz
- 802.11h – 54 Mbit/s at 5GHz using DFS and TPC (Europe)
- 802.11i – Authentication and security
- 802.11j – Japan regulatory conformance
- 802.11k – Radio Resource Management (Signal Quality, 2004)
- 802.11m – Various 802.11 improvements (bugfixes)
- 802.11n – Beyond 100 Mbit/s, longer distances (2007)
- 802.11p – Wireless Access for the Vehicular Environment (WAVE)
- 802.11r – Fast roaming
- 802.11s – Mesh networks
- 802.11T – Wireless Performance Prediction (WPP), test methods and metrics
- 802.11u – Interoperability with non-802 networks (e.g. cellular)
- 802.11v – WLAN Management



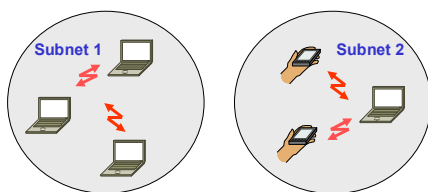
Wireless Fidelity Alliance



- **Wi-Fi Alliance (1999)**
 - ♦ Certifies interoperability of IEEE 802.11 products and promotes them as the global, wireless LAN standard across all market segments
 - ♦ Formerly known as Wireless Ethernet Compatibility Alliance (WECA)
- **Certified substandards**
 - ♦ 802.11i => Wi-Fi Protected Access (WPA)
 - ♦ 802.11e => Wireless Multimedia (WMM)
- **www.wi-fi.com**

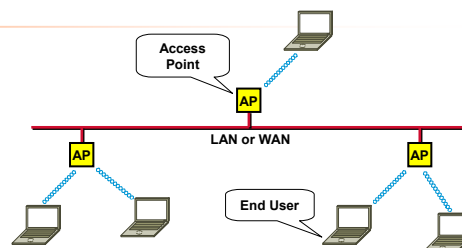


Network Types



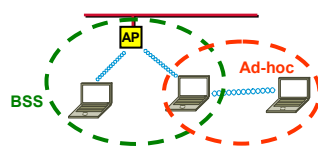
“Ad-hoc”

No infrastructure available. End users communicate directly with each other. No access points. End devices can be more complex if routing required. Typically no security concepts.



“Extended Service Set (ESS)”

Consists of a series of overlapping BSSs (each containing an AP). Requires a Distribution System (DS), typically wired Ethernet. Simple to implement. Connection to other networks possible. Access point for control: no Collisions, acts like (router or) switch. QoS and security features.



“Hybrid Networks”

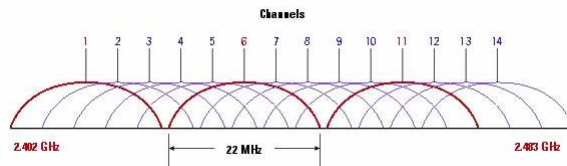
Sometimes supported. Security problem if clients additionally allow ad-hoc mode (no or simple authentication).

802.11b Overview



Channel	Frequency	Channel	Frequency
1	2412 MHz	8	2447 MHz
2	2417 MHz	9	2452 MHz
3	2422 MHz	10	2457 MHz
4	2427 MHz	11	2462 MHz
5	2432 MHz	12	2467 MHz
6	2437 MHz	13	2472 MHz
7	2442 MHz		

- Data rates: 1, 2, 5.5, and 11 Mbit/s
- DSSS @ 2.4 GHz
 - ♦ World-wide ISM
 - ♦ Crowded band
 - ♦ Allows only three non-overlapping (spread-spectrum) channels
- Cell radius approximately 50+ meters
- Multipath problems in urban areas



802.11a Overview



- Data rates: 6, 9, 12, 18, 24, 36, 48, 54 Mbit/s
 - ♦ Bold = mandatory
- OFDM @ 5 GHz
- Smaller cells (20 m) and 8+ channels means: more users supported
- Better SNR
 - ♦ Little multipath problems
 - ♦ Fewer 5 GHz applications
- Whole 5-5.8 GHz band not yet license-free ISM world-wide

802.11g Overview

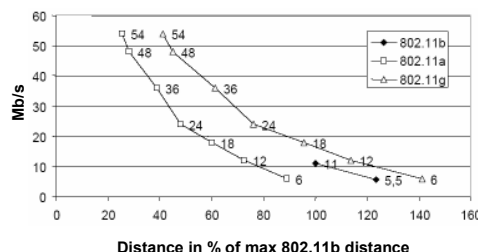


- **Data rates**
 - ◆ DSSS: 1, 2, 5.5, 11 Mbit/s
 - ◆ OFDM: 12, 18, 24, 36, 48, 54 Mbit/s
- **Also uses crowded 2.4 GHz ISM band**
 - ◆ Therefore mostly slower than 802.11a
- **New: "Super G"**
 - ◆ Supports network speeds up to 108 Mbit/s by using channel bonding
 - Additionally, some products support packet bursting to further increase speed
 - ◆ Now integrated in certain APs
 - Might interfere with other networks
 - Might not support all b and g client cards

5 GHz Facts



- **Fall 2002, Germany: RegTP allows OFDM on the 5 GHz band (802.11a), but:**
 - ◆ If TPC and DFS not implemented, then only power-limited indoor applications allowed
 - ◆ This is the main reason of the 802.11a distance problems !!!
- **Difficult migration from 802.11b**
 - ◆ Different bands and powers!
No migration path
- **802.11g provides better reachabilities**
 - ◆ However, 802.11a provides more channels and allows high cell densities

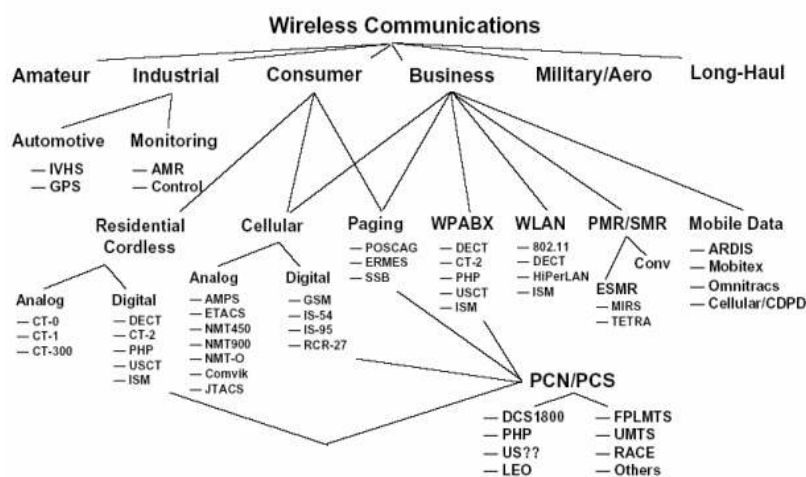


IEEE 802.11n

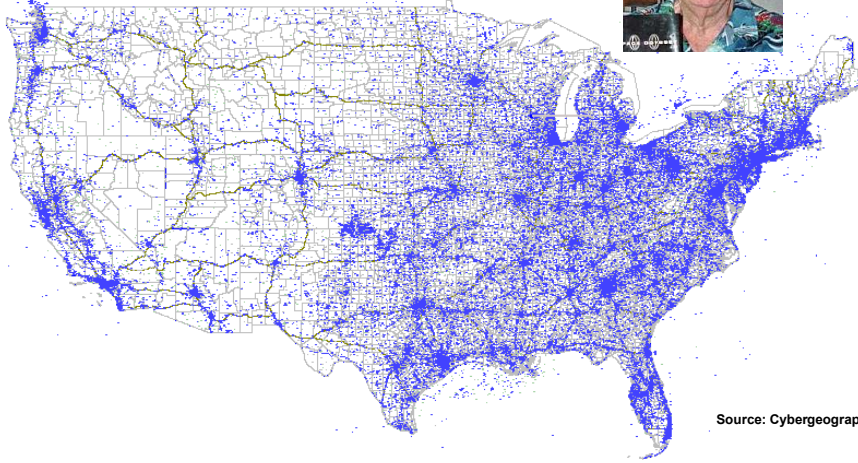
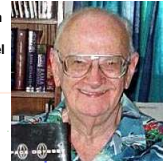


- Formed in January 2004
 - ♦ Standardization process is expected to be completed by the end of 2006
- Goals
 - ♦ Data throughput will be at least 100 Mbit/s
 - Also requires a higher PHY data rate
 - ♦ Better operating distance
- Two competing variants
 - ♦ WWiSE (Broadcom)
 - ♦ TGn Sync (Intel and Philips)
- Uses MIMO (multiple-input multiple-output) OFDM
 - ♦ Additional TX and RX antennas allow for increased data throughput through spatial multiplexing and increased range by exploiting the spatial diversity (probably through Alamouti coding or similar coding schemes)

Wireless Overview



"I've suggested, half seriously, that the next step is **direct mental input** – the 'brain cap,' which you put on your head and then the impressions, sights, everything, go directly into the brain. I'm afraid this may turn us all into permanent 'couch potatoes' because we then need not travel anywhere. We can experience anything, learn anything...just lying on the couch."



Source: Cybergeography.org

A simple dot map of commercial wireless antennas in the USA