Wireless Personal Area Networks: Part II

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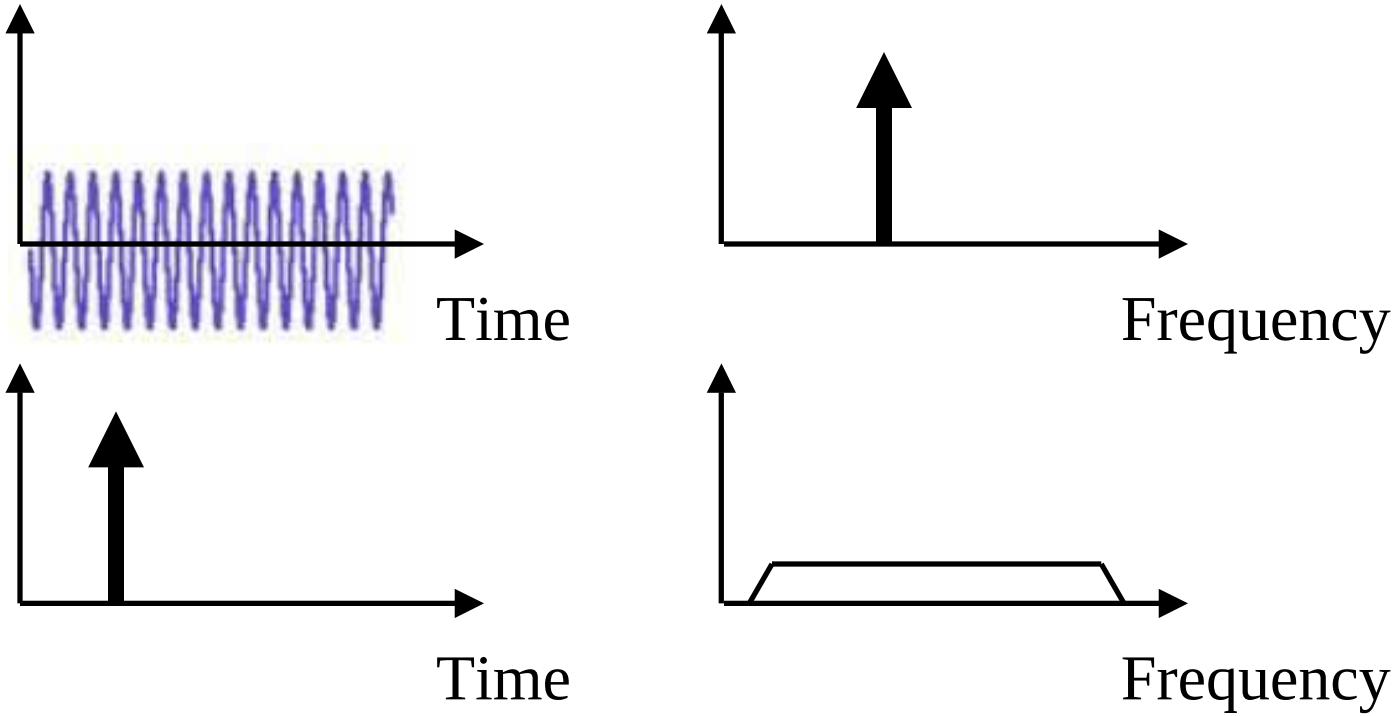
Audio/Video recordings of this lecture are available on-line at:
http://www.cse.wustl.edu/~jain/cse574-08/

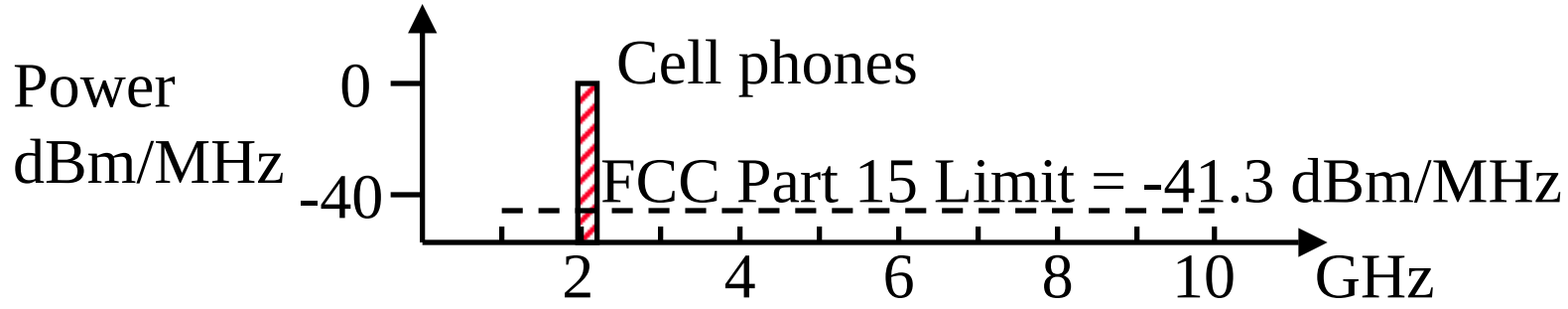
- Ultra-wideband
- Zigbee
- mm waves
- Other IEEE 802.15 WPAN activities
- Body area networks

Ultra-Wideband



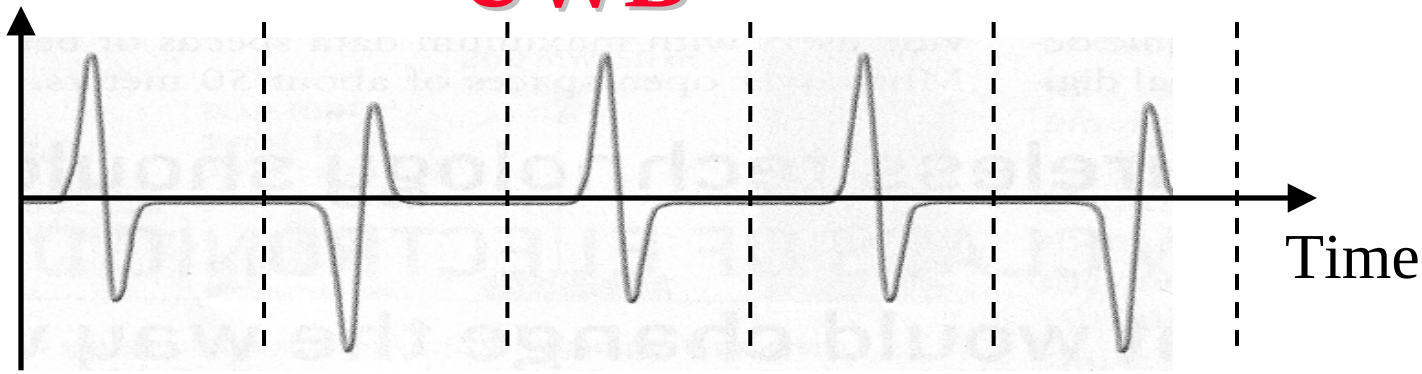
- An impulse in time domain results in a ultra wide spectrum in frequency domain and essentially looks like a white noise to other devices

Ultra-Wideband (UWB)



- FCC rules restrict the maximum noise generated by a wireless equipment (0 dBm = 1mW, -40 dBm = 0.1 μW)
- It is possible to generate very short (sub-nano sec) pulses that have spectrum below the allowed noise level
  ⇒ Possible to get Gbps using 10 GHz spectrum
- FCC approved UWB operation in 2002
- UWB will be used for high-speed over short distances
  ⇒ Wireless USB
- UWB can see through trees and underground (radar)
  ⇒ collision avoidance sensors, through-wall motion detection
- Position tracking: cm accuracies. Track high-value assets

UWB



- Sub-nanosecond impulses are sent many million times per second
- Became feasible with high-speed switching semiconductor devices
- Pulse width = 25 to 400 ps
- Impulses may be position, amplitude, or polarity modulated
- 0.25 ns Impulse ⇒ 4 B pulses/sec ⇒ 100's Mbps
- Two leading proposals: DS-UWB and MB-OFDM

Advantages of UWB

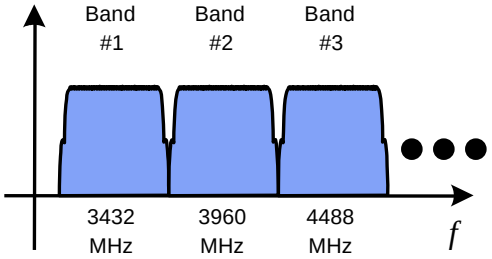
- Very low energy consumption: Good Watts/Mbps
- Line of sight not required. Passes through walls.
- Sub-centimeter resolution allows precise motion detection
- Pulse width much smaller than path delay
  $\Rightarrow$ Easy to resolve multipath
  $\Rightarrow$ Can use multipath to advantage
- Difficult to intercept (interfere)
- All digital logic $\Rightarrow$ Low cost chips
- Small size: 4.5 mm2 in 90 nm process for high data rate designs

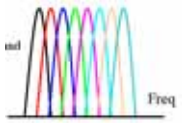
Direct sequence (DS-UWB)

- Championed by Motorola/XtremeSpectrum
- Uses CDMA with multiple chips per bit
- Chips are encoded using pulse
- 2 frequency bands: 3.1-4.85GHz, 6.2-9.7GHz
- Spectrum shaping filter can be used to meet differing spectrum requirements worldwide

Multi-Band OFDM

- From MB-OFDM Alliance (MBOA):
- Originally proposed by TI. Now many companies
- Divide the 3.1-10.6 GHz spectrum in 14x528 MHz bands (FCC requires min 500 MHz use for UWB)



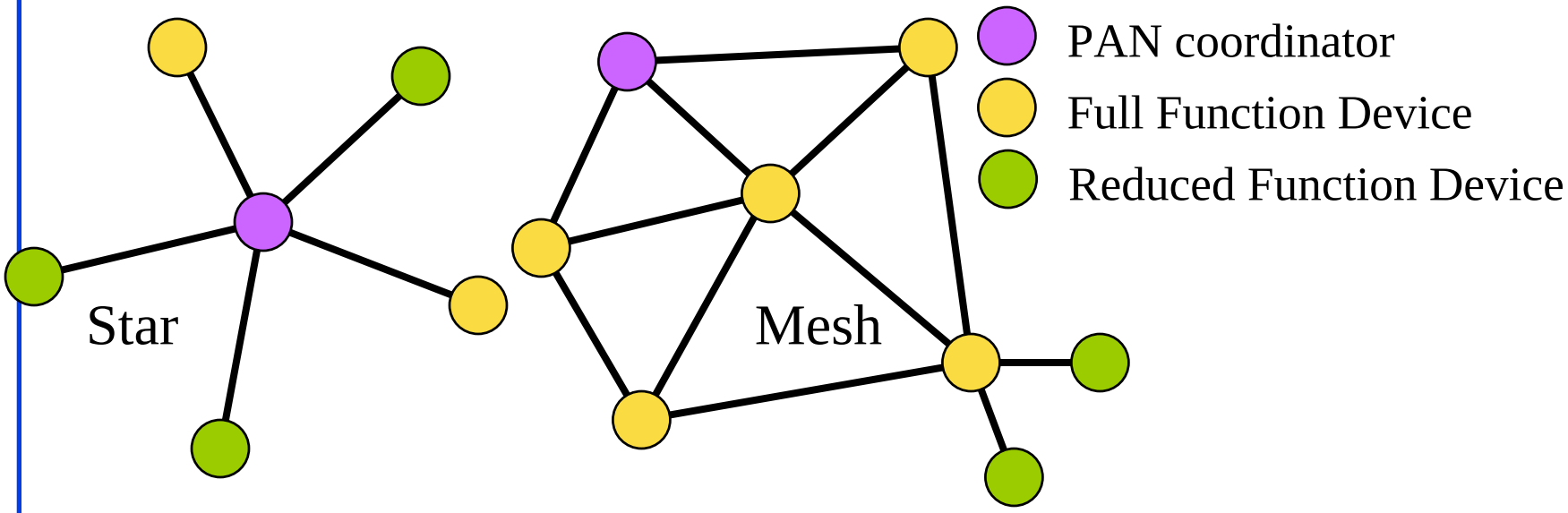


- Simple devices need to support 3 lowest bands
- Spectrum shaping flexibility for international use
  Move off the band if interference
- Use OFDM with 128 subcarriers in a band:
  Similar in nature to 802.11a/g
- Disable a few sub-carriers if required to meet local laws

ZigBee

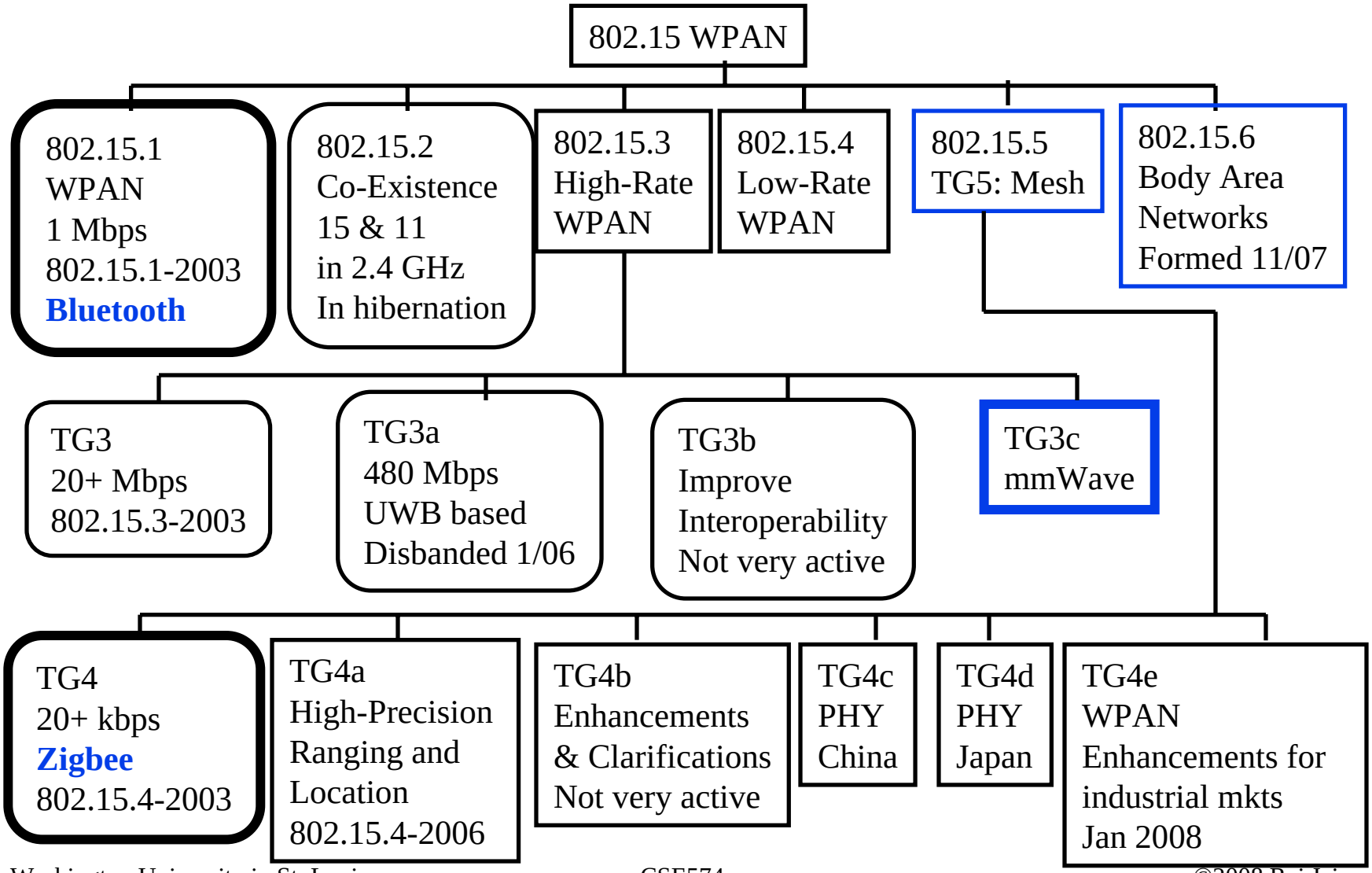
- Ultra-low power, low-data rate, industrial monitoring and control applications requiring small amounts of data, turned off most of the time (<1% duty cycle),
  e.g., wireless light switches, meter reading, patient monitoring
- Power management to ensure low power consumption.
- IEEE 802.15.4-2006
- Less Complex. 32kB protocol stack vs 250kB for Bluetooth
- Range: 1 to 100 m, up to 65000 nodes.
- Tri-Band:
  - 16 Channels at 250 kbps in 2.4GHz ISM
  - 10 Channels at 40 kb/s in 915 MHz ISM band
  - One Channel at 20 kb/s in European 868 MHz band
- Ref: ZigBee Alliance, http://www.ZigBee.org

Network Topology



- Two types of devices:
  - Full Function Devices (FFD) for network routing and link coordination
  - Reduced Function Devices (RFD): Simple send/receive devices

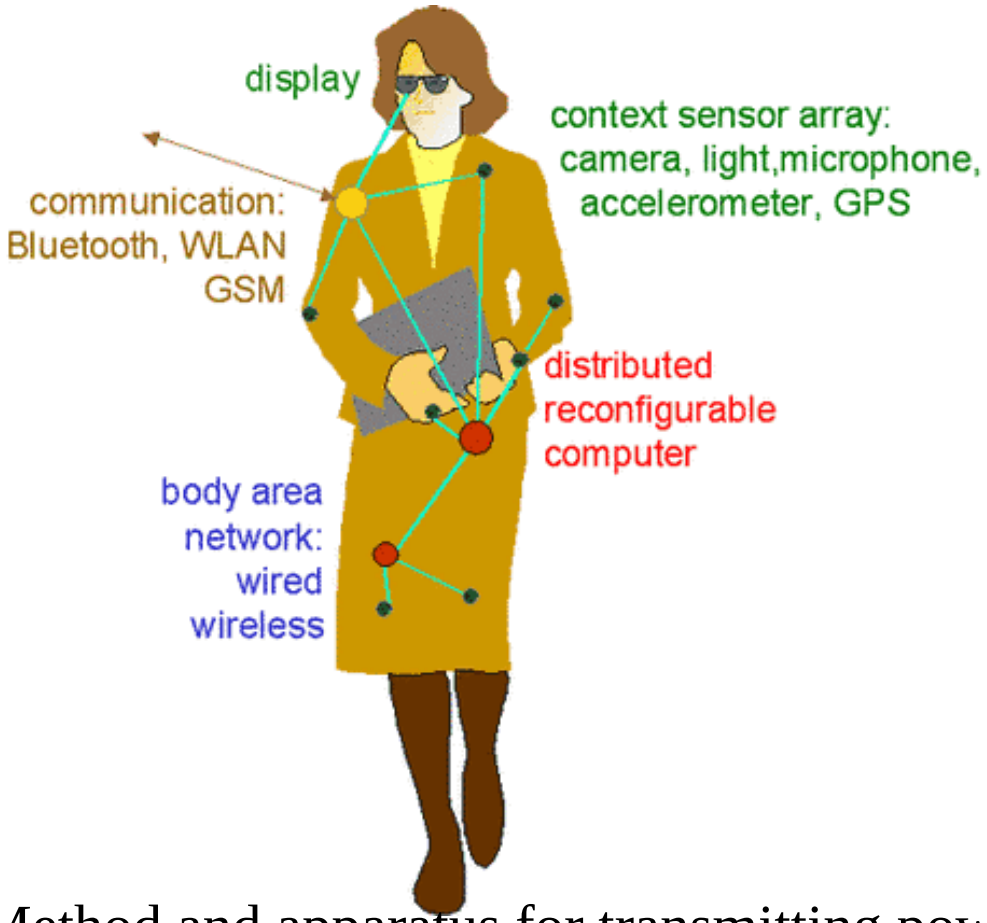
IEEE 802.15 WPAN Activities



Millimeter Wave WPANs

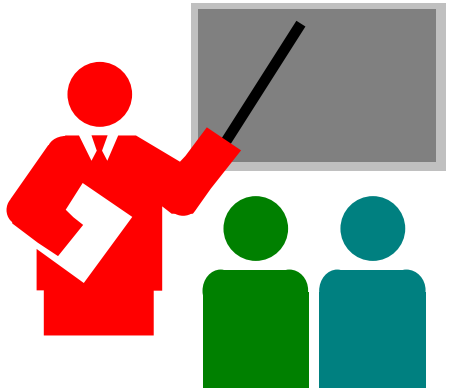
- IEEE802.15.3c
- Millimeter = Approx. 60 GHz and up
- 9.9 GHz allocated by FCC between 57 to 95 GHZ
- Single carrier and OFDM based PHYs
- License based on interference protection on a link-by-link basis for outdoor use
- No license required for indoor use
- Can send multi-gbps over short distances
- Wireless Gigabit Ethernet.
- 1-2+ Gbps Less than 10m. Cable replacement, HDTV server,
- Draft 0 text, January 2008

Body Area Networks (BANs)



- Microsoft, "Method and apparatus for transmitting power and data using the human body," US Patent 6,754,472, June 22, 2004.

Summary



- Impulses in time domain result in a wideband frequency spectrum
- With UWB, average power is below the noise level ⇒ Shares spectrum with current spectrum users
- ZigBee is allows communication at 20/40/250 kbps communication
- Mmwave networks operate at 57-60 Gbps. 1-2 Gbps at 10 ms
- Body area networks allow low power communication around living body

Reading Assignment

- Ultra-Wideband, http://en.wikipedia.org/wiki/Ultra-wideband
- ZigBee, http://en.wikipedia.org/wiki/ZigBee
- Body Area Network, http://en.wikipedia.org/wiki/Body_Area_Network
- Supplementary reading list (Bluetooth, ZigBee, 802.11 and 802.11n, http://www.cse.wustl.edu/~jain/cse574-06/reading.htm

References

- William C. Craig , “Zigbee: Wireless Control That Simply Works," http://www.zigbee.org/en/resources/whitepapers.asp
- Patrick Kinney , “ZigBee Technology: Wireless Control that Simply Works,” http://www.zigbee.org/en/resources/whitepapers.asp
- Axel Sikora, "ZigBee Competitive Technology Analysis" Section Summary,” http://www.zigbee.org/en/resources/whitepapers.asp

References: Books

1. H. Labiod, H. Afifi, C. De Santis, "Wi-Fi, Bluetooth, Zigbee and WiMax," Springer, Jun 2007, 316 pp., ISBN:1402053967.
2. Ramjee Prasad, Luc Deneire, "From WPANs to Personal Networks: Technologies and Applications," Artech House, Nov 2005, 302 pp., ISBN:1580538266.
3. Jose A. Gutierrez, Edgar H. Callaway, Raymond Barrett, "IEEE 802.15.4 Low-Rate Wireless Personal Area Networks: Enabling Wireless Sensor Networks," IEEE Press, Nov 2003, 155 pp., ISBN:0738135577.
4. Todor Cooklev, "Wireless Communication Standards: A Study of IEEE 802.11, 802.15, and 802.16," Standards Information Network/ IEEE Press, Aug 2004, 365 pp., ISBN:073814066X.