

# Wireless Personal Area Networks: Part II

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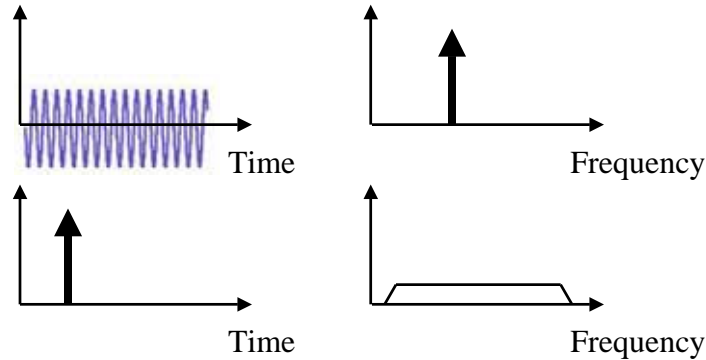
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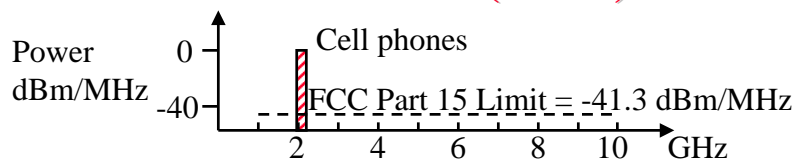
- Ultra-wideband
- Zigbee
- mm waves
- Other IEEE 802.15 WPAN activities
- Body area networks

## 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  $\mu$ W)
- It is possible to generate very short (sub-nano sec) pulses that have spectrum below the allowed noise level  
 $\Rightarrow$  Possible to get Gbps using 10 GHz spectrum
- FCC approved UWB operation in 2002
- UWB will be used for high-speed over short distances  
 $\Rightarrow$  Wireless USB
- UWB can see through trees and underground (radar)  
 $\Rightarrow$  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  $\Rightarrow$  4 B pulses/sec  $\Rightarrow$  100's Mbps
- ❑ Two leading proposals: DS-UWB and MB-OFDM

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**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 mm<sup>2</sup> in 90 nm process for high data rate designs

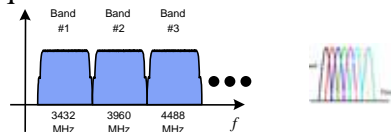
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## Direct sequence (DS-UWB)

- ❑ 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)

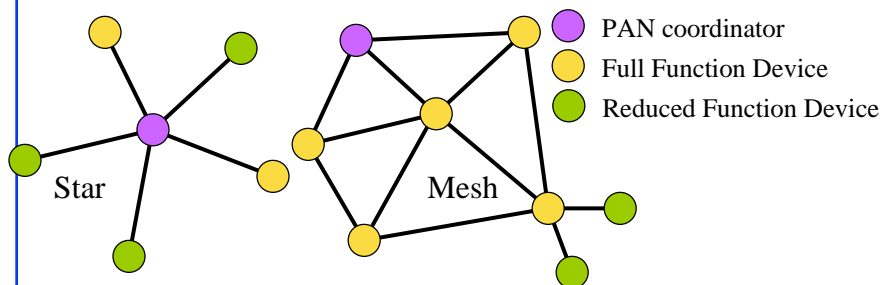


- ❑ Simple devices need to support 3 lowest bands
- ❑ Spectrum shaping flexibility for international use  
Move off the band if interference
- ❑ Use OFDM with 128 subcarriers in a band:  
Similar in nature to 802.11a/g
- ❑ Disable a few sub-carriers if required to meet local laws

## ZigBee

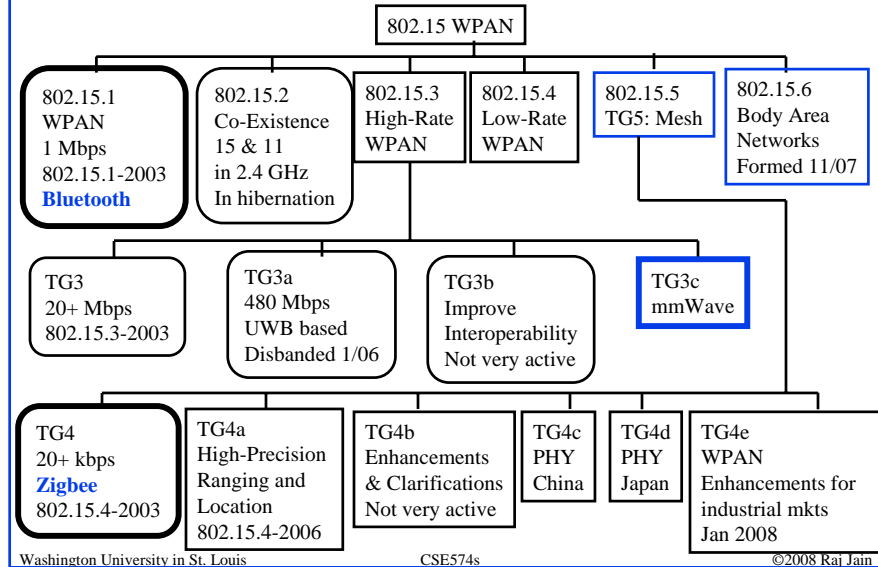
- ❑ Ultra-low power, low-data rate, industrial monitoring and control applications requiring small amounts of data, turned off most of the time (<1% duty cycle), e.g., wireless light switches, meter reading, patient monitoring
- ❑ Power management to ensure low power consumption.
- ❑ IEEE 802.15.4-2006
- ❑ 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



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## 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

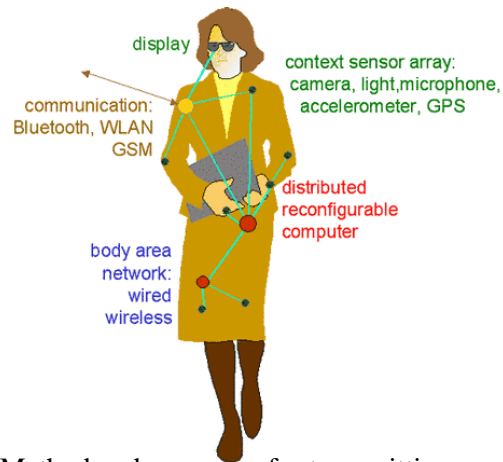
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## Body Area Networks (BANs)



- 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  $\Rightarrow$  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](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.