

Wireless Personal Area Networks: Part II

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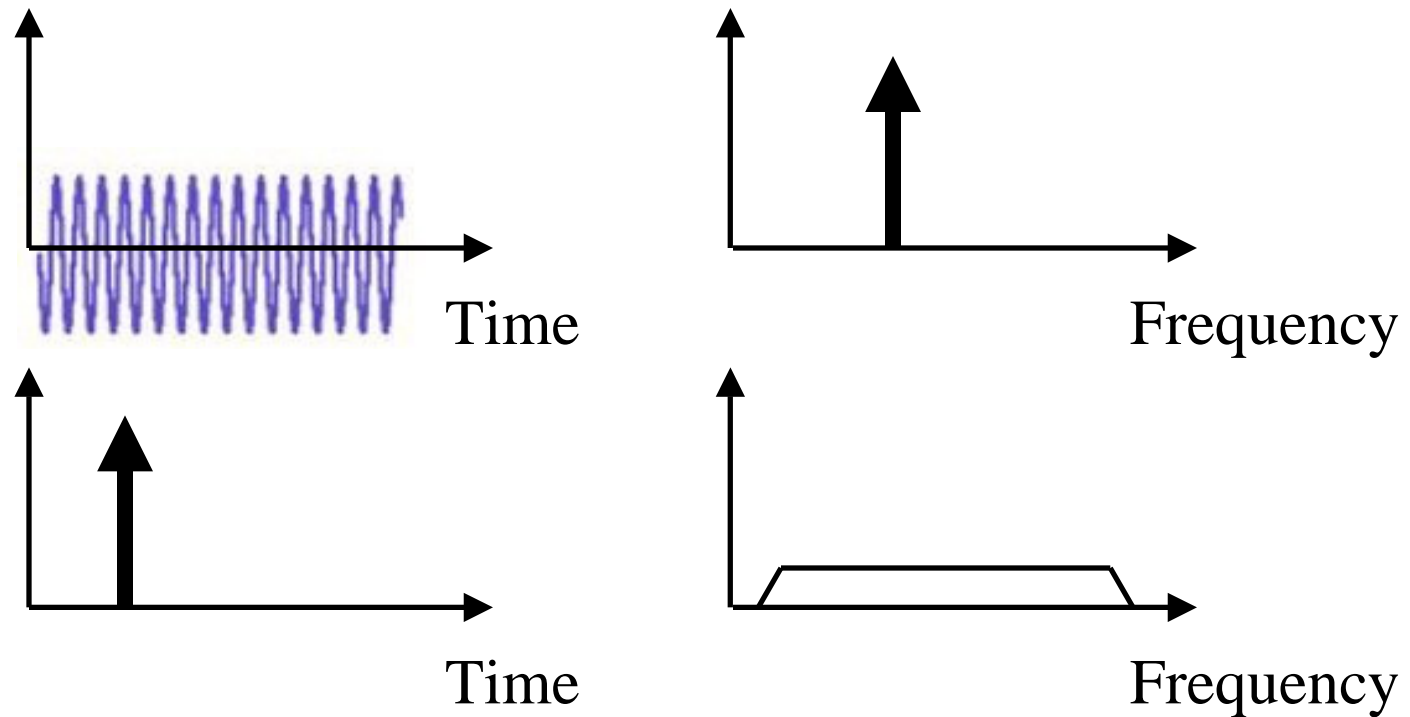
Audio/Video recordings of this lecture are available on-line at:

<http://www.cse.wustl.edu/~jain/cse574-10/>



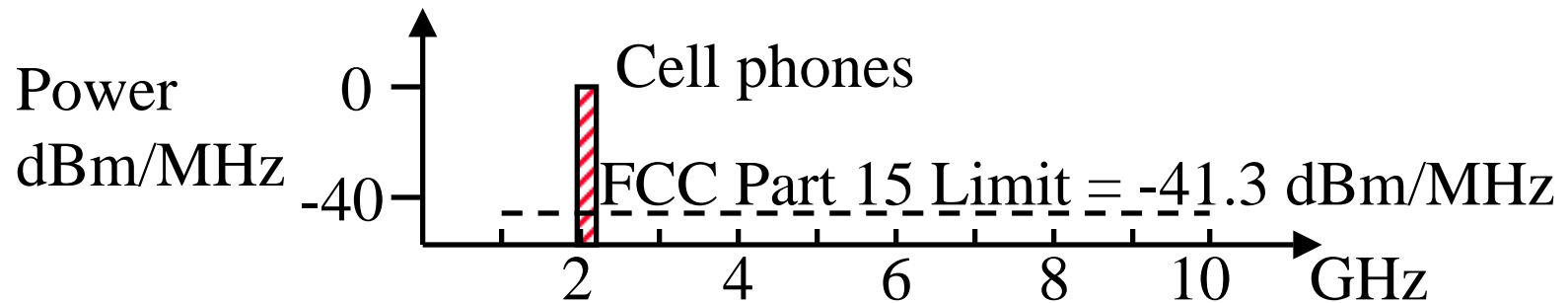
- ❑ Ultra-wideband
- ❑ Zigbee
- ❑ mm waves
- ❑ Other IEEE 802.15 WPAN activities
- ❑ Body area networks

Ultra-Wideband

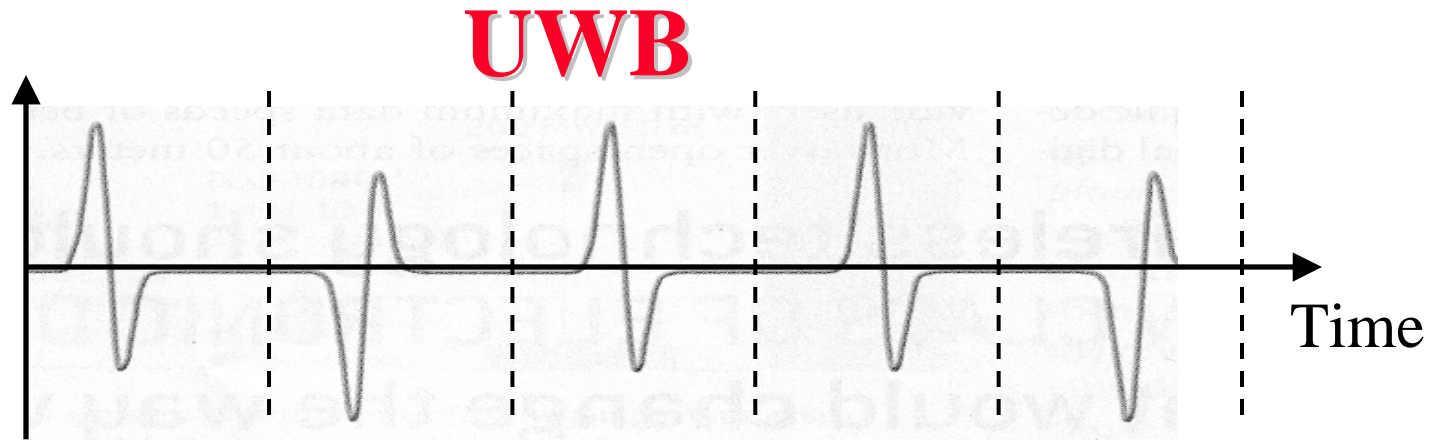


- An impulse in time domain results in a ultra wide spectrum in frequency domain and essentially looks like a white noise to other devices

Ultra-Wideband (UWB)



- ❑ FCC rules restrict the maximum noise generated by a wireless equipment (0 dBm = 1mW, -40 dBm = 0.1 μ 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



- ❑ 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

Advantages of UWB

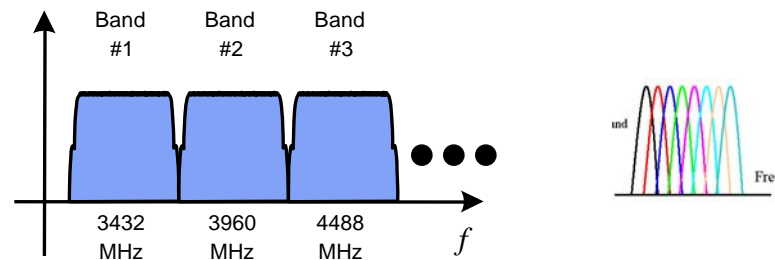
- ❑ Very low energy consumption: Good Watts/Mbps
- ❑ Line of sight not required. Passes through walls.
- ❑ Sub-centimeter resolution allows precise motion detection
- ❑ Pulse width much smaller than path delay
 - ⇒ Easy to resolve multipath
 - ⇒ Can use multipath to advantage
- ❑ Difficult to intercept (interfere)
- ❑ All digital logic ⇒ 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
- ❑ UWB Forum was formed but then disbanded in 2006.

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)

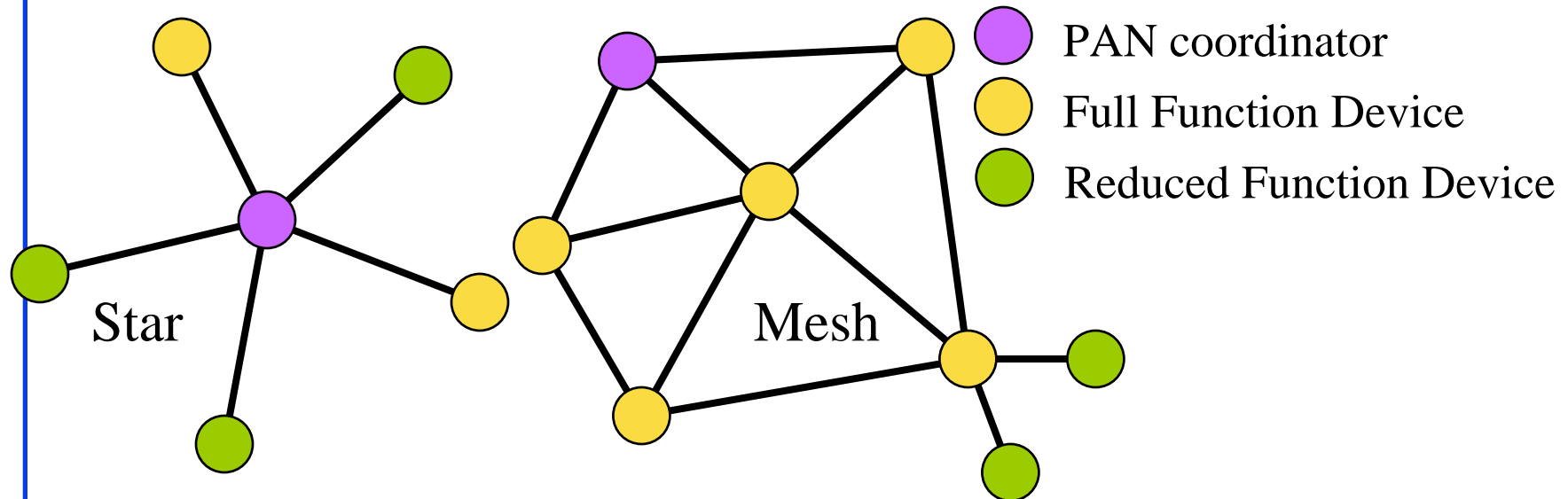


- ❑ Simple devices need to support 3 lowest bands
- ❑ Spectrum shaping flexibility for international use
Move off the band if interference
- ❑ Use OFDM with 128 subcarriers in a band:
Similar in nature to 802.11a/g
- ❑ Disable a few sub-carriers if required to meet local laws

ZigBee

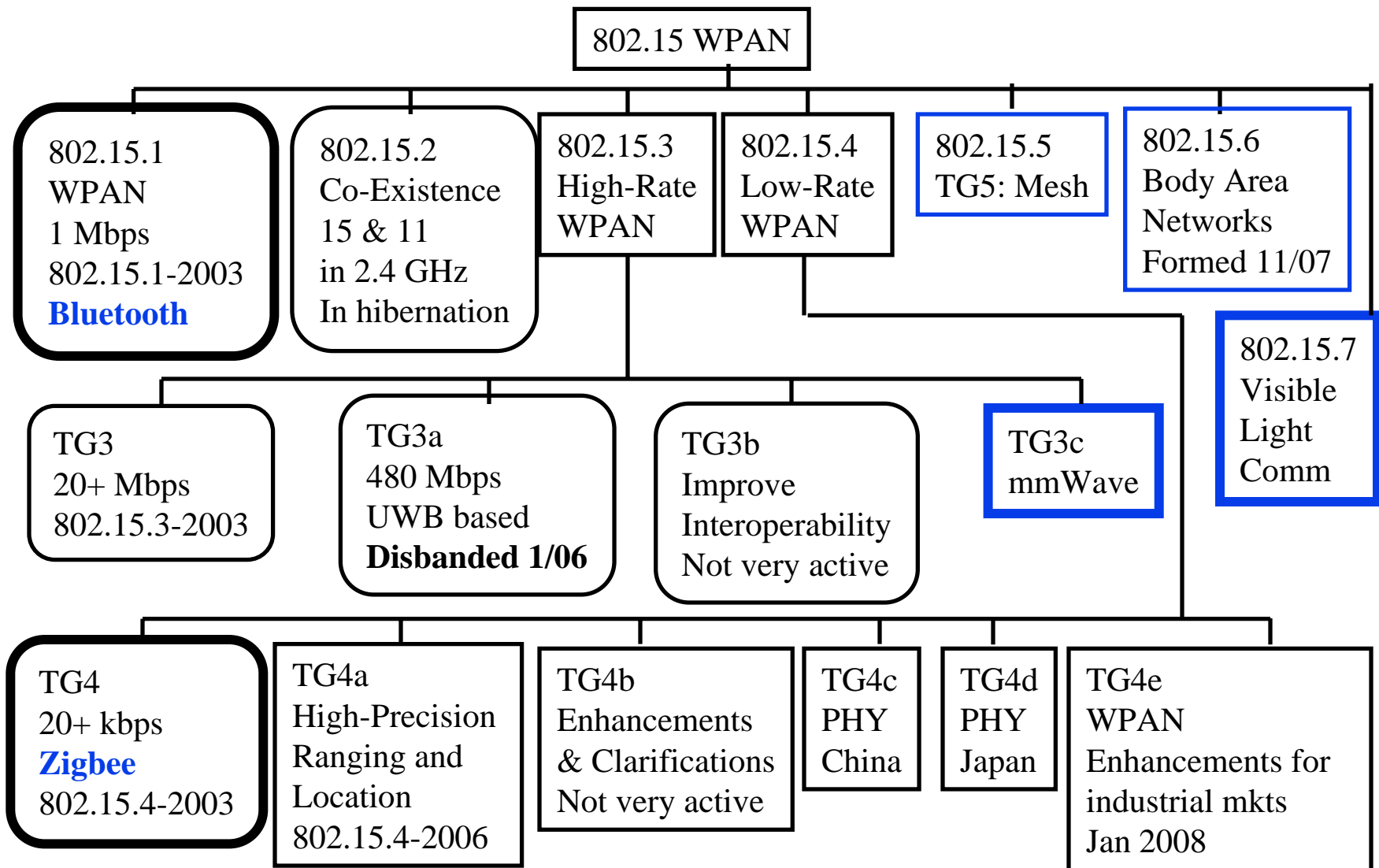
- ❑ Ultra-low power, low-data rate, industrial monitoring and control applications requiring small amounts of data, turned off most of the time (<1% duty cycle), e.g., wireless light switches, meter reading, patient monitoring
- ❑ Power management to ensure low power consumption.
- ❑ IEEE 802.15.4-2006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

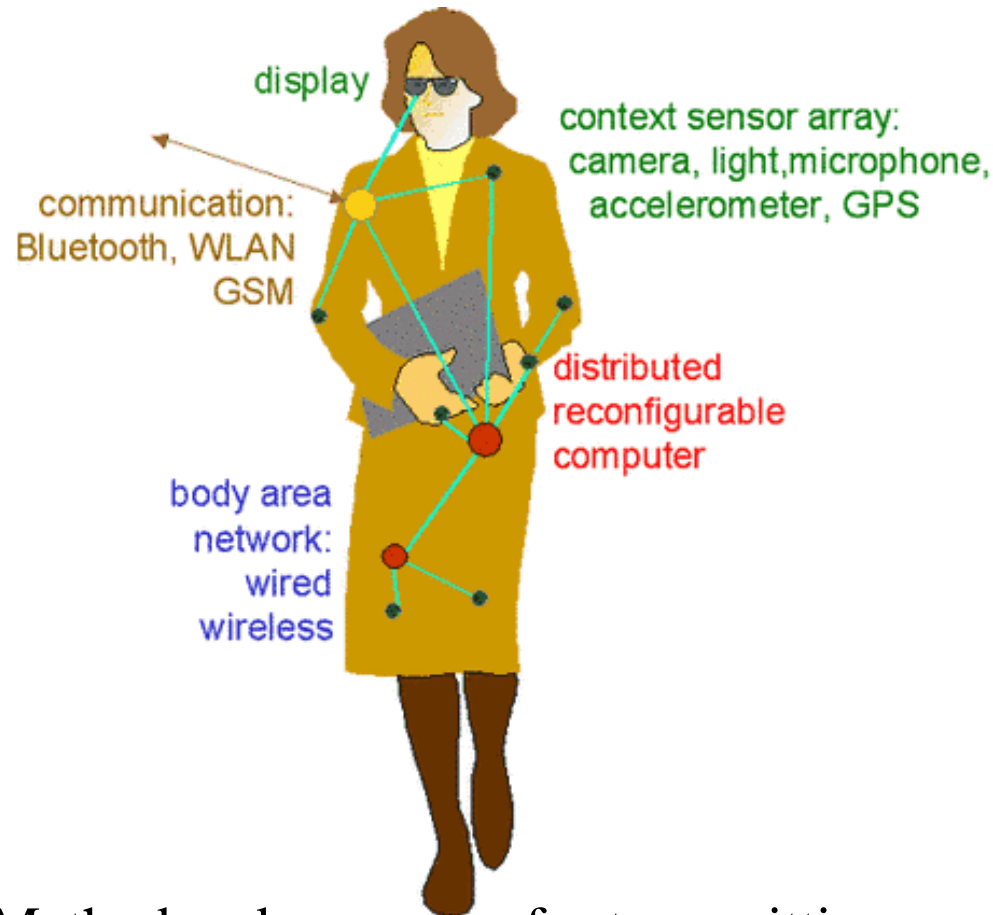
IEEE 802.15 WPAN Activities



Millimeter Wave WPANs

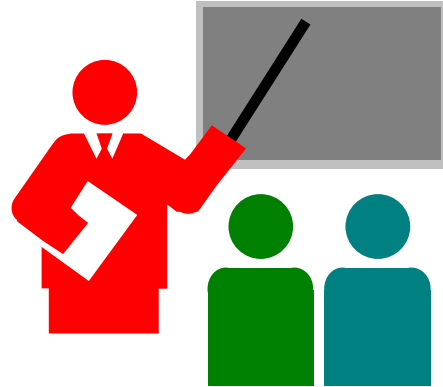
- ❑ IEEE802.15.3c
- ❑ Millimeter = Approx. 60 GHz and up
- ❑ 9.9 GHz allocated by FCC between 57 to 95 GHz
- ❑ Single carrier and OFDM based PHYs
- ❑ License based on interference protection on a link-by-link basis for outdoor use
- ❑ No license required for indoor use
- ❑ Can send multi-gbps over short distances
- ❑ Wireless Gigabit Ethernet.
- ❑ 1-2+ Gbps Less than 10m. Cable replacement, HDTV server,
- ❑ Published as IEEE 802.15.3c-2009

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 GHz. 1-2 Gbps at 10 m
- ❑ Body area networks allow low power communication around living body

Reading Assignment

- ❑ Supplementary reading list (Bluetooth, ZigBee, 802.11 and 802.11n,
<http://www.cse.wustl.edu/~jain/cse574-06/reading.htm>

References

- ❑ ZigBee Alliance Technical Documents,
<http://www.zigbee.org/Products/TechnicalDocumentsDownload/tabid/237/Default.aspx>
- ❑ ZigBee Alliance Whitepapers,
<http://www.zigbee.org/LearnMore/WhitePapers/tabid/257/Default.aspx>

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.

Related Wikipedia Pages

- ❑ <http://en.wikipedia.org/wiki/6LoWPAN>
- ❑ http://en.wikipedia.org/wiki/Body_Area_Network
- ❑ <http://en.wikipedia.org/wiki/C-UWB>
- ❑ http://en.wikipedia.org/wiki/Comparison_of_802.15.4_radio_modules
- ❑ http://en.wikipedia.org/wiki/Detect_and_Avoid
- ❑ http://en.wikipedia.org/wiki/Electromagnetic_interference
- ❑ http://en.wikipedia.org/wiki/Extremely_high_frequency
- ❑ http://en.wikipedia.org/wiki/IEEE_802.15
- ❑ http://en.wikipedia.org/wiki/IEEE_802.15#3c_.28WPAN_Millimeter_Wave_Alternative_PHY.29
- ❑ http://en.wikipedia.org/wiki/IEEE_802.15.4-2006
- ❑ http://en.wikipedia.org/wiki/IEEE_802.15.4a

Related Wikipedia Pages (Cont)

- ❑ http://en.wikipedia.org/wiki/Orthogonal_frequency-division_multiplexing
- ❑ http://en.wikipedia.org/wiki/Title_47_CFR_Part_15
- ❑ <http://en.wikipedia.org/wiki/UWB>
- ❑ http://en.wikipedia.org/wiki/UWB_Forum
- ❑ <http://en.wikipedia.org/wiki/Ultra-wideband>
- ❑ http://en.wikipedia.org/wiki/WiMedia_Alliance
- ❑ <http://en.wikipedia.org/wiki/WirelessHD>
- ❑ http://en.wikipedia.org/wiki/Wireless_USB
- ❑ http://en.wikipedia.org/wiki/Wireless_USB_specification
- ❑ <http://en.wikipedia.org/wiki/ZigBee>
- ❑ http://en.wikipedia.org/wiki/ZigBee_specification

List of Acronyms

- ❑ BANs Body Area Networks
- ❑ CDMA Code Division Multiple Access
- ❑ CSMA Carrier Sense Multiple Access
- ❑ DS Direct sequence
- ❑ GHz Giga Hertz
- ❑ HDTV High-Definition Television
- ❑ MB-OFDM Multi-Band Orthogonal Frequency Division Multiplexing
- ❑ MHz Mega Hertz
- ❑ OFDM Orthogonal Frequency Division Multiplexing
- ❑ UWB Ultra Wideband