

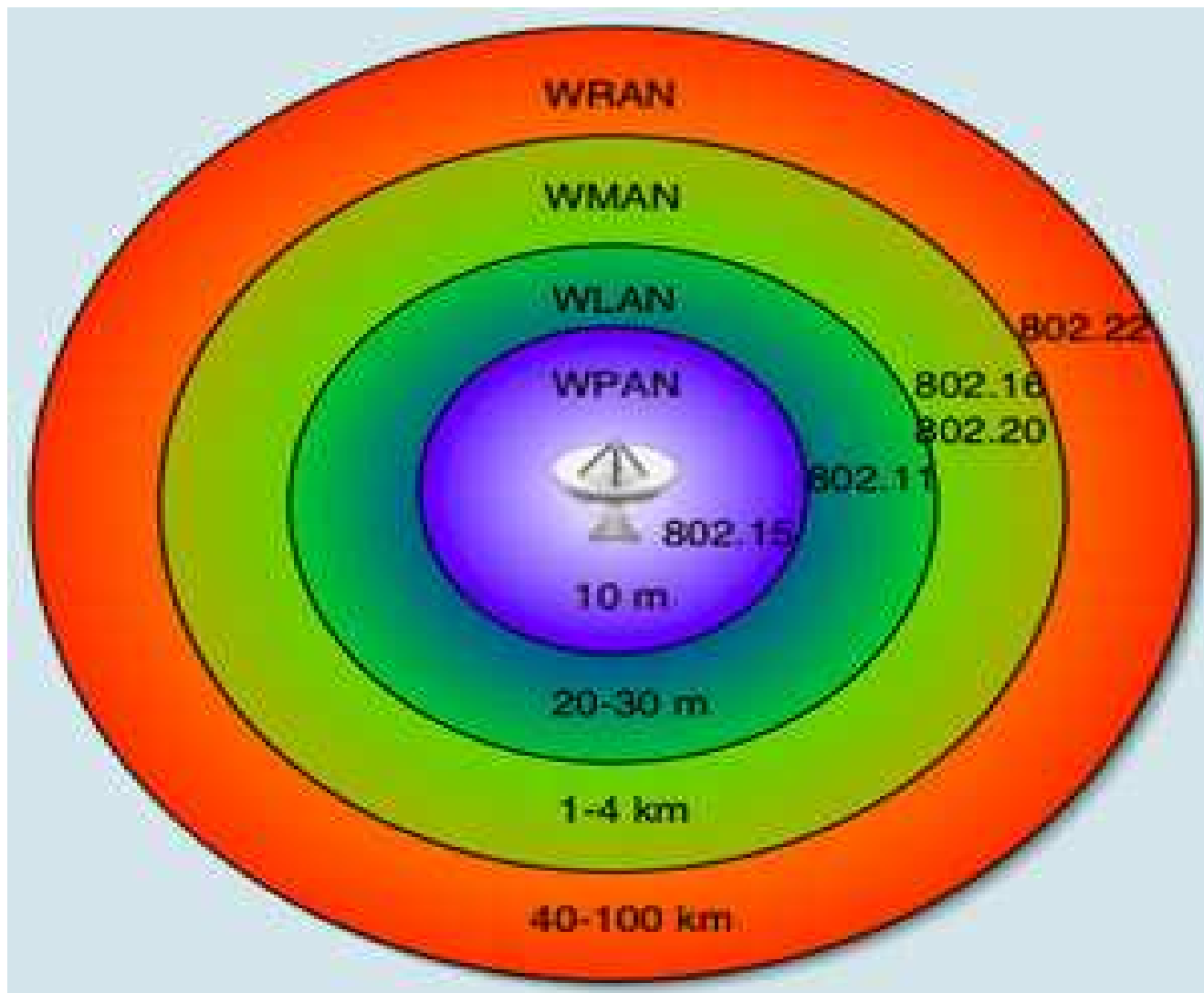
Wireless Data communication standards

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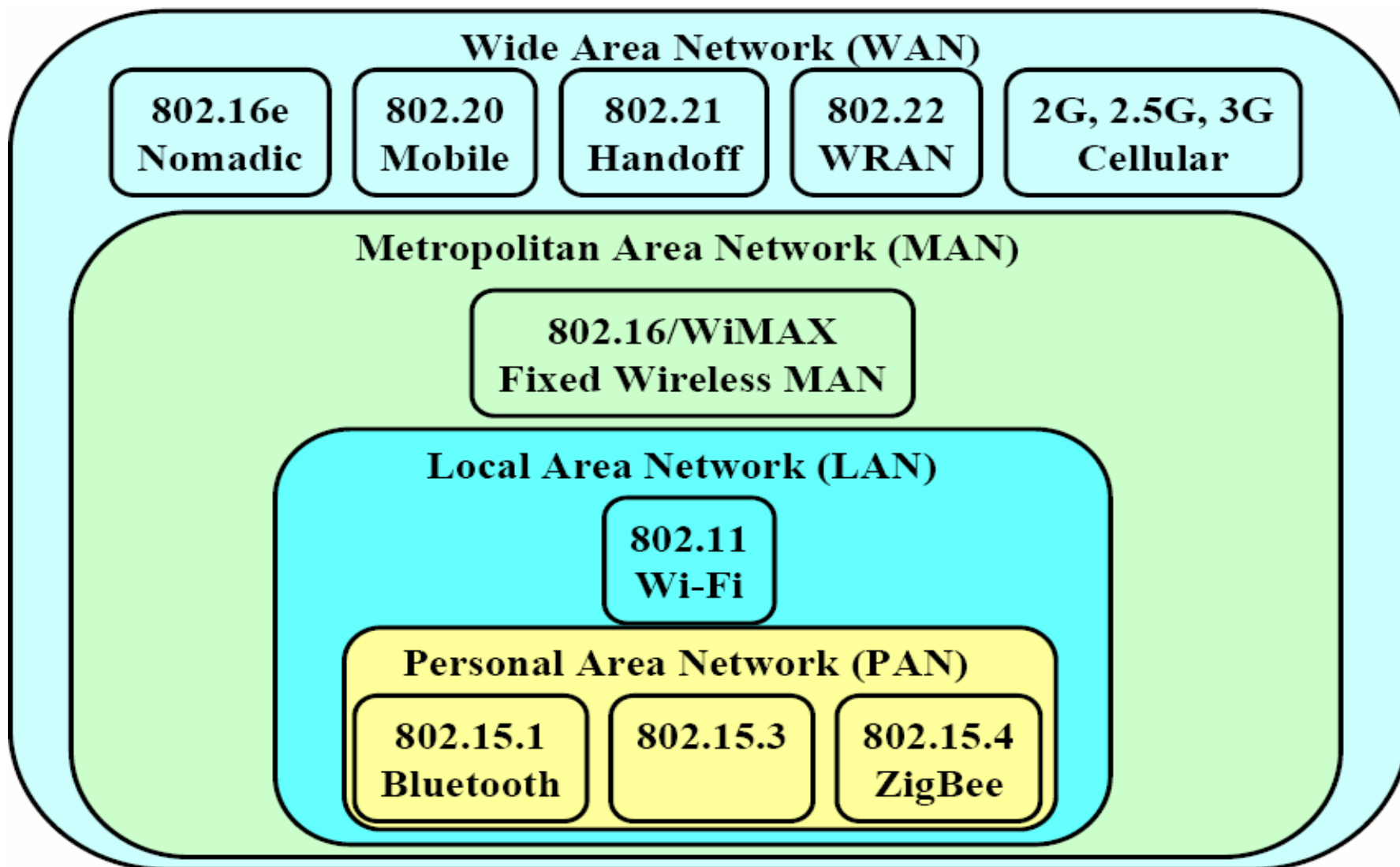
Overview

- Wireless Personnel Area Networks (WPAN)
 - Zigbee
 - Bluetooth
 - UWB
 - IrDA
 - Wireless USB
- Wireless Local Area Networks (WLAN)
 - Wi-Fi
 - HIPERLAN
- Wireless Metropolitan Area Networks (WMAN)
 - WiMax

Wireless Standards



Wireless Standards



Wireless Personnel Area Networks

- Intended for short range communications
- Main application areas include personnel computing, health care as well as industrial and home automation
- Most of the standards are defined in license free 2.4 GHz Band
- The range ranges from 10 meters to a maximum of 1 Km
- Ad-Hoc networking

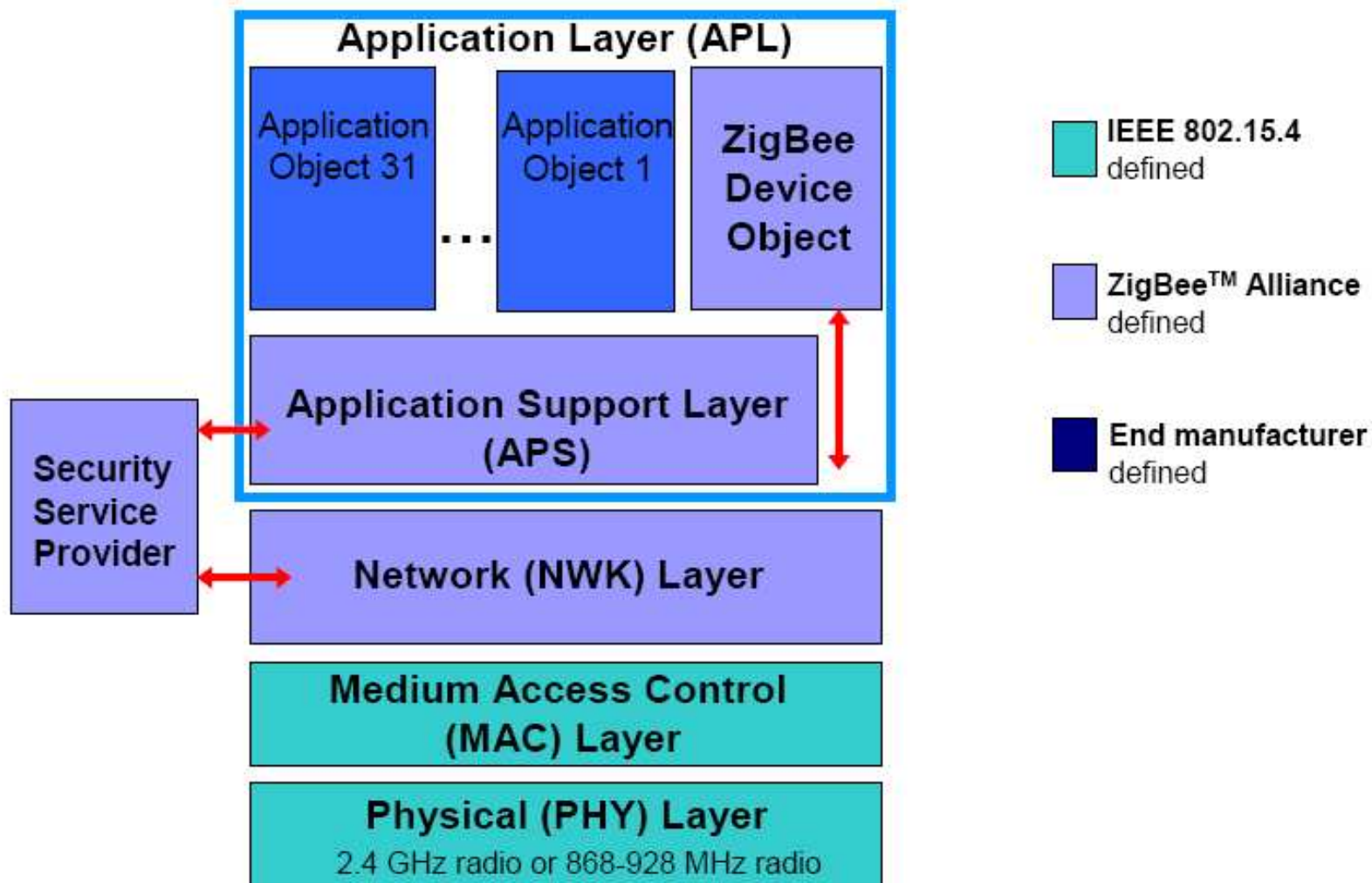
Zigbee

- Zigbee Feature Set
 - Ad-hoc self forming networks
 - Mesh and Cluster Tree
 - Logical device types
 - Coordinator, router and end device
 - Standard application services
 - Device and Service Discovery
 - Optional acknowledged service
 - Optional fragmentation/re-assembly service

Zigbee

- Zigbee Feature Set
 - Security
 - Symmetric Key with AES-128
 - Authentication and Encryption at Network and Application levels.
 - Distance limitations
 - The range can be extended from 10 meters to 1 kilometer
 - Low Power
 - The node can operate for a maximum period of one year with two AA cells and varies with applications.

Zigbee

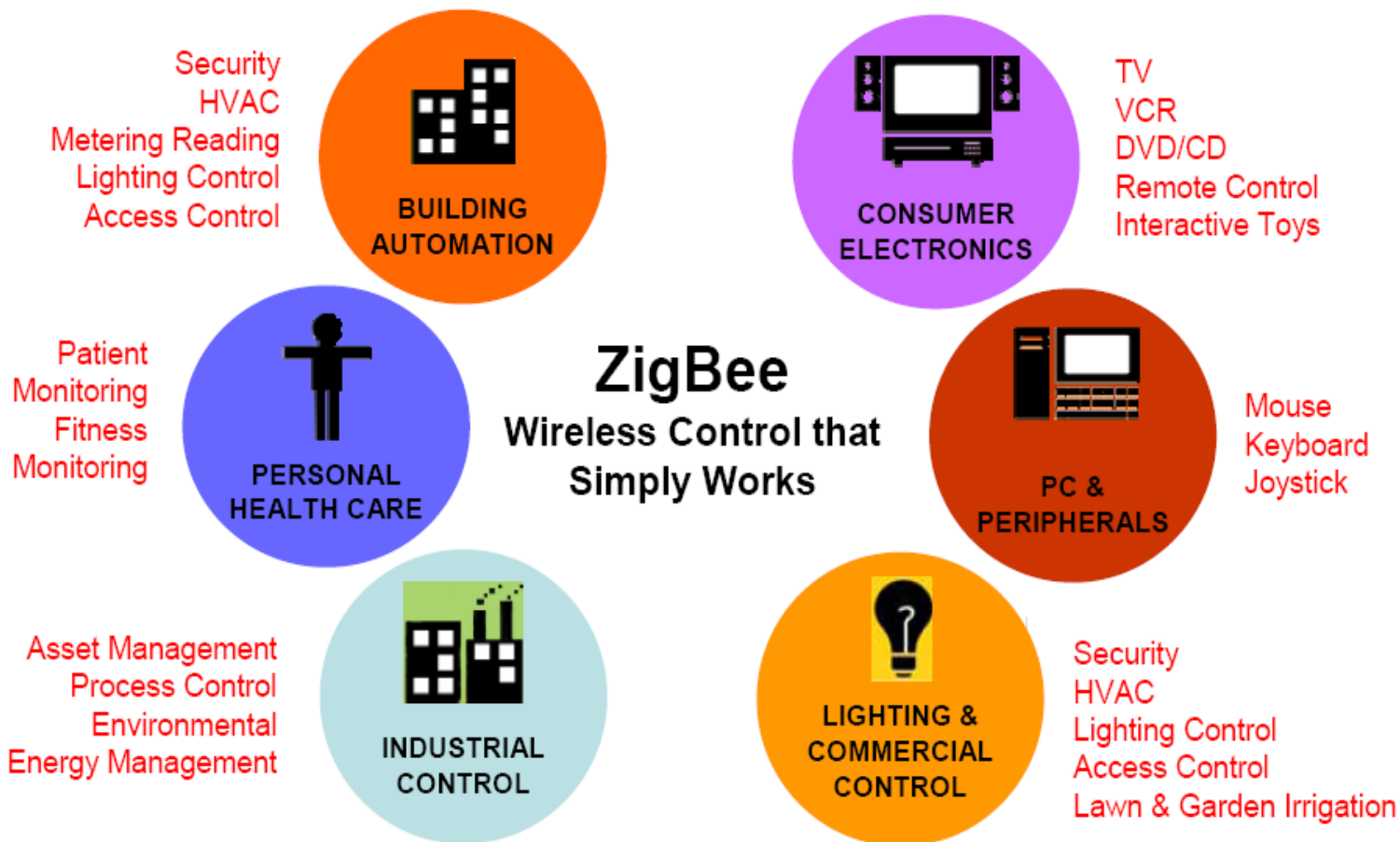


Zigbee

- IEEE 802.15.4 physical layer
 - Channel access is via CSMA with collision avoidance
 - At 2.4 GHz frequency band 16 channels are possible
 - Message acknowledgement and an optional beacon structure
 - Uses DSSS coding with OQPSK modulation
- IEEE 802.15.4 MAC layer
 - Employs 64 bit IEEE & 16 bit short addresses
 - Three devices specified (RFD, FFD, coordinator)
 - Simple frame structure
 - Reliable data transfer
 - Supports association and disassociation
 - Supports 128 bit AES security
 - Employs CSMA-CA channel access for better coexistence

Zigbee

- Zigbee application areas

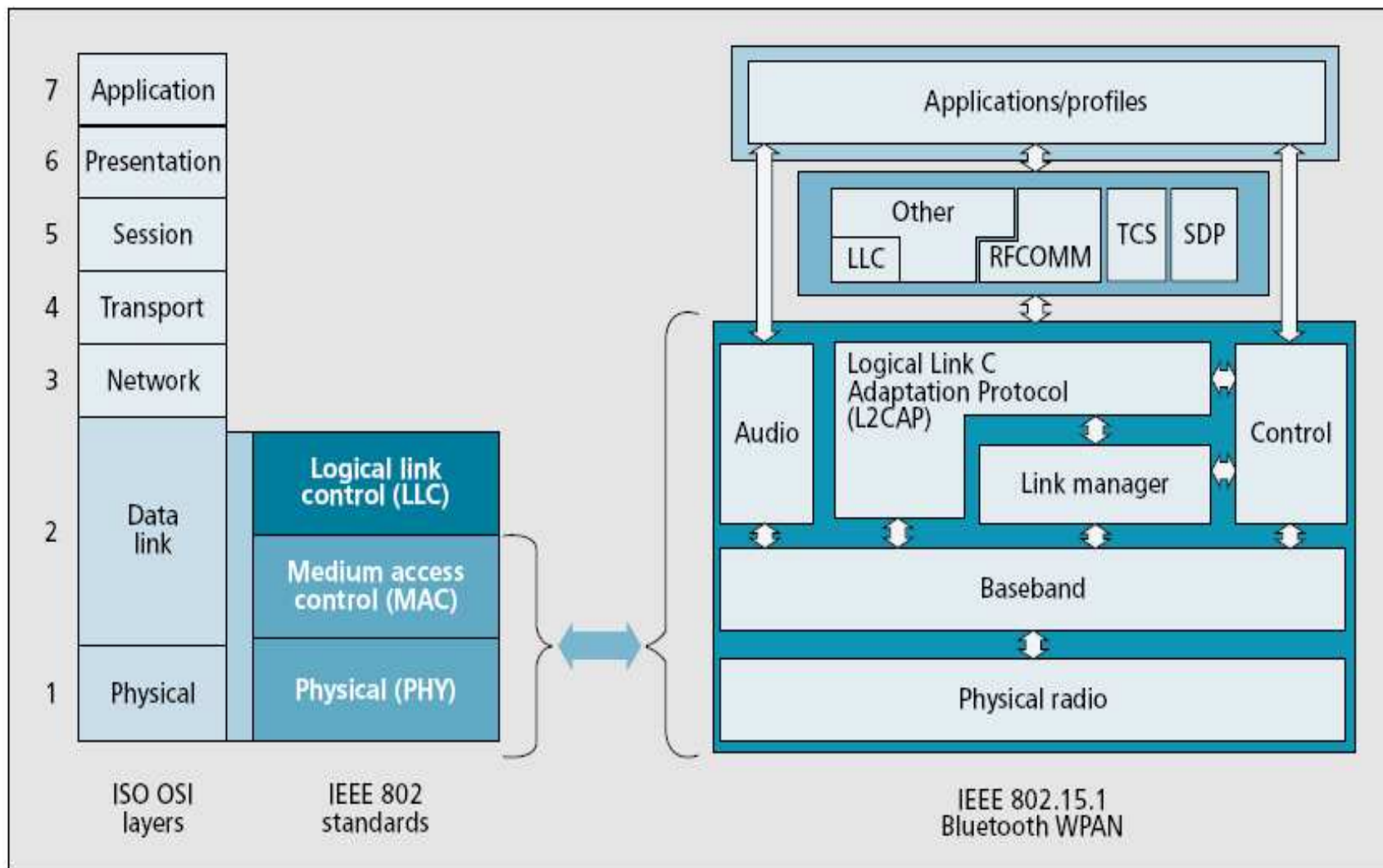


Bluetooth

- Bluetooth Features

- Operates in the unlicensed frequency spectrum at 2.4 GHz
- Data rates up to 1 Mbps
- Range up to 10 meters
- Security : challenge/response authentication –128 bit encryption
- Piconet is the simplest form of network connection
 - Up to 7 active slaves
 - Up to 255 parked slaves
- Piconets may be connected together to form scatternet

Bluetooth protocol stack

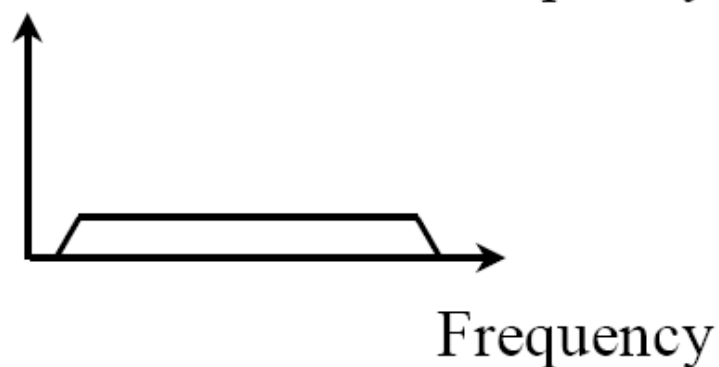
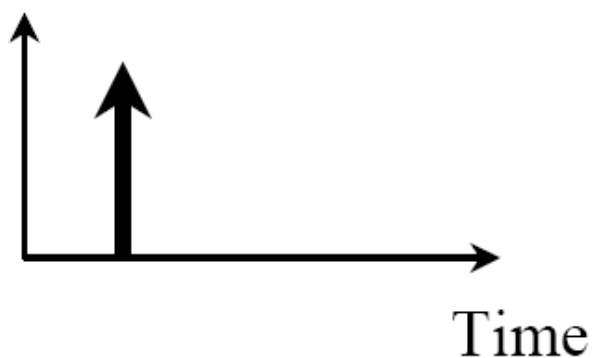
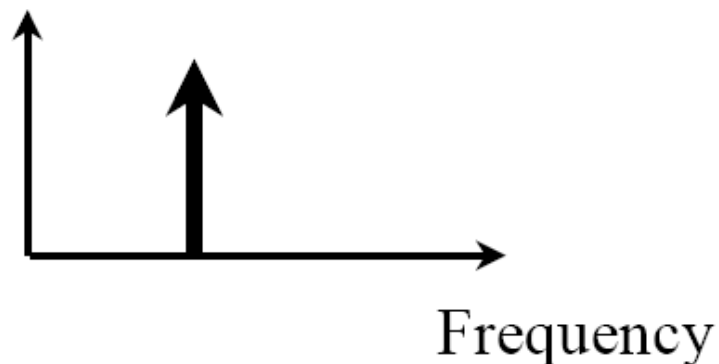
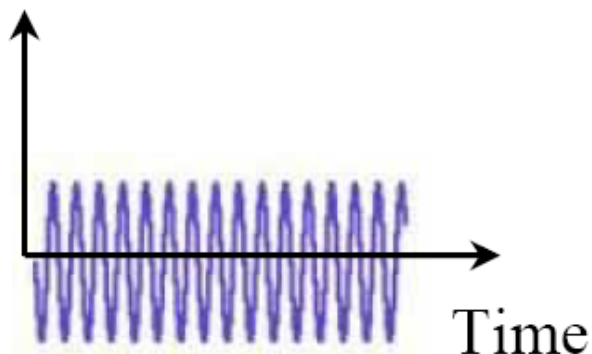


Bluetooth

- PHY uses FHSS signals with Gaussian shaped frequency shift keying (GFSK)
- Uses multi hop for communication between the devices that are not directly connected in a scatternet environment
- Two different types of links defined
 - Asynchronous connectionless links (ACL)
 - Synchronous connection oriented links (SCO)

Ultra Wide Band (UWB)

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



Advantages of UWB

- Very low energy consumption: Good Watts/Mbps
- Line of sight not required. Passes through walls.
- 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

Multi Band OFDM

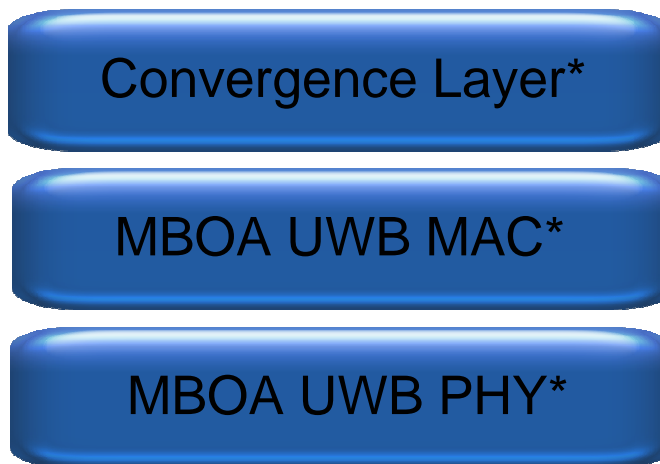
- Originally proposed by TI. Now many companies
- Divide the 3.1-10.6 GHz spectrum in 14x528 MHz bands (FCC requires min 500 MHz use for UWB)
- Simple devices need to support 3 lowest bands
- Spectrum shaping flexibility for international use
 - Move off the band if interference
- Use OFDM with 128 subcarriers in a band: Similar in nature to 802.11a/g
- Disable a few sub-carriers if required to meet local laws

UWB layered structure

Various technology solutions running over the common platform



Common Ultrawide Band Radio Platform



IrDA

- **IrDA Modes**

- Serial Infrared SIR: 9.6kbps to 115.2kbps
- Medium Infrared MIR: 576kbps to 1.152Mbps
- Fast Infrared FIR: 4Mbps

- **Range**

- 1 meter

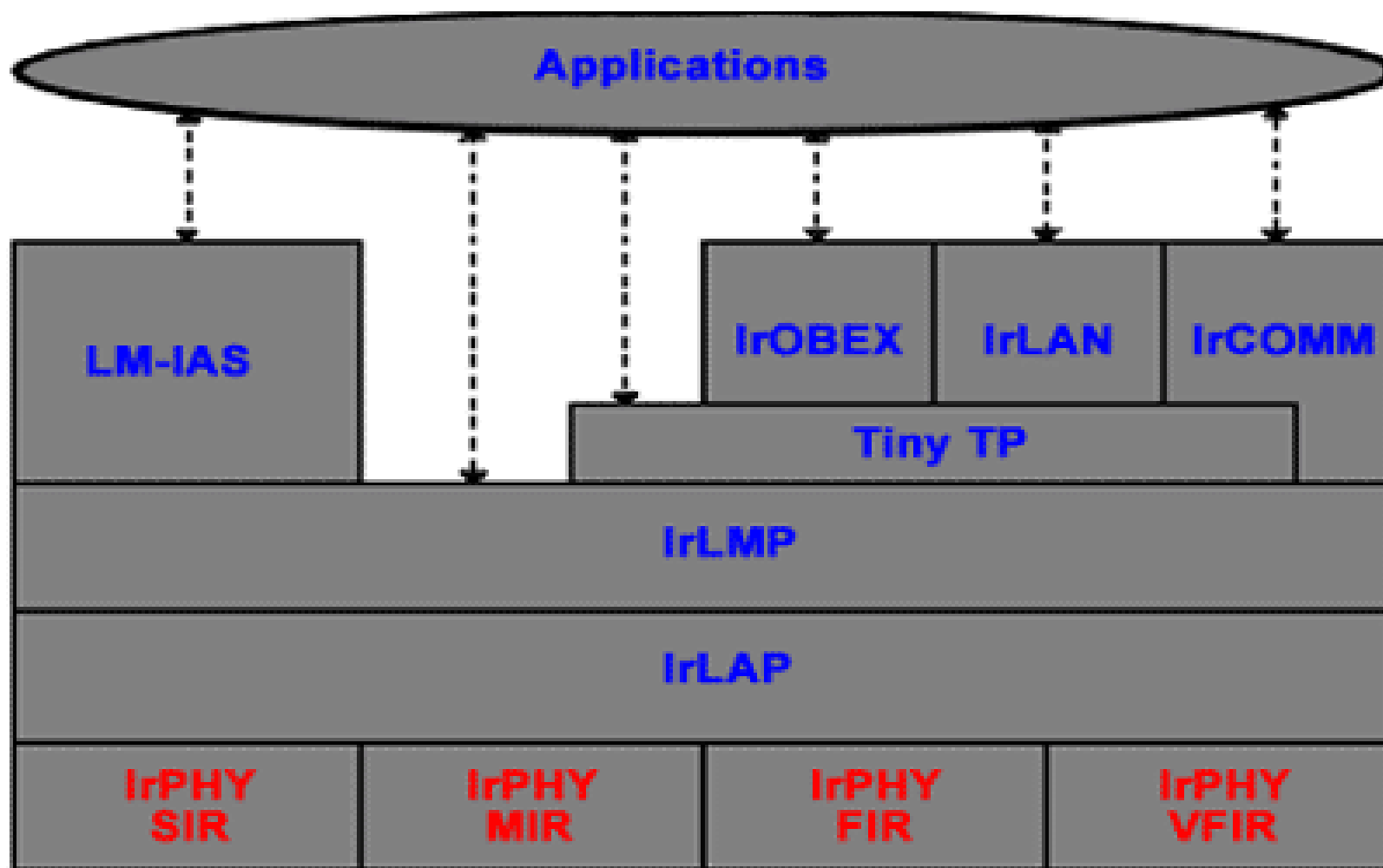
- **Advantages**

- Low cost
- Low power consumption
- Widely available (>50million units already installed on laptops, PDAs, mobile phones, printers and other peripherals)

- **Disadvantages**

- Requires line of sight & narrow angle
- Low Range
- IR transmission is unregulated with concern over eye safety with laser diodes and LEDs

IrDA layer stack



Layer Stack compared to OSI and Bluetooth

OSI Layer	IrDA	Bluetooth
7 – Application <i>(authentication, user services)</i>	Point and Shoot Profile (PnS)	<ul style="list-style-type: none"> ▪ File Transfer Profile (FTP) ▪ Generic Object Exchange Profile (GOEP)
6 – Presentation <i>(data format, encryption)</i>	Object Exchange Protocol (OBEX)	
5 – Session <i>(session management)</i>		
4 – Transport <i>(error recovery, flow control)</i>	<ul style="list-style-type: none"> ▪ Tiny TP ▪ Information Access Service (IAS) ▪ Link Management Protocol (IrLMP) ▪ Link Access Protocol (IrLAP) 	<ul style="list-style-type: none"> ▪ RFCOMM ▪ Service Discovery Protocol (SDP) ▪ Logical Link Control and Adaptation Protocol (L2CAP)
3 – Network <i>(switching, routing, addressing)</i>		
2 – Data Link <i>(encoding/decoding, media access control)</i>		
1 – Physical <i>(signal)</i>	Infrared Controller, Transceiver	Radio Hardware

Mandatory layers

- **Physical Layer**– Specifies optical characteristics, encoding of data, and framing for various speeds.
- **IrLAP**– Establishes the basic reliable connection.
- **IrLMP**– Multiplexes services and applications on the LAP connection.
- **IAS**– Provides a “yellow pages” of services on a device.

Optional Layers

- **Tiny TP**- Adds per-channel flow control.
- **IrCOMM**- Serial and Parallel Port emulation.
- **IrOBEX**- Easy transfer of files and other data object.
- **IrLAN**- enables IR LAN access for laptops and other devices

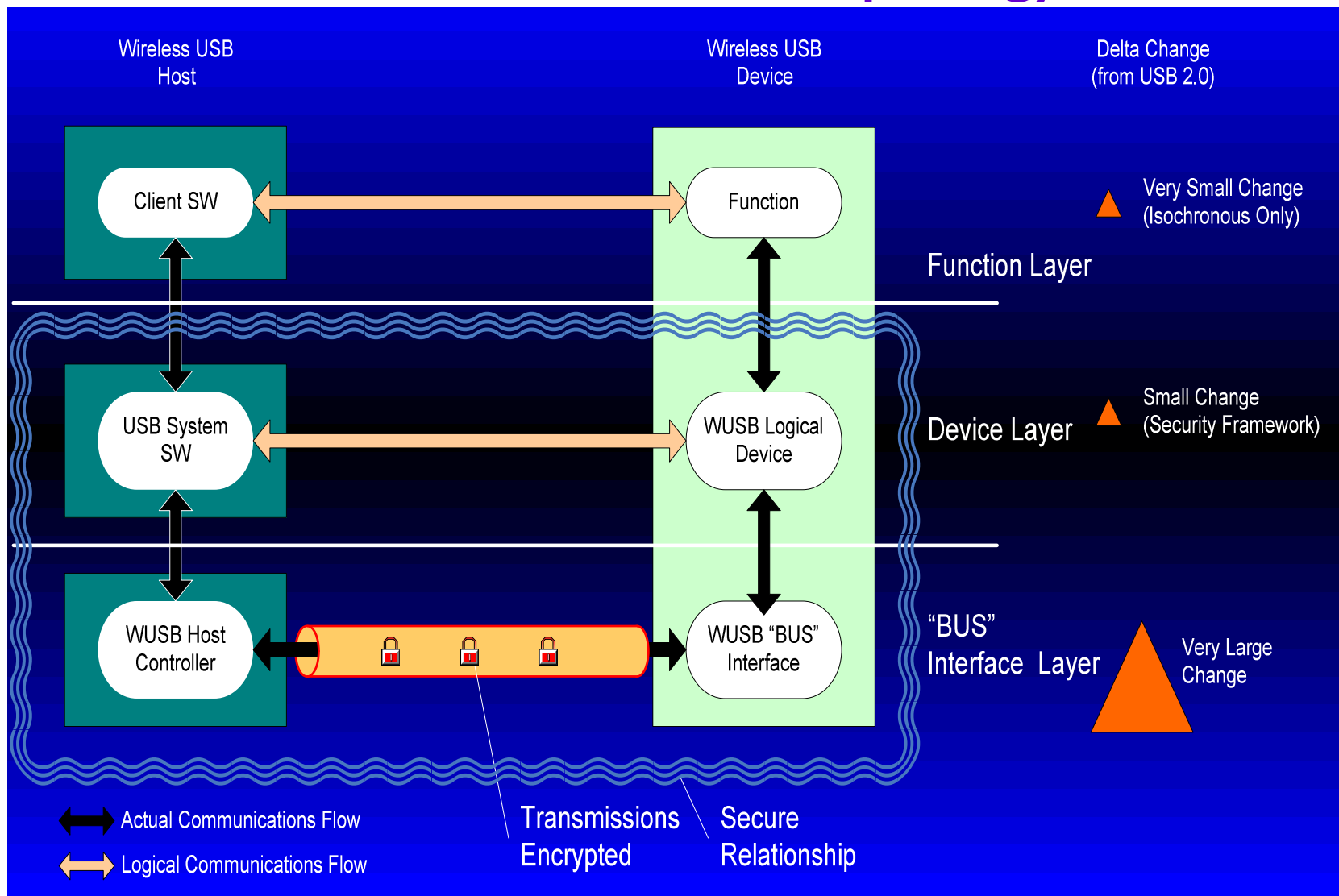
Wireless USB

- Similarities to wired USB
 - Host – device topology
 - Up to 127 devices per host
 - Class driver protocol maintained
 - Keep complexity in host to make devices cheap
- Bandwidth
 - 480 Mbps @ ~3M
 - 110 Mbps @ ~10M
 - Scalable architecture (up to 1 Gbps and beyond)

Wireless USB

- Power Management
 - Battery preservation very important
 - PHY: 130-160mW for Tx/Rx
- Security
 - SECURE device association and authentication
 - Low encryption overhead, minimal perf impact
- Ease of Use
 - Easy install and setup
 - Backwards Compatibility with wired USB software
 - Low “device end” cost model

Communication topology



WPANs compared

Characteristic	Zigbee	Bluetooth	UWB	IrDA	Wireless USB
Data rate	256 kbps	1 Mbps	Up to 600 Mbps	4 Mbps	480 Mbps @ 3m
Maximum Range	75 ft	30 ft	500 ft	5 ft	30 ft
Spectrum	2.4 GHz	2.4 GHz	3.1 – 10.6 GHz	Above 100 GHz	3.1- 10.6 GHz
Power	Ultra Low	Low	Low	Low	Low
Modulation	DSSS	FHSS	OFDM	Light emitting	OFDM
Security	128 bit AES	LFSR	128 bit AES	Line of sight	128 bit AES

Wireless Local Area Networks

- Almost all wireless LANs now are IEEE 802.11 based
- Competing technologies, e.g., HiperLAN can't compete on volume and cost
- 802.11 is also known as WiFi = “Wireless Fidelity”
- Fidelity = Compatibility between wireless equipment from different manufacturers
- WiFi Alliance is a non-profit organization that does the compatibility testing (WiFi.org)

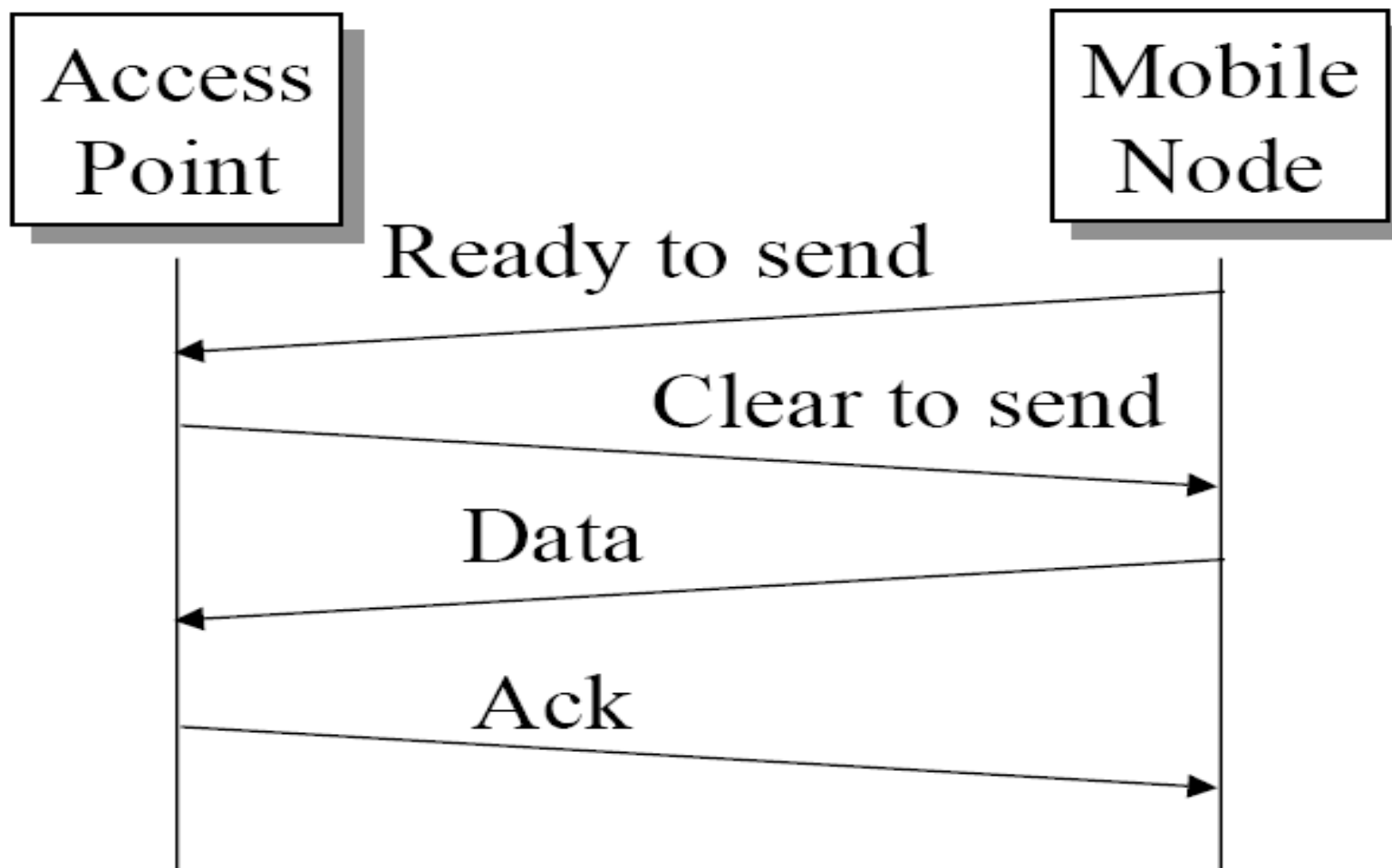
IEEE 802.11 Features

- Original 802.11 at 1 and 2 Mbps
- Supports both Ad-hoc and base-stations
- Spread Spectrum
- No licensing required.
- Three Phys: Direct Sequence, Frequency Hopping, 915-MHz, **2.4 GHz** (Worldwide ISM), 5.2 GHz, and Diffused Infrared (850-900 nm) bands.
- Supports multiple priorities
- Supports time-critical and data traffic
- Power management allows a node to doze off

Wireless-Fidelity (Wi-Fi)

- 802.11b is very popular
- Wireless Ethernet Compatibility Alliance (WECA) formed for certifying the compatible products for interoperability
- WECA is renamed to Wi-Fi (Wireless Fidelity)
- Wi-Fi certification is extended to 802.11g
- Wi-Fi5 for 802.11a

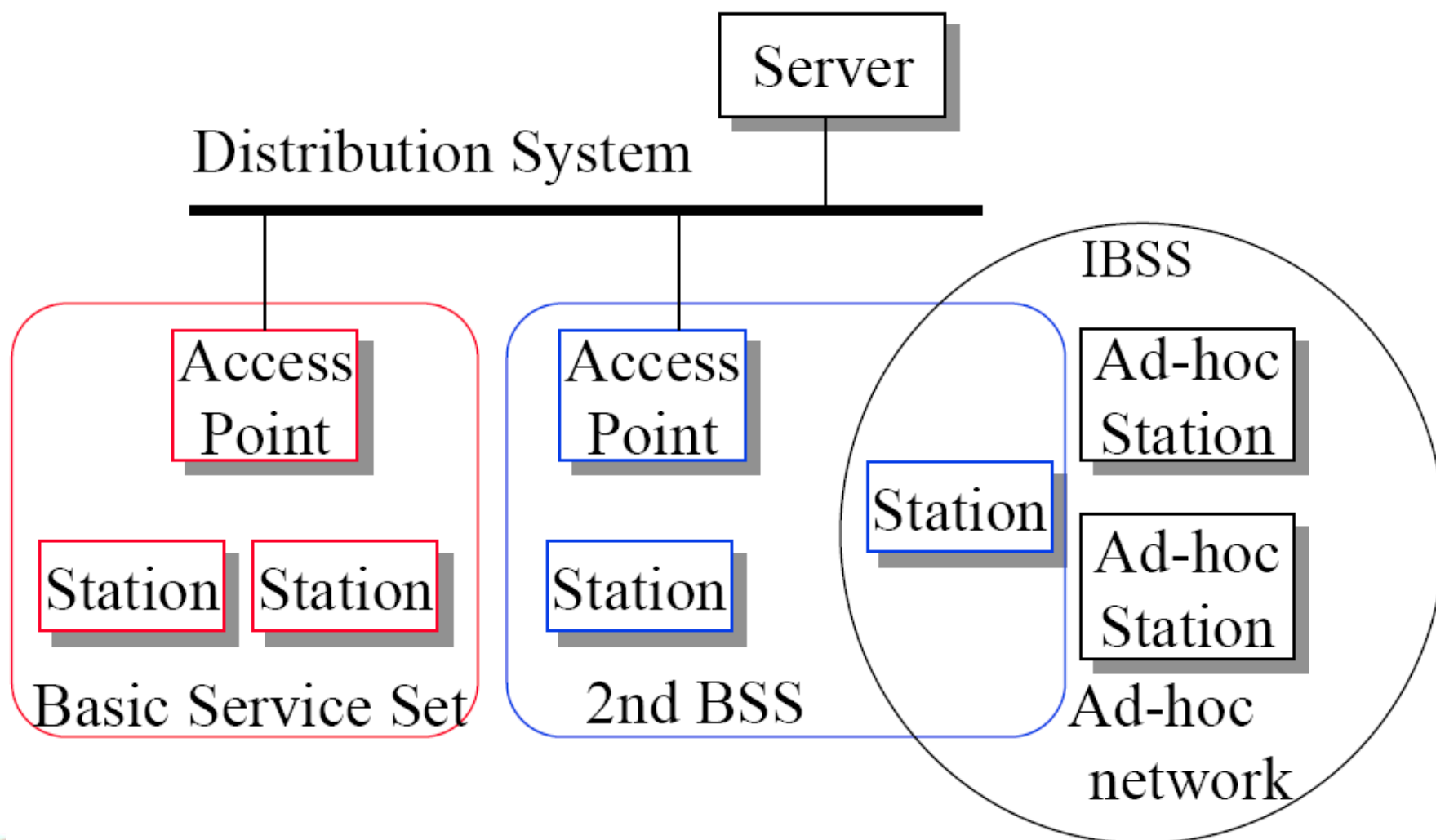
4-Way Handshake



IEEE 802.11 MAC

- Carrier Sense Multiple Access with collision Avoidance (CSMA/CA)
- Listen before you talk. If the medium is busy, the transmitter backs off for a random period.
- Avoids collision by sending a short message: Ready to send (RTS)
- RTS contains dest. address and duration of message. Tells everyone to backoff for the duration.
- Destination sends: Clear to send (CTS). Other stations set their network allocation vector (NAV) and do not transmit for that duration
- Can not detect collision Each packet is acked.
- MAC level retransmission if not acked.

IEEE 802.11 Architecture



IEEE 802.11 Architecture

- Basic Service Area (BSA) = Cell
- Each BSA may have several wireless LANs
- Distribution System (DS) - wired backbone
- Extended Service Area (ESA) = Multiple BSAs interconnected via Access Points (AP)
- Basic Service Set (BSS) = Set of stations associated with an AP
- Extended Service Set (ESS) = Set of stations in an ESA
- Independent Basic Service Set (IBSS): Set of computers in adhoc mode. May not be connected to wired backbone.
- Ad-hoc networks coexist and interoperate with infrastructure based networks

HIPERLAN

- Next generation, high-speed wireless LAN technology
- Standard is complete
 - Leading wireless LAN vendor Proxim is now delivering products based on it
- Offers the fastest route to market for a high-speed wireless LAN technology while minimizing the complexity of the radio technology

HIPERLAN

- Uses Gaussian Minimum Shift Keying (GMSK)
 - Well understood
 - Broadly used in GSM (Global System for Mobile Communications) cellular networks & CDPD
- Throughput up to 54 Mbps

LANs compared

Characteristic	802.11	802.11b	802.11a	HiperLAN2
Spectrum	2.4 GHz	2.4 GHz	5GHz	5 GHz
Maximum physical rate	2 Mbps	11 Mbps	54 Mbps	54 Mbps
Maximum data rate , Layer3	1.2 Mbps	5 Mbps	32 Mbps	32 Mbps
Medium Access control	CSMA/CA	CSMA/CA	CSMA/CA	Central resource control/TDMA/TDD
Multicast	yes	yes	yes	yes
Frequency selection	Frequency hopping or DSSS	DSSS	single carrier	Single carrier with dynamic frequency selection
Range	100 meters	100 meters	100 meters	150 meters
Encryption	40 bit RC4	40 bit RC4	40 bit RC4	DES, triple DES

IEEE 802.16

- Broadband Wireless Access
- Up to 50 km. Up to 70 Mbps.
- Data rate vs. Distance trade off using adaptive modulation.
- 64QAM to BPSK
- Offers non-line of site (NLOS) operation
- 1.5 to 20 MHz channels
- Hundreds of simultaneous sessions per channel
- Delivers >1 Mbps per user
- Both Licensed and license-exempt spectrum
- QoS for voice, video, and T1/E1, continuous and bursty traffic
- Support Point-to-multipoint and Mesh network models

IEEE 802.16 PHYs

	Function	LOS	Freq. Band	Carrier	Duplexing
WirelessMAN SC	Pt-to-pt	LOS	10-66 GHz	Single	TDD, FDD
WirelessMAN SCa	Pt-to-pt	LOS	2-11 GHz Licensed	Single	TDD, FDD
WirelessMAN OFDM	Pt-to-mpt	NLOS	2-11 GHz Licensed	256	TDD, FDD
WirelessMAN OFDMA (16e)	Pt-to-mpt	NLOS	2-11 GHz Licensed	2048	TDD, FDD
WirelessHUMAN (High-speed Unlicensed)	Pt-to-mpt	NLOS	2-11 GHz License Exempt	1/256/2048	TDD Dynamic Freq. Sel.

IEEE 802.11 Vs 802.16

	802.11	802.16
Application	In-Building, Enterprise	Service providers => Carrier Class
Range	Optimized for 100m	Optimized for 7-10 km Up to 50 km
Range Spread	No near-far compensation	Handles users spread out over several kms
# Users	10's of users	Thousands of users
Coverage	Optimized for indoor	Optimized for outdoor. Adaptive modulation. Advanced Antenna
Bands	License exempt	License and license exempt bands Allows Cell Planning
Channels	Fixed 20 MHz Channel	1.5 MHz to 20 MHz Channels Size chosen by operator
Spectral Efficiency	2.7 bps/Hz => 54 Mbps in 20 MHz	3.8 bps/Hz => 75 Mbps in 20 MHz 5 bps/Hz => 100 Mbps in 20 MHz
Delay Spread	Designed to handle indoor multipath Delay spread of 0.8 \ms	Designed for longer multipaths. Multipath delay spread of 10\ms.
Duplexing	TDD only - Asymmetric	TDD/FDD/HFDD - Symmetric or asymmetric
MAC	Contention based. Distributed control.	Grant based. Centralized control.
QoS	No delay or throughput guarantees	Guarantees QoS
User Differentiation	All users receive same service	Different users can have different levels of service. T1 for businesses. Best effort for residential.
Security	WEP, WPA, WPA2	128-bit 3DES and 1024-bit RSA

Conclusion

- WPAN are meant for building systems that work around you and suitable for designing WSN.
- WLAN are replacement for wired LAN systems
- WMAN are meant for replacing broad band systems

Thank You