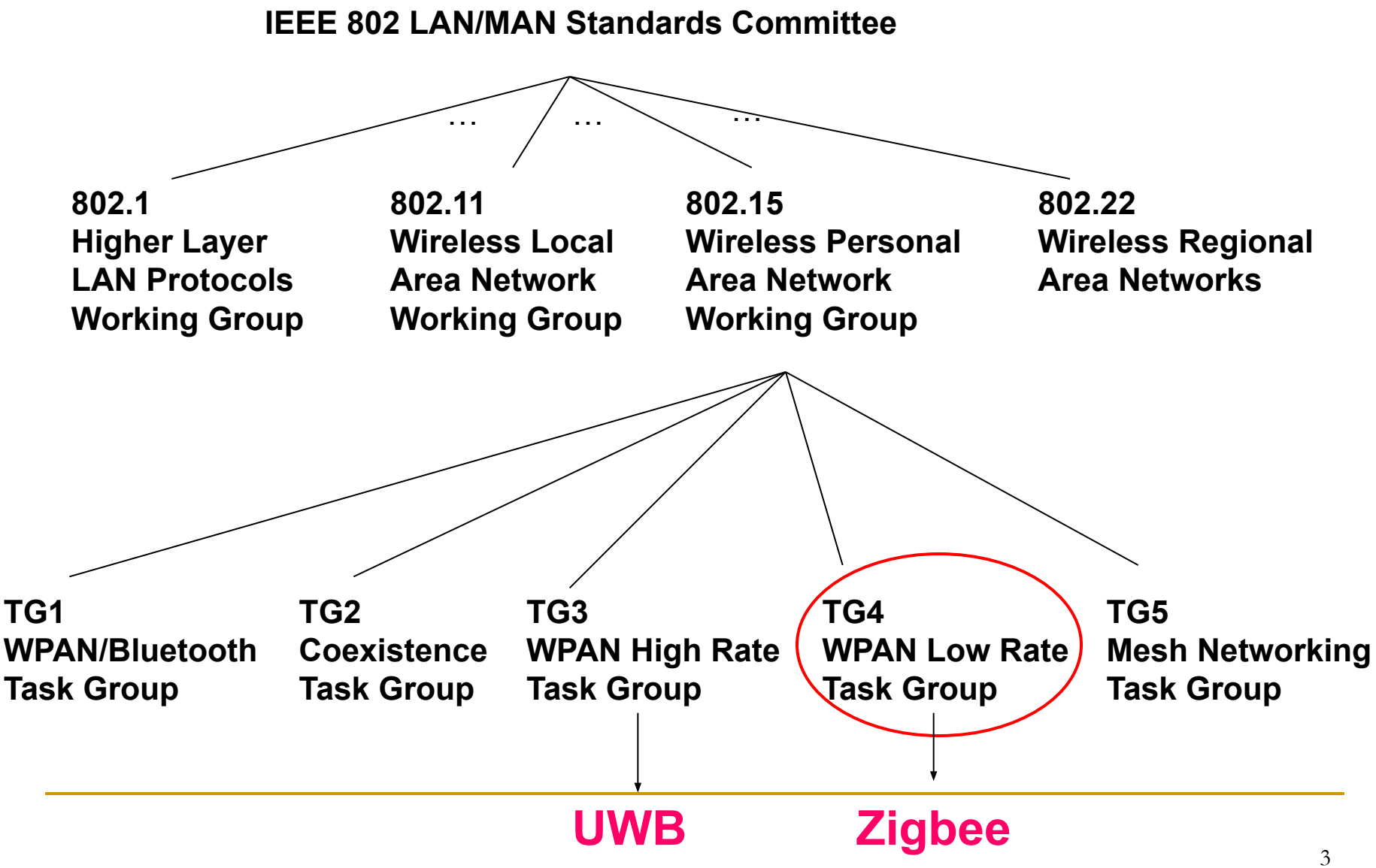
LR-WPAN
(ZigBee and IEEE 802.15.4)

New Trend of Wireless Technology

- Most Wireless industry focus on increasing high data throughput
  - 802.11b □ 802.11a/g
- A set of applications requiring simple wireless connectivity, relaxed throughput, very low power, short distance and inexpensiveness
  - Industrial
  - Agricultural
  - Vehicular
  - Residential
  - Medical

IEEE 802.15 Working Group



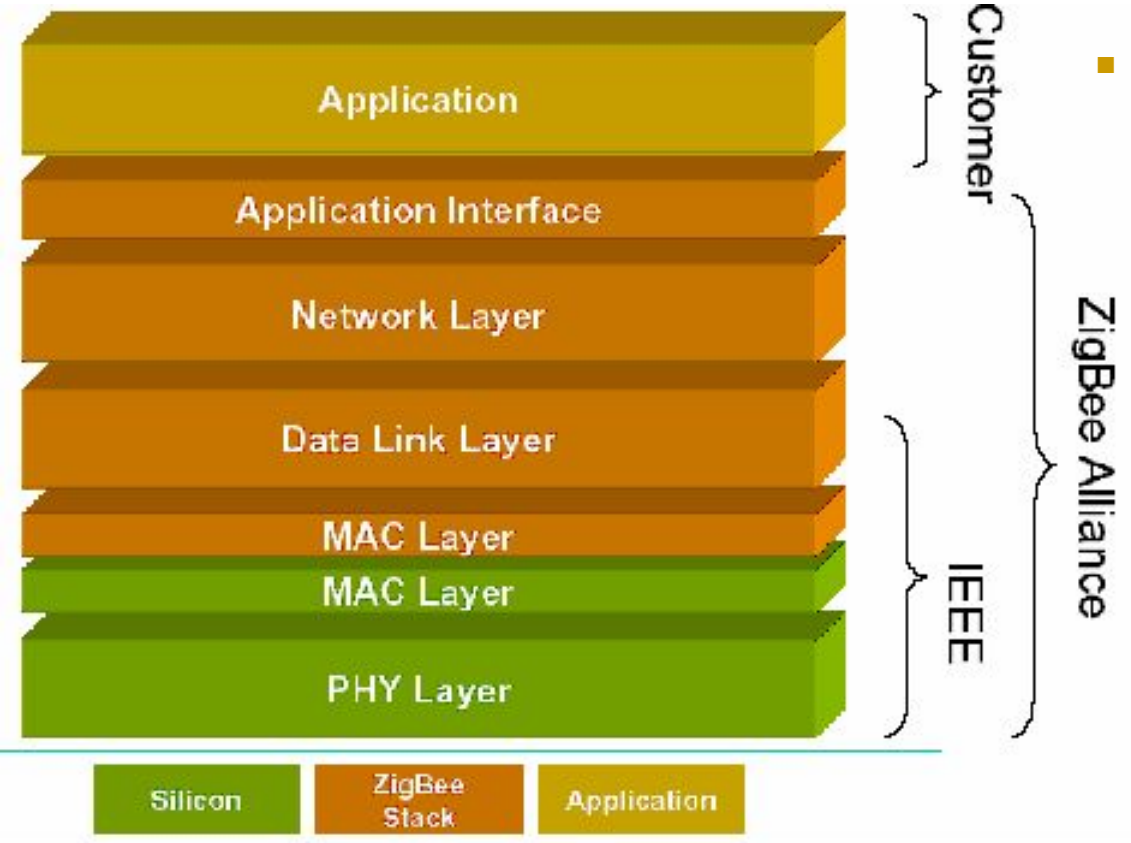
Comparison Between WPAN

Project	Data Rate	Range	Configuration	Other Features
802.15.1 (Bluetooth)	721 kbps	1 M (class3) 100 M (class1)	8 active device Piconet/ Scatternet	Authentication, Encryption, Voice
802.15.3 High Rate	22, 33, 44, 55 Mbps	10 M	peer-to-peer	FCC part 15.249 QoS, Fast Join, Multi-media
802.15.4 Low Rate	Up to 250 kbps	10 M nominal 1~100 M (based on settings)	Star peer-to-peer	Battery life: multi-month to multi-year

What is ZigBee Alliance?

- An organization with a mission to define reliable, cost effective, low-power, wirelessly networked, monitoring and control products based on an open global standard
- The alliance provides interoperability, certification testing, and branding
- 45+ companies: semiconductor mfrs, IP providers, OEMs, etc.
- Defining upper layers of protocol stack: from network to application, including application profiles
- First profiles published mid 2003

Zigbee/IEEE 802.15.4 Protocol Stack

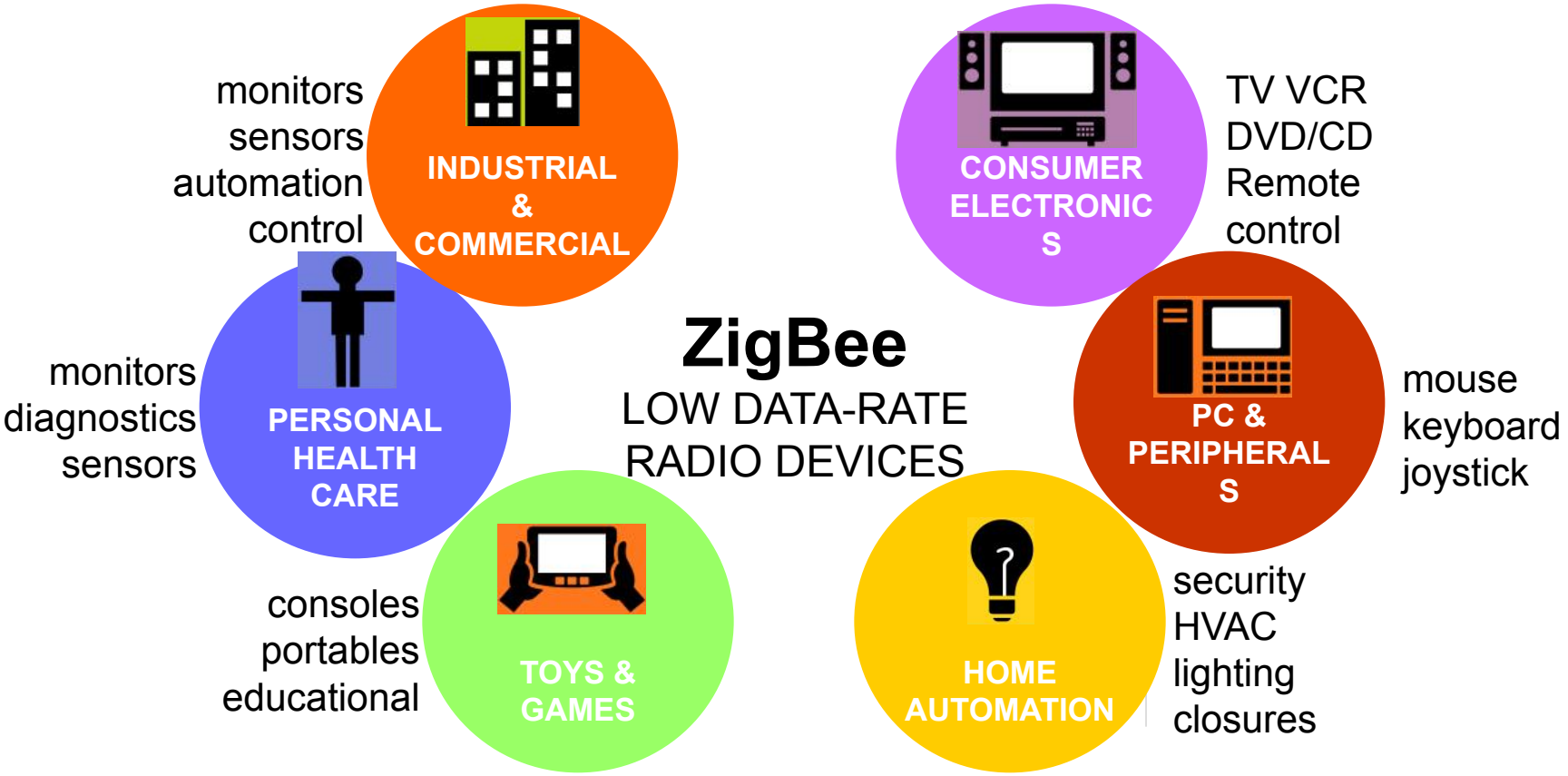


- Divided Responsibility
  - Lower (MAC/PHY) stacks IEEE 802.15.4
  - Upper stacks Zigbee Alliance
  - IEEE 802 compatible LLC protocol can be used

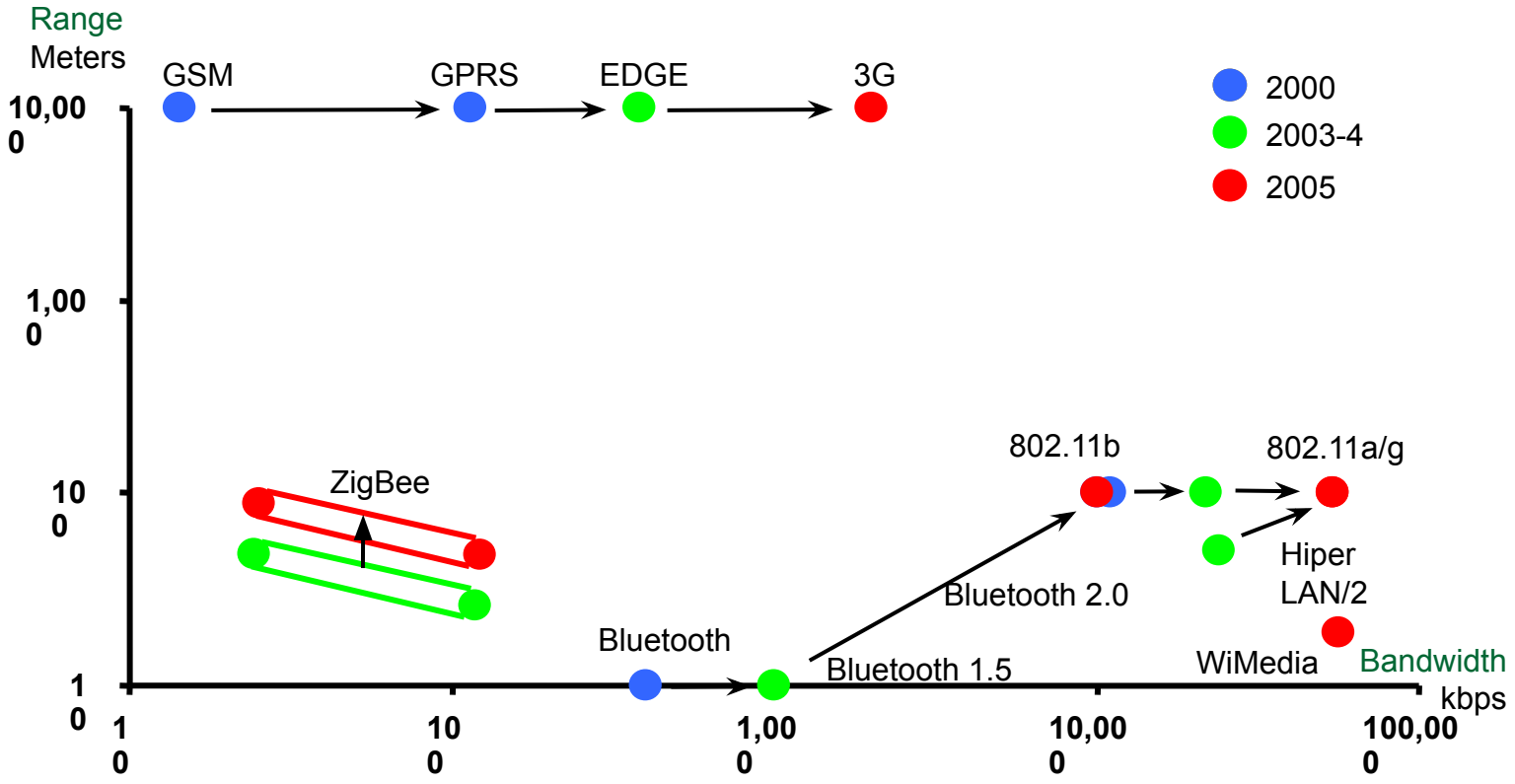
ZigBee/IEEE 802.15.4 Market Feature

- Low power consumption
- Low cost
- Low offered message throughput
- Supports large network orders (<= 65k nodes)
- Low to no QoS guarantees
- Flexible protocol design suitable for many applications

ZigBee Network Applications



Wireless Technologies



How is ZigBee related to IEEE 802.15.4?

- ZigBee takes full advantage of a powerful physical radio specified by IEEE 802.15.4
- ZigBee adds logical network, security and application software
- ZigBee continues to work closely with the IEEE to ensure an integrated and complete solution for the market

802.15.4 Technology: General Characteristics

- Data rates of 250 kbps, 40 kbps, and 20 kbps
- Star or peer-to-peer operation
- Allocated 16 bit short or 64 bit extended addresses
- Allocation of guaranteed time slots (GTSs)
- CSMA-CA channel access
- Fully acknowledged protocol for transfer reliability
- Low power consumption
- Energy detection (ED)
- Link quality indication (LQI)
- 16 channels in the 2450 MHz band, 10 channels in the 915 MHz band, and 1 channel in the 868 MHz band (European)
- Extremely low duty-cycle (<0.1%)

IEEE 802.15.4 Basics

- 802.15.4 is a simple packet data protocol for lightweight wireless networks
  - Channel Access is via Carrier Sense Multiple Access with collision avoidance and optional time slotting
  - Message acknowledgement and an optional beacon structure
  - Multi-level security
  - Works well for
    - Long battery life, selectable latency for controllers, sensors, remote monitoring and portable electronics
  - Configured for maximum battery life, has the potential to last as long as the shelf life of most batteries

IEEE 802.15.4 Device Types

- There are two different device types :
  - A full function device (FFD)
  - A reduced function device (RFD)
- The FFD can operate in three modes serving
  - Device
  - Coordinator (PAN coordinator)
- The RFD can only operate in a mode serving:
  - Device

IEEE 802.15.4 Physical Layer

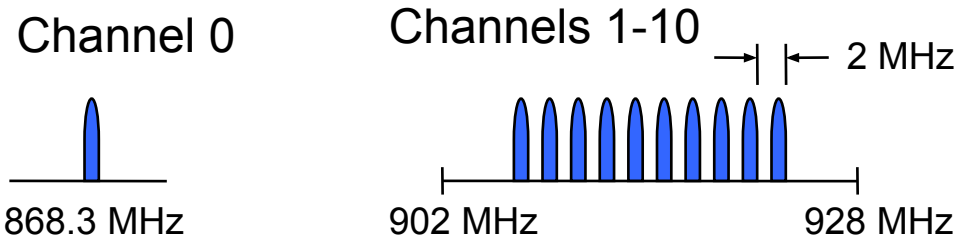
IEEE 802.15.4 PHY Overview

- PHY functionalities:
  - Activation and deactivation of the radio transceiver
  - Energy detection within the current channel
  - Link quality indication for received packets
  - Clear channel assessment for CSMA-CA
  - Channel frequency selection
  - Data transmission and reception
- PHY provides 2 services
  - PHY data service
  - PHY management service

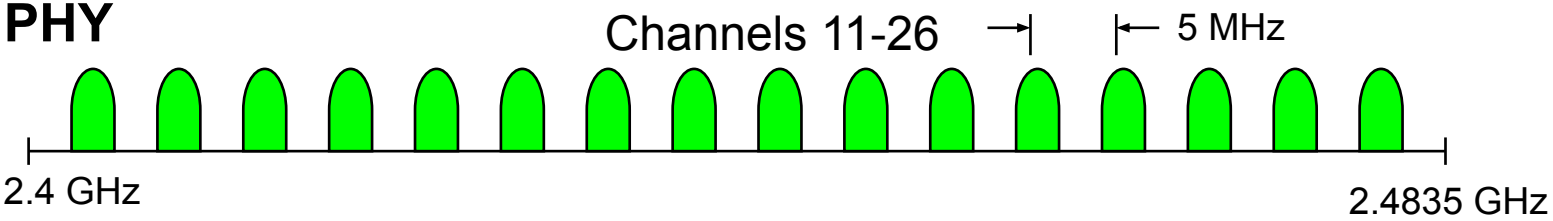
IEEE 802.15.4 PHY Overview

- Operating Frequency Bands

868MHz/ 915MHz PHY



2.4 GHz PHY



Frequency Bands and Data Rates

- The standard specifies two PHYs :
  - 868 MHz/915 MHz direct sequence spread spectrum (DSSS) PHY (11 channels)
    - 1 channel (20kbps) in European 868MHz band
    - 10 channels (40kbps) in 915 (902-928)MHz ISM band
  - 2450 MHz direct sequence spread spectrum (DSSS) PHY (16 channels)
    - 16 channels (250kbps) in 2.4GHz band

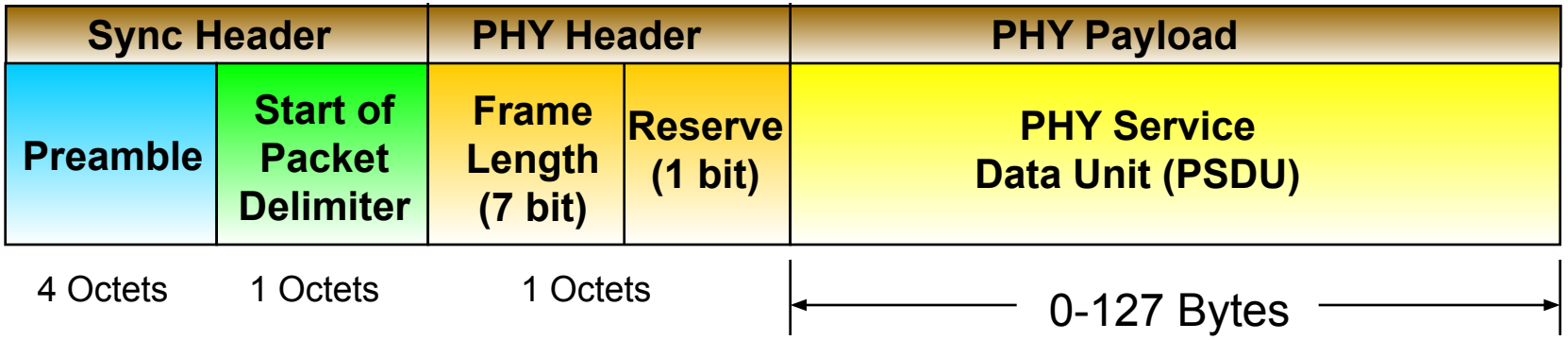
Frequency Bands and Data Rates (cont'd)

Table 1. Frequency bands and data rates

Band	Bit rate	Symbol mapping	Symbol rate	Chip modulation	Chip rate
868-868.6 MHz (Europe, 1 ch)	20 kb/s	Binary	20 ksym/s	BPSK	300 kchip/s
902-928 MHz (U.S., 10 ch)	40 kb/s	Binary	40 ksym/s	BPSK	600 kchip/s
2400-2483.5 GHz (worldwide, 16 ch)	250 kb/s	16-ary quasi –orthogonal	62.5 ksym/s	O-QPSK	2 Mchip/s

PHY Frame Structure

- PHY packet fields
  - Preamble (32 bits) – synchronization
  - Start of packet delimiter (8 bits) – shall be formatted as "11100101"
  - PHY header (8 bits) –PSDU length
  - PSDU (0 to 127 bytes) – data field



General Radio Specifications

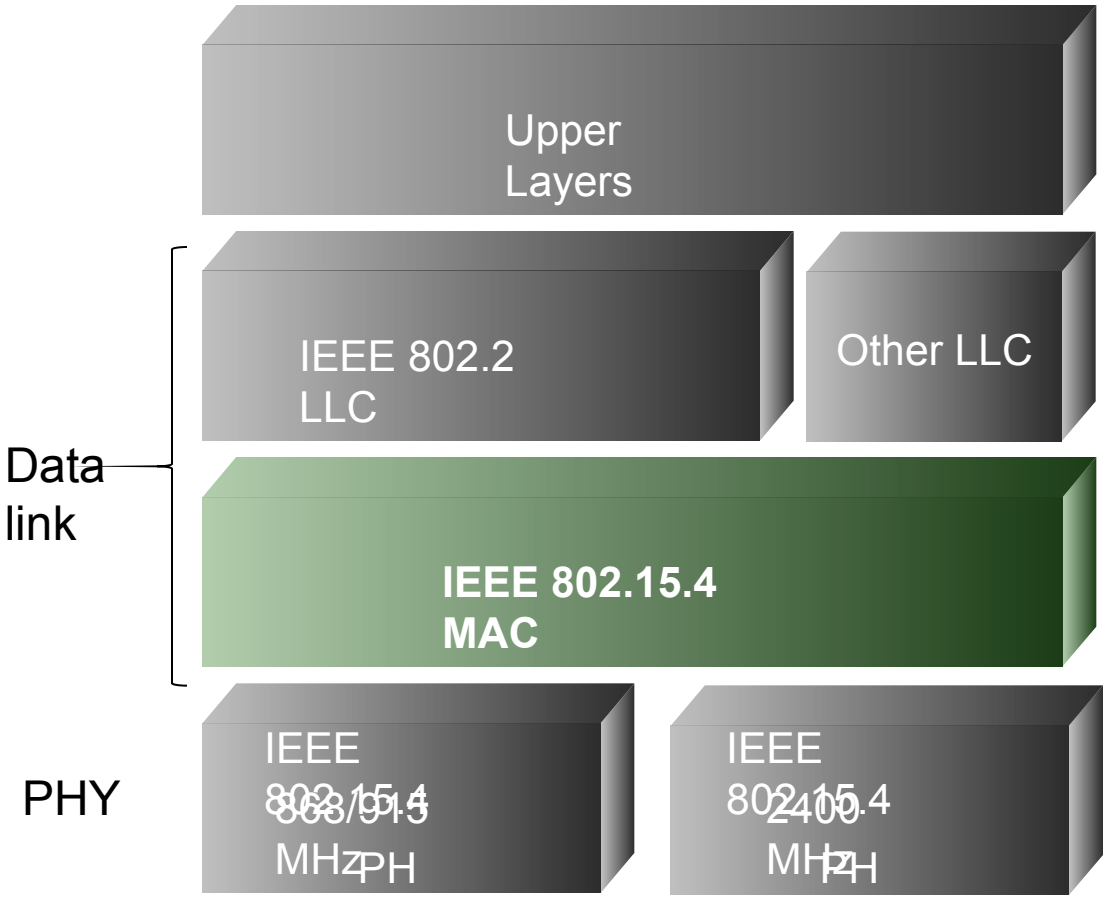
- Transmit Power
  - Capable of at least –3dBm
- Receiver Sensitivity
  - -85 dBm (2.4GHz) / -91dBm (868/915MHz)
- Link quality indication
  - A characterization of the strength and/or quality of a received packet
  - The measurement may be implemented using
    - Receiver energy detection
    - Signal to noise ratio estimation

General Radio Specifications (cont'd)

- Clear Channel Assessment (CCA)
  - CCA Mode 1: energy above threshold (ED threshold)
  - CCA Mode 2: carrier sense only (modulation and spreading characteristics of IEEE 802.15.4)
  - CCA Mode 3: carrier sense with energy above threshold
- The ED threshold shall be at most 10 dB above the specified receiver sensitivity
- The CCA detection time shall equal to 8 symbol periods

IEEE 802.15.4 MAC

MAC Functionalities



- Beacon management
- Channel access mechanism
- Dynamic channel selection (GTS management)
- Frame reception and acknowledgments
- (Dis)association
- Security (AES-128)

https://www.electronicdesign.com/what-s-difference-between/what-s-difference-between-ieee-802154-and-zigbee-wireless

Thanks