

Northwestern University

Wireless Sensor Networks and RFIDs

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IEEE 802.15.4/Zigbee

- In this part, we will look at the IEEE 802.15.4/Zigbee standard.
 - main networking standard for sensor network applications.
- Also several proprietary networking protocols have been developed.

IEEE 802.15 working group

- Develops standards for short range wireless networks
 - (WPANs).
- Projects:
 - 802.15.1 –cable replacement (Bluetooth)
 - 802.15.2 –interop. with 802.11
 - 802.15.3 - high data rate WPAN
 - 802.15.4 - low data rate WPAN (ZigBee)

ZigBee/802.15.4

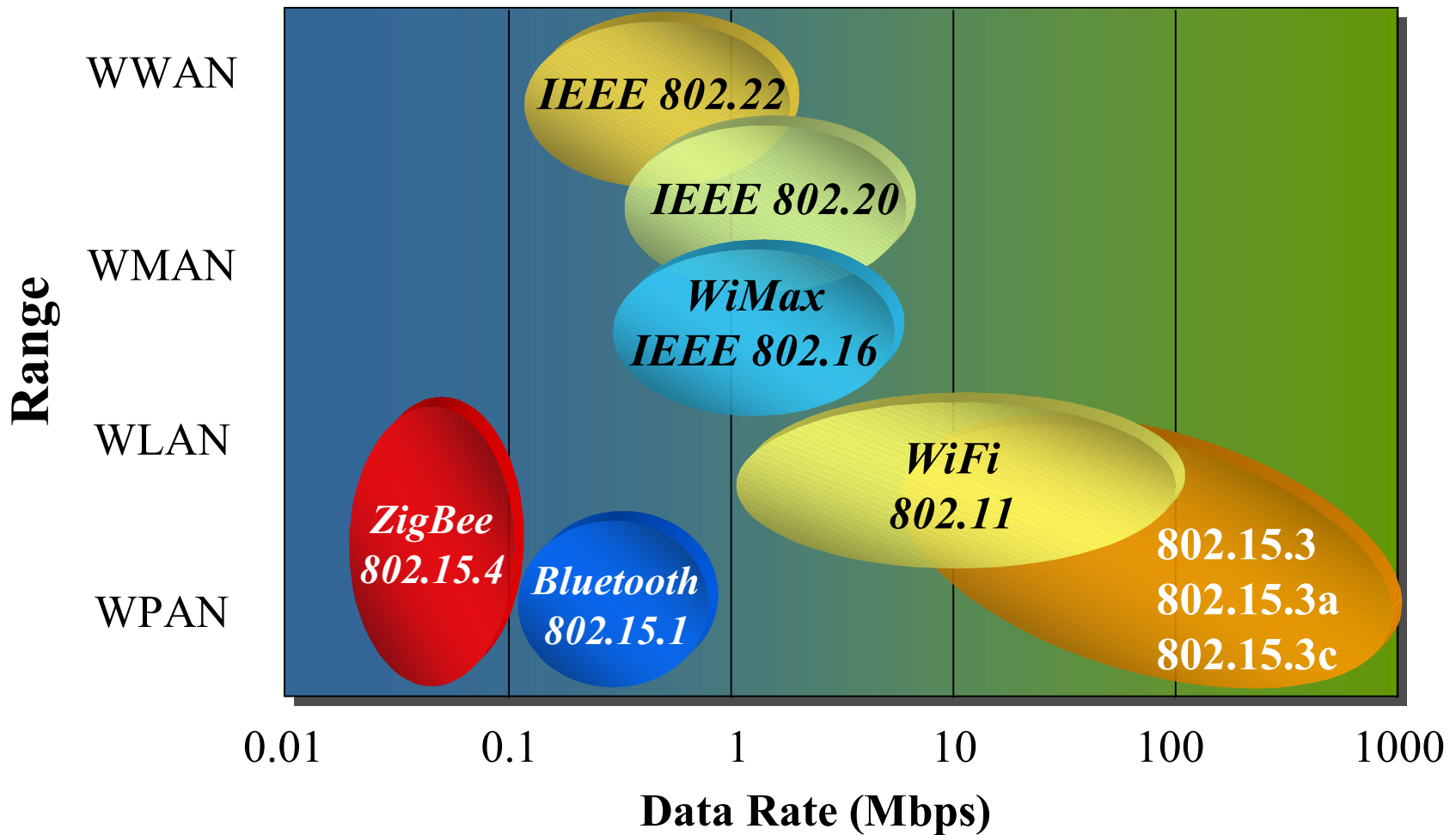
- **802.15.4** standardizes lower layers (Phy-MAC).
- **ZigBee** refers to additional set of higher-layer standards.
 - developed by industry group “**the ZigBee Alliance**”
- Alliance provides
 - upper layer stack and application profiles
 - compliance and certification testing
 - Branding
- Over 150 member companies
 - including Ember, Freescale, Honeywell, Invensys, Mitsubishi, Motorola, Philips, and Samsung.

ZigBee/802.15.4

ZigBee targets extremely low power/long-lifetime devices.

	802.11	Bluetooth	RFID	Zigbee
Power	Hours	Days	Passive:no power Active:months	Years
Configuration	Ad-hoc (DCF) and Access point (PCF) modes	Master- few slaves	Reader-tags	Master-many slaves
Nodes	30	7	100s	64000
Data rates	Few Mbps to 50 Mbps	1 Mbps	10 Kbps to 100 Kbps	250 Kbps
Range	100 meters	10 meters	Cm to a meter	70 – 100 meter

ZigBee and other 802 protocols



ZigBee Frequency bands

BAND COVERAGE DATA RATE CHANNEL(S)

2.4 GHz

ISM

Worldwide

250 kbps

11-26

868 MHz

Europe

20 kbps

0

915 MHz

ISM

Americas

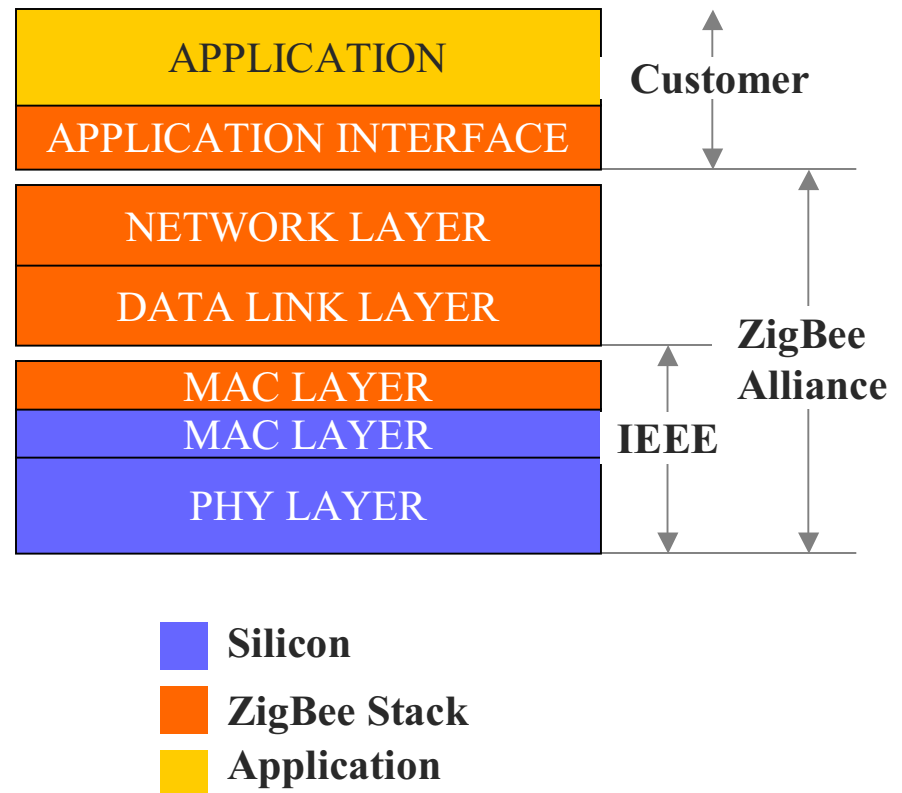
40 kbps

1-10

ZigBee Protocol Stack

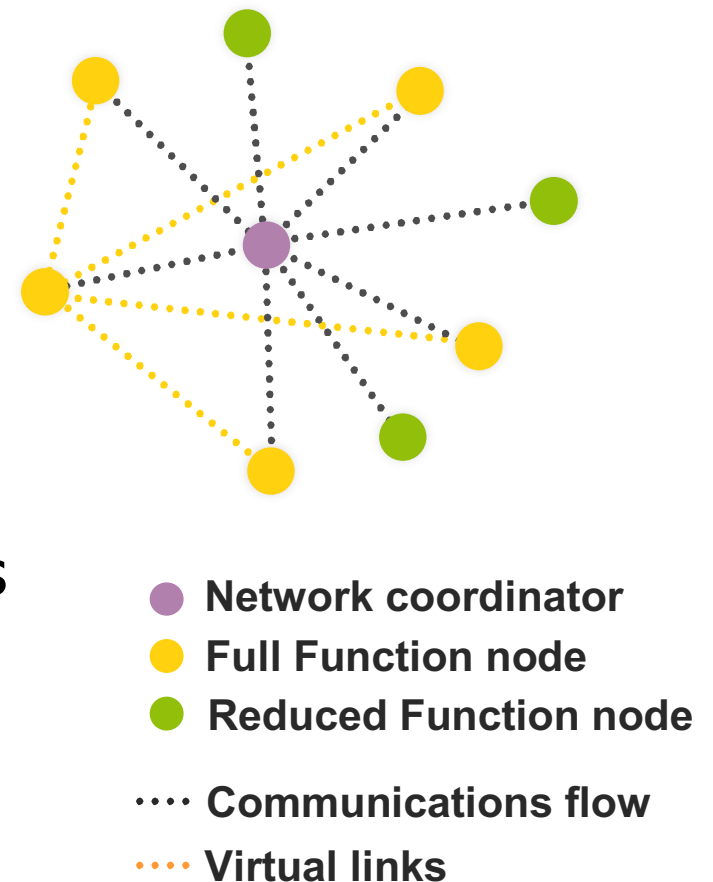
Optimized for limited processing/memory

- 8-bit microcontroller
- Full protocol stack <32 k
- Simple node-only stack ~4k
- Coordinators require extra RAM
 - Node device database
 - Transaction table
 - Pairing table



Basic Network Characteristics

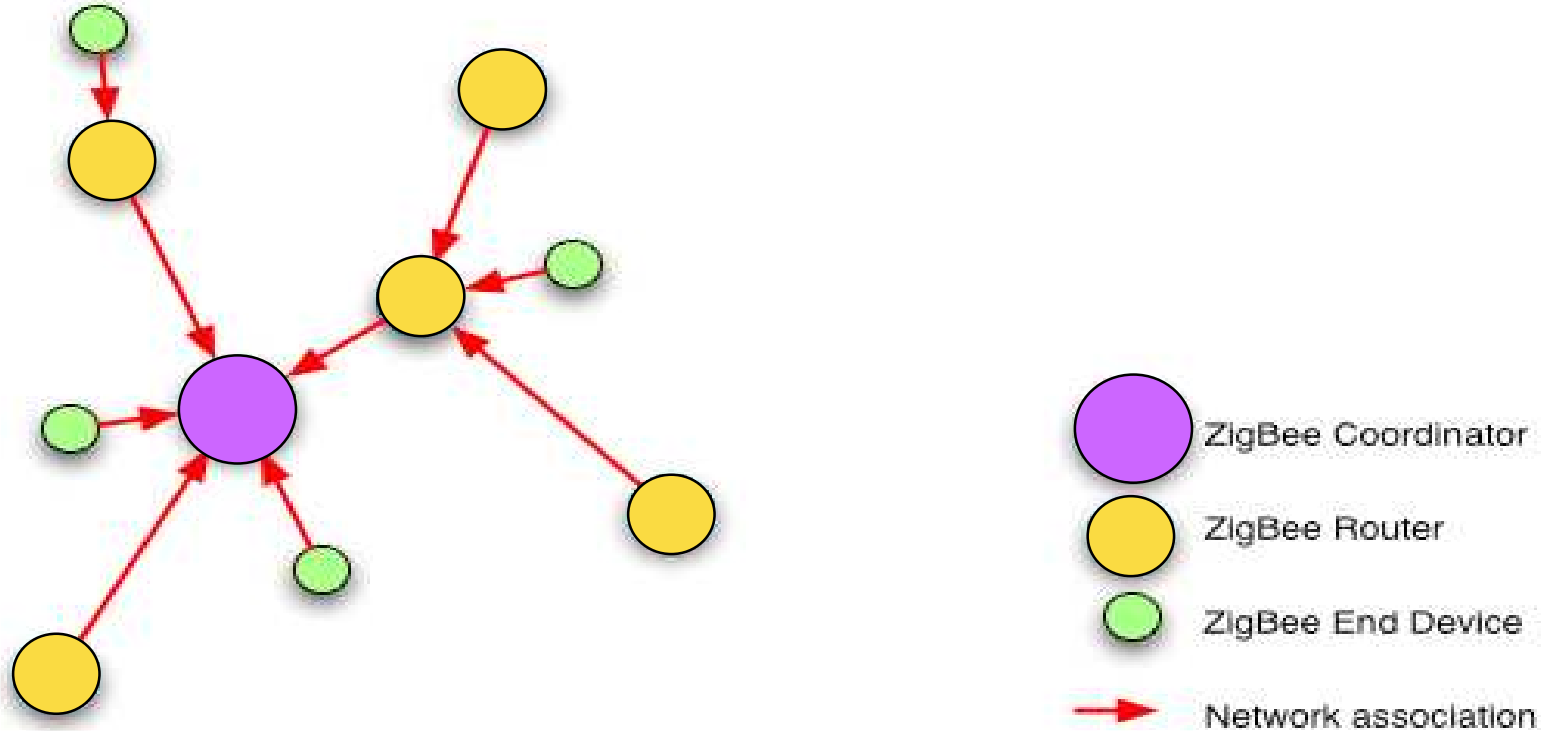
- Up to 65,536 network (client) nodes
- Optimized for timing-critical applications and power management
 - Time to Join Network: <30ms
 - Sleeping to active: <15ms
 - Channel access time: <15ms
- Full Mesh Networking Support



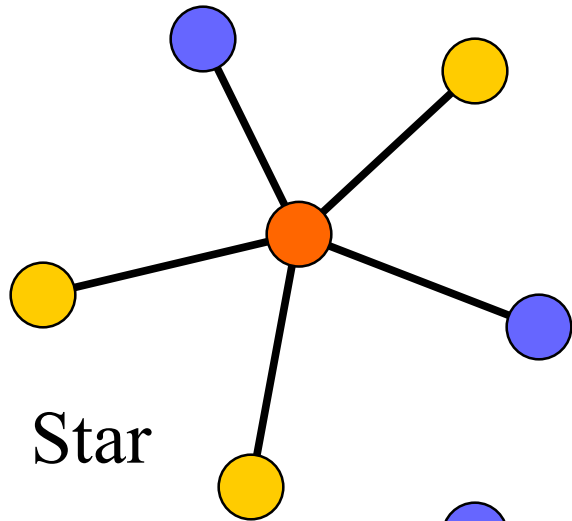
ZigBee Device Types

- ZigBee Coordinator (ZC)
 - One and only one required for each ZB network.
 - Initiates network formation.
 - Acts as 802.15.4 2003 PAN coordinator (FFD).
 - May act as router once network is formed.
- ZigBee Router (ZR)
 - Optional network component.
 - May associate with ZC or with previously associated ZR.
 - Acts as 802.15.4 2003 coordinator (FFD).
 - Participates in multihop routing of messages.
- ZigBee End Device (ZED) (some times called RFD)
 - Optional network component.
 - Shall not allow association.
 - Shall not participate in routing.

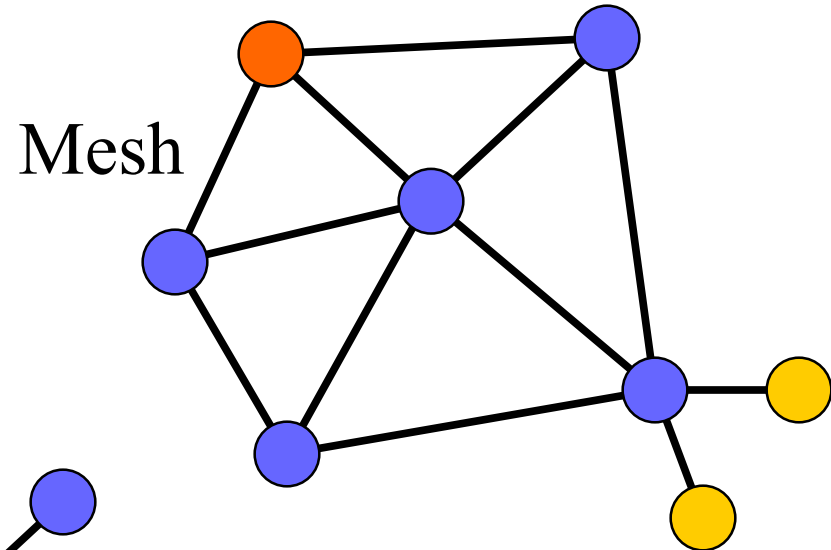
Device Associations



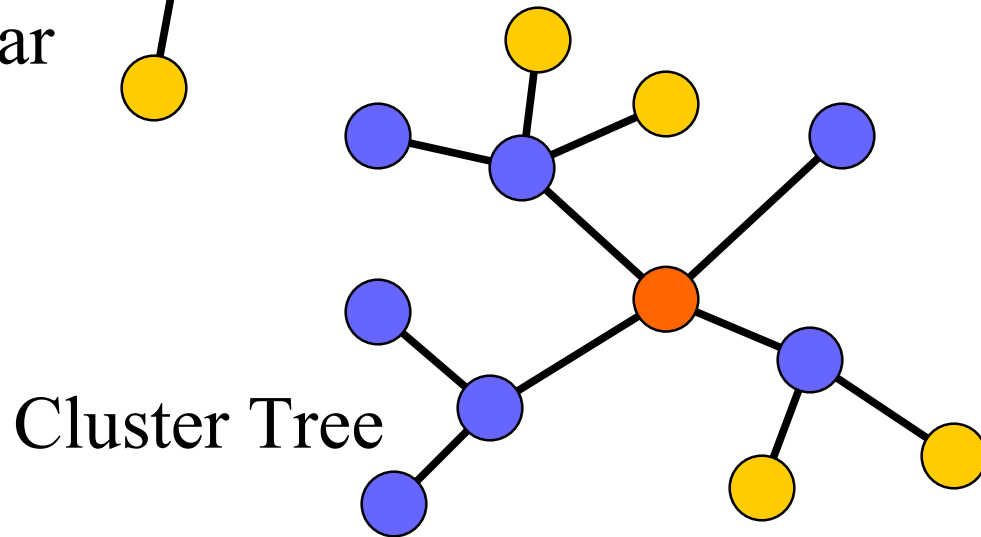
Topology Models



Star



Mesh



Cluster Tree

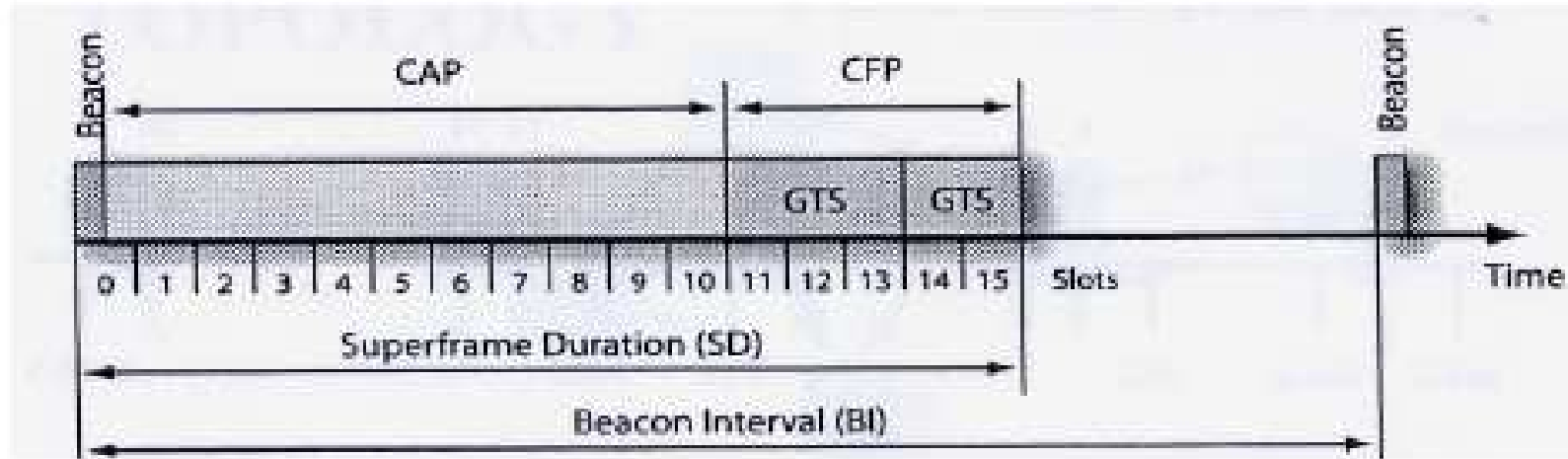
-  **PAN coordinator**
-  **Full Function Device**
-  **Reduced Function Device**

MAC options

Two channel access mechanisms:

- Non-beacon network
 - A simple, traditional multiple access system used in simple peer and near-peer networks
 - Standard ALOHA CSMA-CA communications
 - Positive acknowledgement for successfully received packets
- Beacon-enabled network
 - Superframe structure- network coordinator transmits beacons at predetermined intervals
 - Dedicated bandwidth and low latency
 - Low Power Consumption mode for Coordinator

802.15.4 super frame example



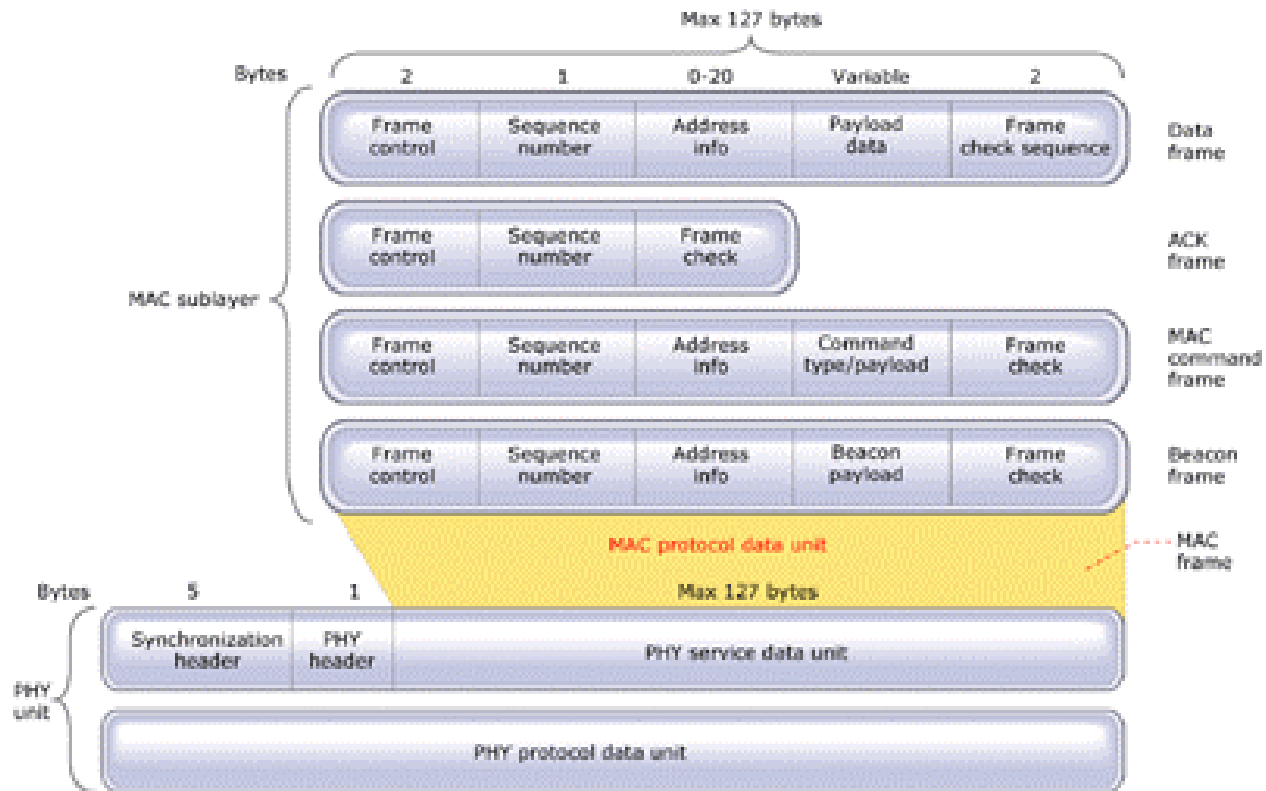
Three parts to each frame:

1. contention access period.
2. contention free period.
3. Sleep period

Must send one beacon at least every 252 sec.

(as fast as every 0.015 sec)

Frame structure



Frame structure

- 4 basic frame types.
 - Data frame payload of up to 104 bytes.
 - Uses standard 64-bit IEEE and optional 16-bit short addressing.

Network layer

- Supports two routing algorithms:
 - Cluster tree
 - “on demand” mesh routing.
- Network layer is also responsible for starting new networks, assigning addresses, etc.

Security

- ZigBee has security at multiple layers.
 - Application/network and MAC layer security.
 - Includes access control
 - List of “trusted devices”
 - Also use encryption keys (128 –bits)