ZigBee Architecture

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Introduction

- ZigBee is a technological standard designed for control and sensor networks
- Based on the IEEE 802.15.4 Standard
- Created by the ZigBee Alliance

Introduction

- Operates in Personal Area Networks (PAN's) and device-to-device networks
- Connectivity between small packet devices
- Control of lights, switches, thermostats, appliances, etc.

History

- Developement started 1998, when many enginereers realized that WiFi and Bluetooth were going to be unsuitable for many applications
- IEEE 802.15.4 standard was completed in May 2003

ZigBee Alliance

- Organization defining global standards for reliable, cost-effective, low power wireless applications
- A consortium of end users and solution providers, primarily responsible for the development of the 802.15.4 standard
- Developing applications and network capability utilizing the 802.15.4 packet delivery mechanism

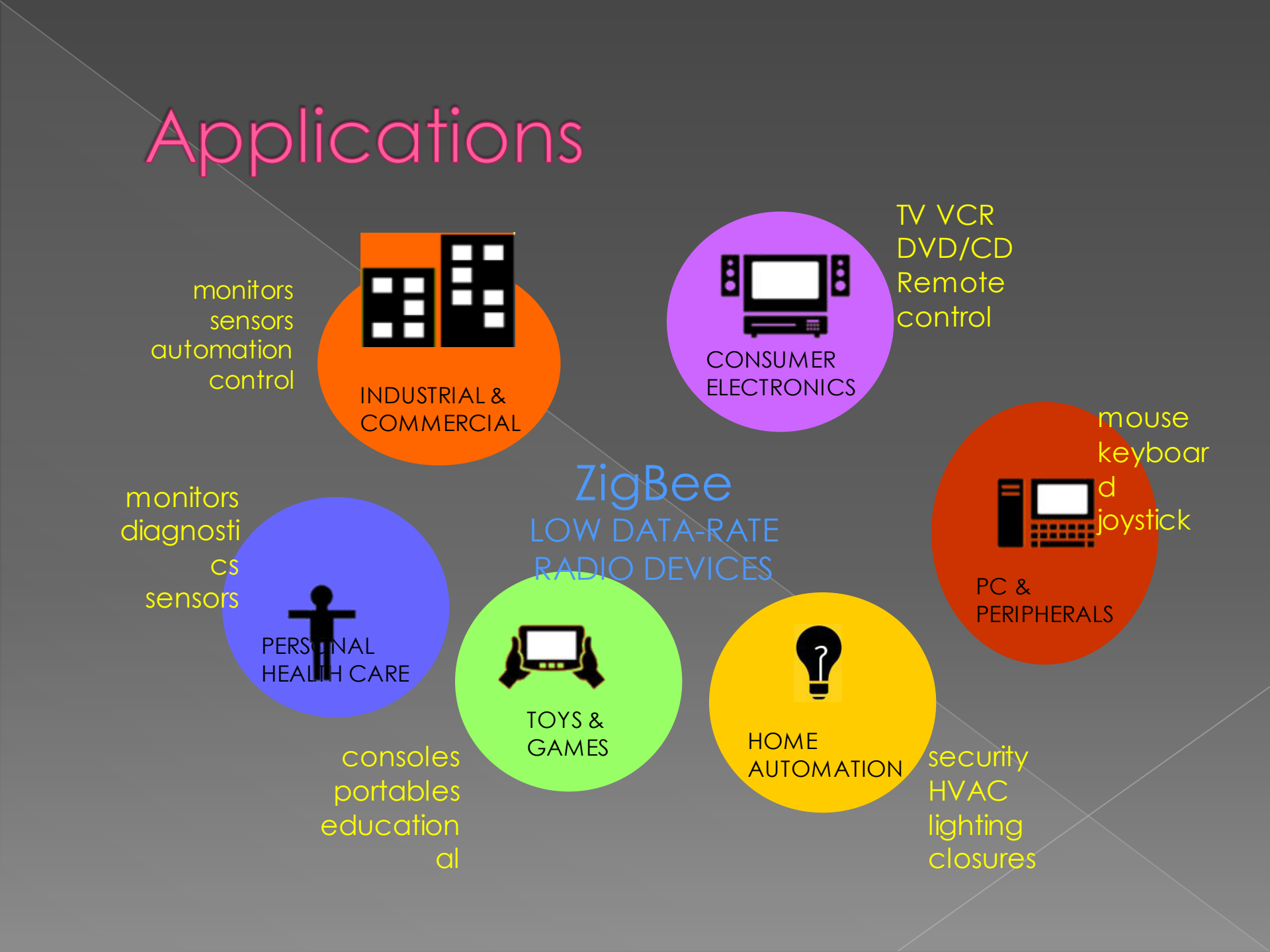
Characteristics

- Low cost
- Low power consumption
- Low data rate
- Relatively short transmission range
- Scalability
- Reliability
- Flexible protocol design suitable for many applications

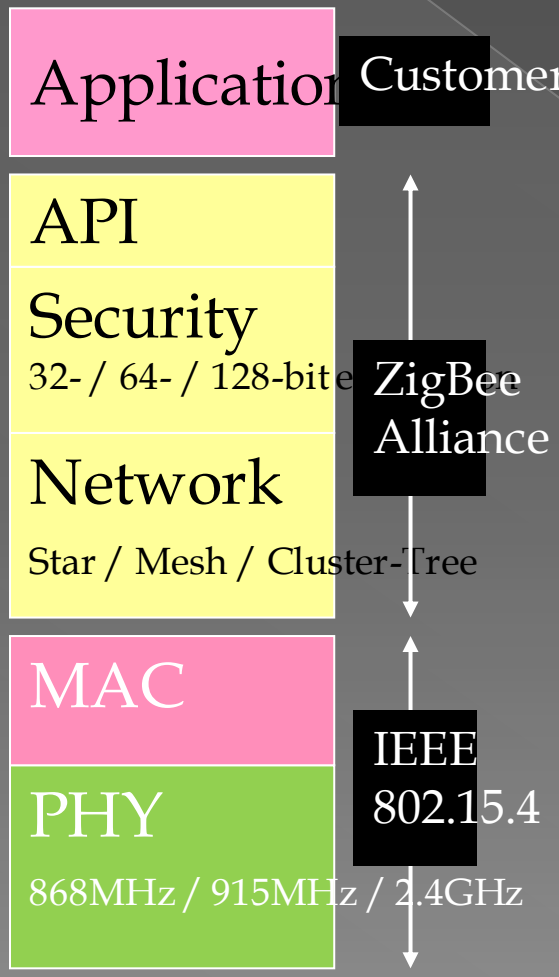
Security

- Encryption specified for MAC, Network and APS layers
- Encryprion/Authentication mode CCM(CTR +CBC-MAC)
  - CTR is a counter based encryption mode
  - CBC-MAC provides data integrity
- All security is based on 128bit key and AES-128 block encryption method

Applications



ZigBee/IEEE 802.15.4

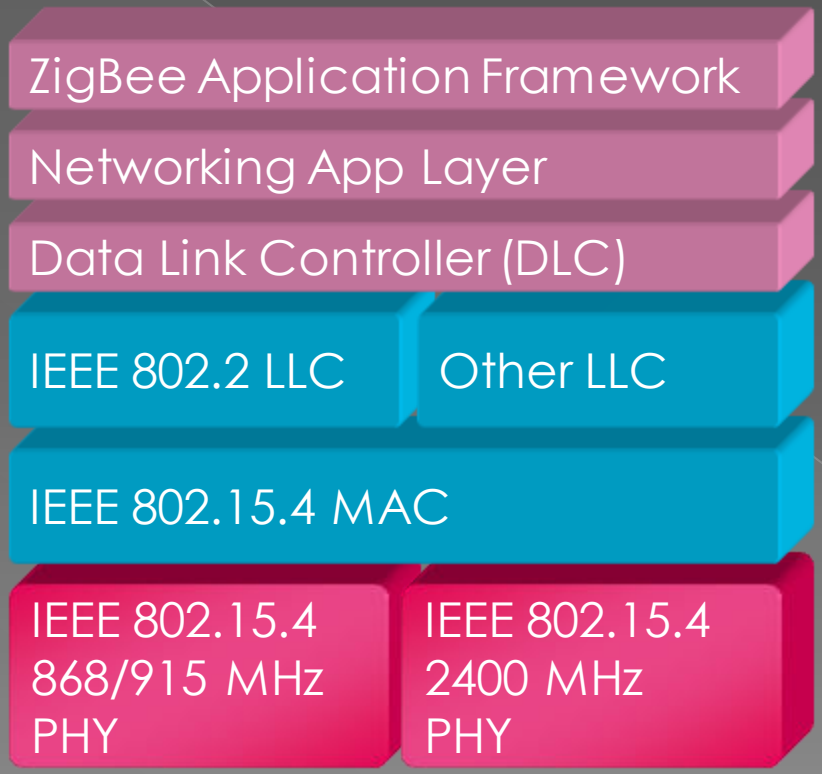


ZigBee Alliance
- -"the software"
- -Network, Security & Application layers
- -Brand management

IEEE 802.15.4
- -"the hardware"
- -Physical & Media Access Control layers

IEEE 802.15.4

- IEEE 802.15.4 Architecture



IEEE 802.15.4 Physical Layer

- 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 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

IEEE 802.15.4 MAC Layer

- Traffic Type
  - Periodic data
    - e.g. sensors
  - Intermittent data
    - e.g. light switch
  - Repetitive low latency data
    - e.g. mouse

IEEE 802.15.4 MAC Layer

- Device Classes
  - Full function device (FFD)
    - Can function in any topology
    - Capable of being Network coordinator
    - Can talk to any other device (FFD/RFD)
  - Reduced function device (RFD)
    - Limited to star topology
    - Cannot become network coordinator
    - Talks only to FFDs
- Address
  - All devices must have 64 bit IEEE addresses
  - Short (16 bit) addresses can be allocated to reduce packet size

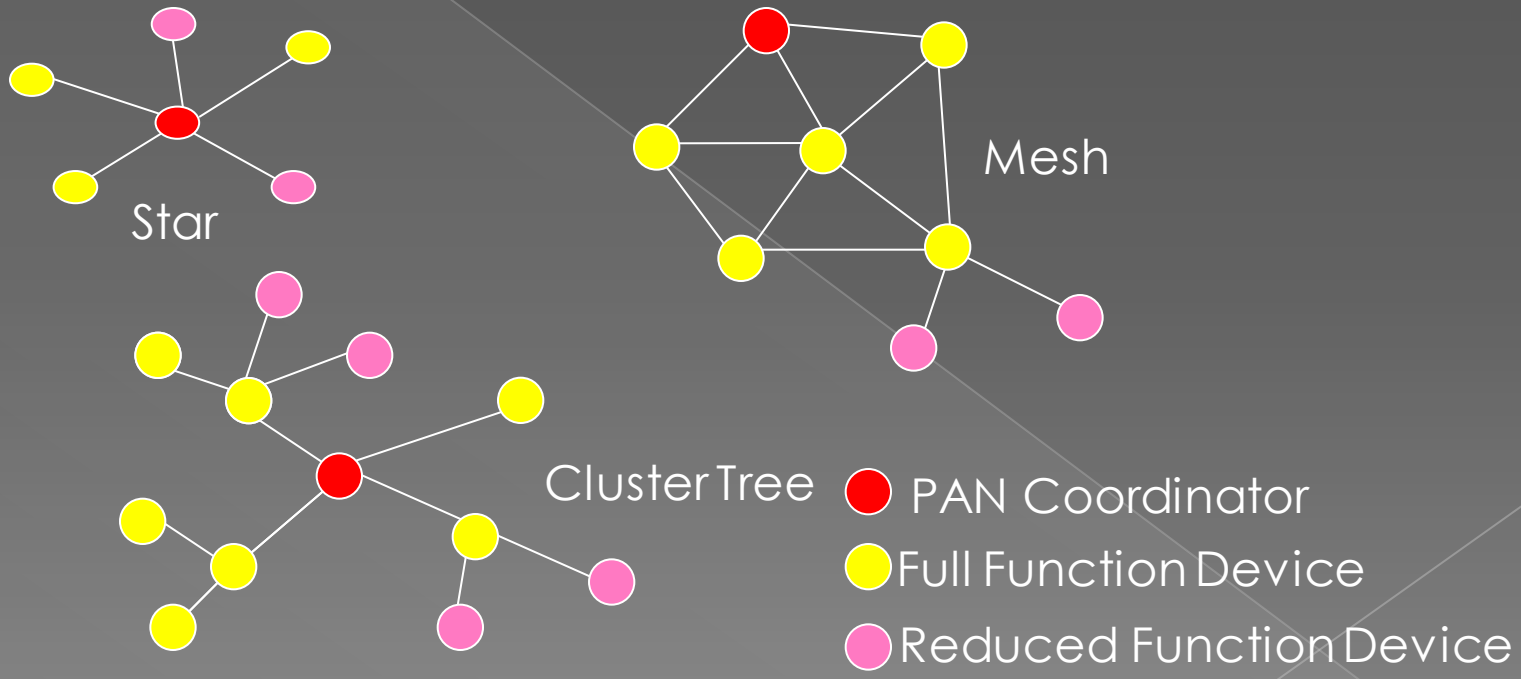
IEEE 802.15.4 MAC Layer

- Frame Types
  - Data Frame
    - used for all transfers of data
  - Beacon Frame
    - used by a coordinator to transmit beacons
  - Acknowledgment Frame
    - used for confirming successful frame reception
  - MAC Command Frame
    - used for handling all MAC peer entity control transfers

IEEE 802.15.4 MAC Layer

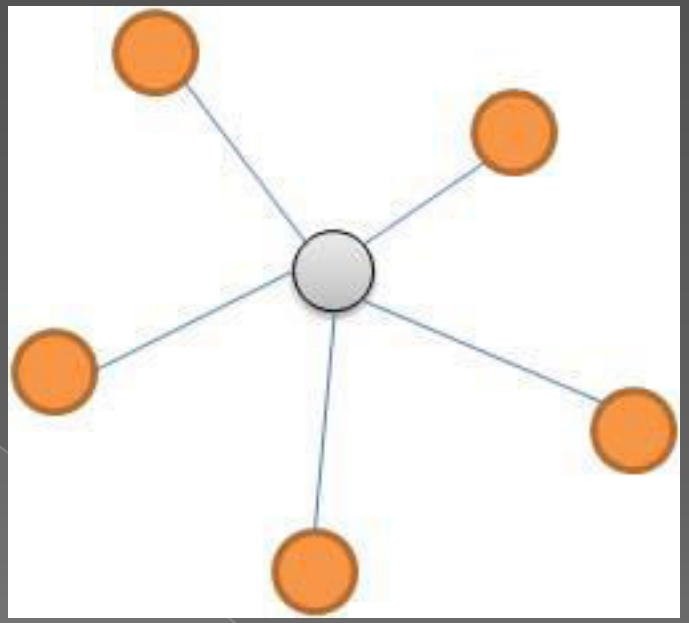
- Transmission Mode
  - Slotted (Beacon enable mode)
    - Periodic data and Repetitive low latency data using.
  - Un-slotted (Non-Beacon enable mode)
    - Intermittent data using.

ZigBee Network Topologies



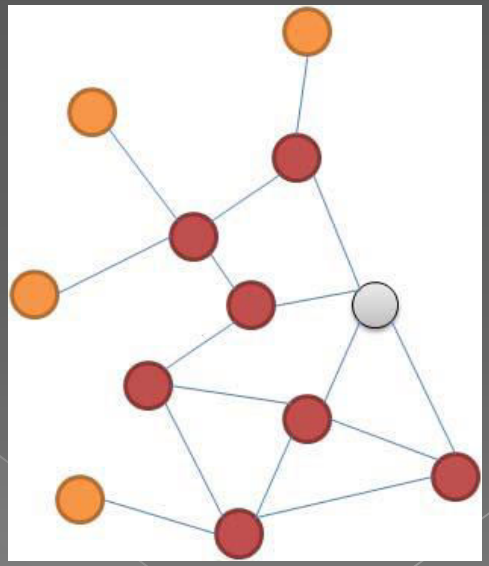
ZigBee Network Topologies

- Star Topology
  - Advantage
    - Easy to synchronize
    - Low latency
  - Disadvantage
    - Small scale



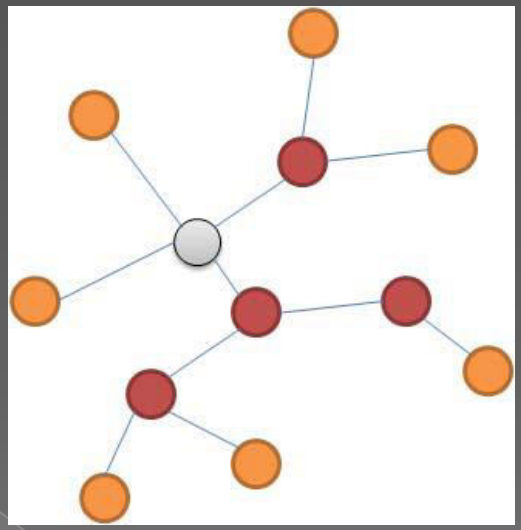
ZigBee Network Topologies

- Mesh Topology
  - Advantage
    - Robust multihop communication
    - Network is more flexible
    - Lower latency
  - Disadvantage
    - Route discovery is costly
    - Needs storage for routing table



ZigBee Network Topologies

- Cluster Tree
  - Advantage
    - Low routing cost
    - Allow multihop communication
  - Disadvantage
    - Route reconstruction is costly
    - Latency may be quite long



ZigBee and Bluetooth Comparison

- *Optimized for different applications*
  - ZigBee
    - Smaller packets over large network
    - Mostly Static networks with many, infrequently used devices
    - Home automation, toys, remote controls, etc.
  - Bluetooth
    - Larger packets over small network
    - Ad-hoc networks
    - File transfer
    - Screen graphics, pictures, handsfree audio, Mobile phones, headsets, PDAs, etc.

ZigBee and Bluetooth Comparison

Feature(s)	Bluetooth	ZigBee
Power Profile	days	years
Complexity	complex	Simple
Nodes/Master	7	64000
Latency	10 seconds	30 ms – 1s
Range	10m	70m ~ 300m
Extendibility	no	Yes
Data Rate	1 Mbps	250 Kbps
Security	64bit, 128bit	128bit AES and Application Layer