CSE 425: Internet of Things

Dept. of CSE, BUBT| Summer 2021

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IoT Access Technologies

Courtesy: David Hanes and Co.,Many Websites, and Google

Communications Criteria

Range: This section examines the importance of signal propagation and distance.

Frequency Bands: This section describes licensed and unlicensed spectrum, including sub-GHz frequencies.

Power Consumption: This section discusses the considerations required for devices connected to a stable power source compared to those that are battery powered.

Topology: This section highlights the various layouts that may be supported for connecting multiple smart objects.

Constrained Devices: This section details the limitations of certain smart objects from a connectivity perspective.

Constrained-Node Networks: This section highlights the challenges that are often encountered with networks connecting smart objects.

IoT Access Technologies

Standardization and alliances: The standards bodies that maintain the protocols for a technology

Physical layer: The wired or wireless methods and relevant frequencies

MAC layer: Considerations at the Media Access Control (MAC) layer, which bridges the physical layer with data link control

Topology: The topologies supported by the technology

Security: Security aspects of the technology

Competitive technologies: Other technologies that are similar and may be suitable alternatives to the given technology

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Connectivity Technologies – Part I

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Communication Protocols

The following communication protocols have immediate importance to consumer and industrial IoTs:

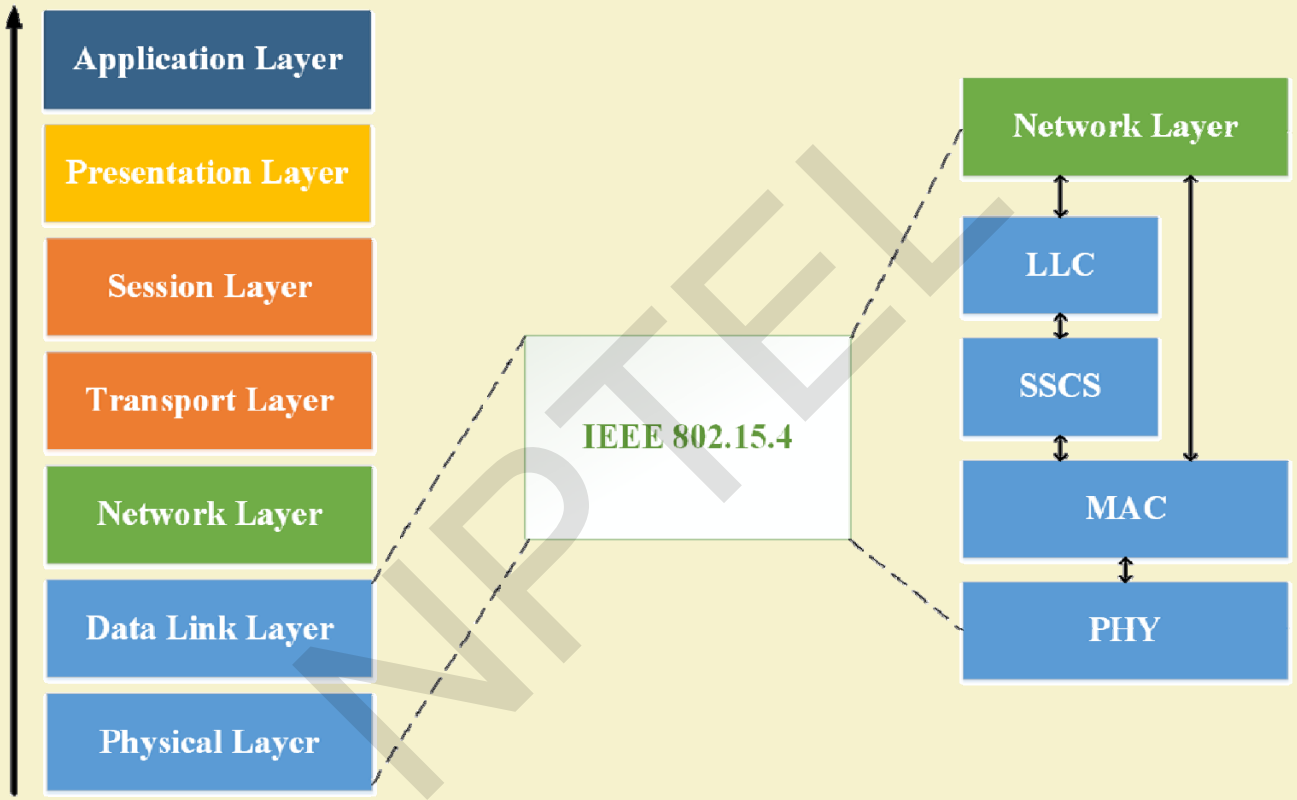
- ✓ IEEE 802.15.4
- ✓ Zigbee
- ✓ 6LoWPAN
- ✓ Wireless HART
- ✓ Z-Wave
- ✓ ISA 100
- ✓ Bluetooth
- ✓ NFC
- ✓ RFID

IEEE 802.15.4

Features of IEEE 802.15.4

- ✓ Well-known standard for low data-rate WPAN.
- ✓ Developed for low-data-rate monitoring and control applications and extended-life low-power-consumption uses.
- ✓ This standard uses only the first two layers (PHY, MAC) plus the logical link control (LLC) and service specific convergence sub-layer (SSCS) additions to communicate with all upper layers
- ✓ Operates in the ISM band.

Source: L.Fenzel, "What's The Difference Between IEEE 802.15.4 And ZigBee Wireless?", Electronic Design (Online), Mar. 2013


Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer
IEEE 802.15.4
Network Layer
LLC
SSCS
MAC
PHY

- ✓ Uses direct sequence spread spectrum (DSSS) modulation.
- ✓ Highly tolerant of noise and interference and offers link reliability improvement mechanisms.
- ✓ Low-speed versions use Binary Phase Shift Keying (BPSK).
- ✓ High data-rate versions use offset-quadrature phase-shift keying (O-QPSK).
- ✓ Uses carrier sense multiple access with collision avoidance (CSMA-CA) for channel access.
- ✓ Multiplexing allows multiple users or nodes interference-free access to the same channel at different times.

Source: L.Fenzel, "What's The Difference Between IEEE 802.15.4 And ZigBee Wireless?", Electronic Design (Online), Mar. 2013

- ✓ Power consumption is minimized due to infrequently occurring very short packet transmissions with low duty cycle (<1%).
- ✓ The minimum power level defined is –3 dBm or 0.5 mW.
- ✓ Transmission, for most cases, is Line of Sight (LOS).
- ✓ Standard transmission range varies between 10m to 75m.
- ✓ Best case transmission range achieved outdoors can be upto 1000m.
- ✓ Networking topologies defined are -- Star, and Mesh.

Source: L.Fenzel, "What's The Difference Between IEEE 802.15.4 And ZigBee Wireless?", Electronic Design (Online), Mar. 2013

IEEE 802.15.4 Variants

A/B
- Base version

C
- For China

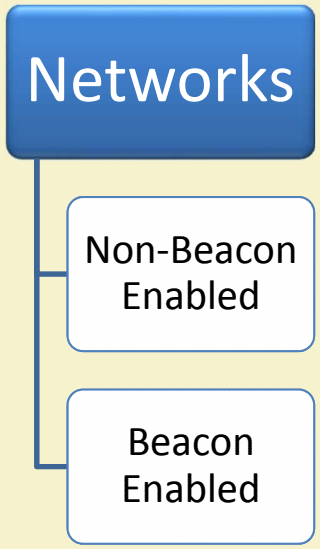
D
- For Japan

E
- Industrial applications

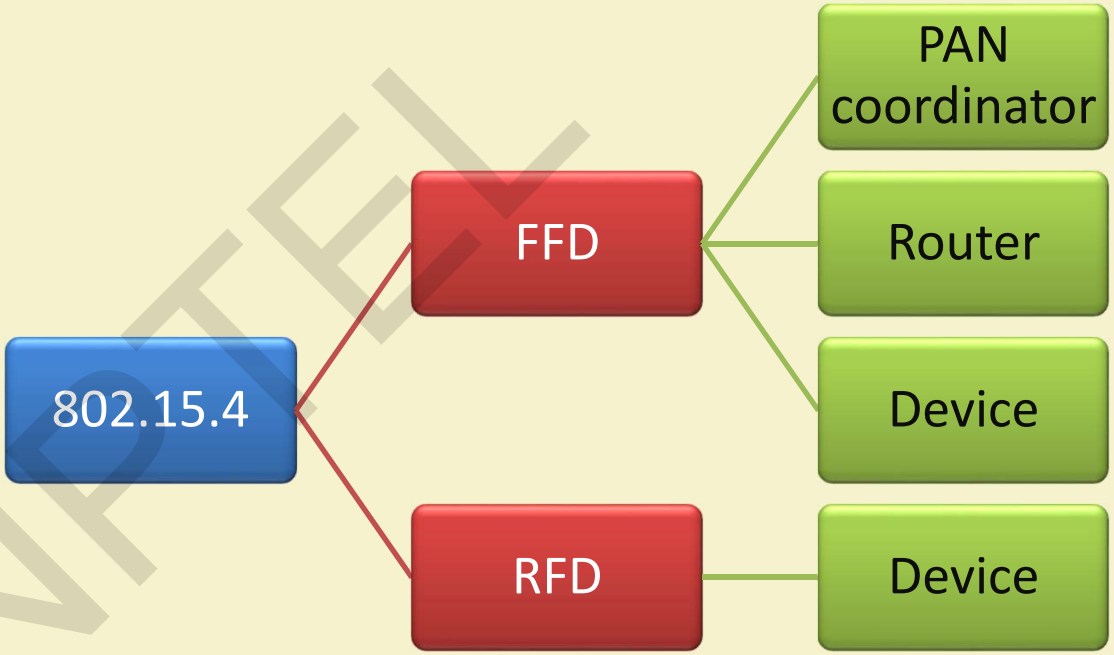
F
- Active RFID uses

G
- Smart utility networks (Smart Grids)

IEEE 802.15.4 Types



(a)

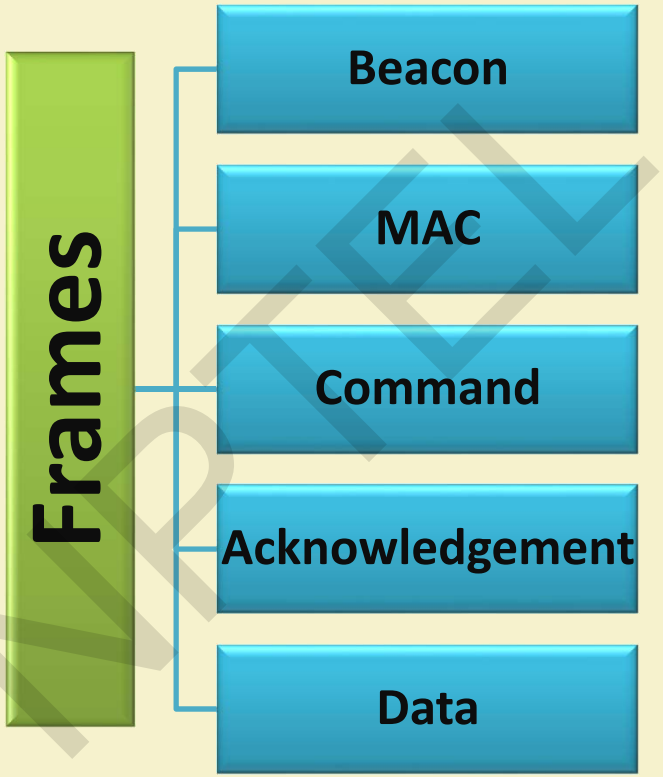


(b)

- **Full Function Device (FFD)**
  - Can talk to all types of devices
  - Supports full protocol

- **Reduced Function Device (RFD)**
  - Can only talk to an FFD
  - Lower power consumption
  - Minimal CPU/RAM required

IEEE 802.15.4 Frames



Beacon Enabled Networks

- Periodic transmission of beacon messages
- Data-frames sent via Slotted CSMA/CA with a super frame structure managed by PAN coordinator
- Beacons used for synchronization & association of other nodes with the coordinator
- Scope of operation spans the whole network.

Non-Beacon Enabled Networks

- Data-frames sent via un-slotted CSMA/CA (Contention Based)
- Beacons used only for link layer discovery
- Requires both source and destination IDs.
- As 802.15.4 is primarily, a mesh protocol, all protocol addressing must adhere to mesh configurations
- De-centralized communication amongst nodes

Zigbee

Features of ZigBee

- ✓ Most widely deployed enhancement of IEEE 802.15.4.
- ✓ The ZigBee protocol is defined by **layer 3 and above**. It works with the 802.15.4 layers 1 and 2.
- ✓ The standard uses layers 3 and 4 to define additional communication enhancements.
- ✓ These enhancements include authentication with valid nodes, encryption for security, and a data routing and forwarding capability that enables mesh networking.
- ✓ The most popular use of ZigBee is wireless sensor networks using the mesh topology.

Source: L.Fenzel, "What's The Difference Between IEEE 802.15.4 And ZigBee Wireless?", Electronic Design (Online), Mar. 2013


Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer
Zigbee
IEEE 802.15.4

Important Components

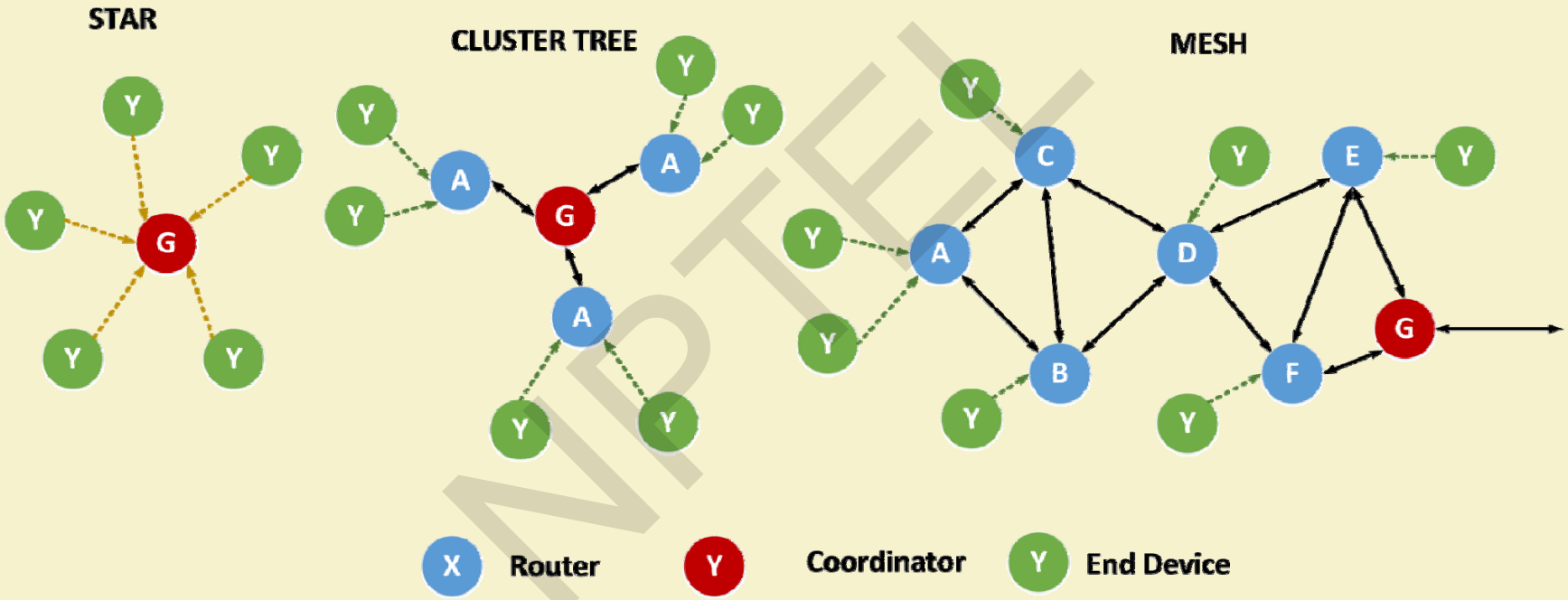
ZDO

- ZigBee Device Object
  (Device management, Security, Policies)

APS

- Application Support Sub-layer
  (Interfacing and control services, bridge between network and other layers)

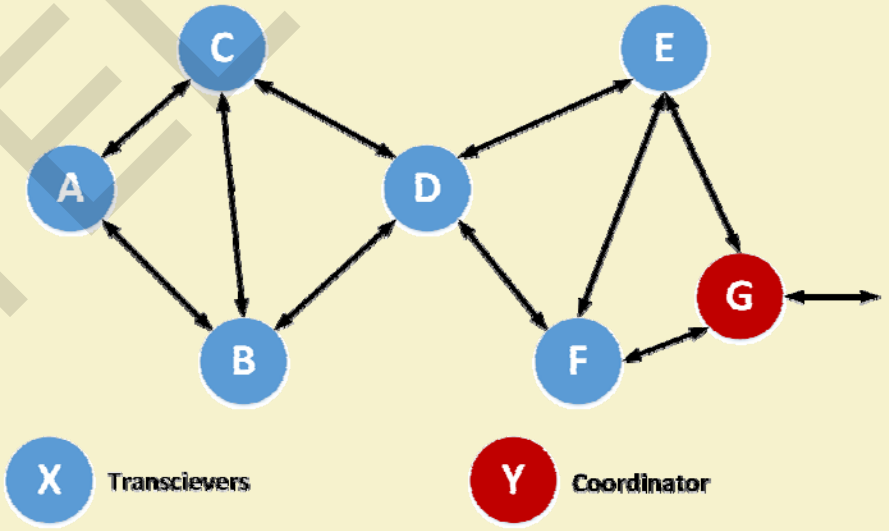
ZigBee Topologies



Source: T. Agarwal, "ZigBee Wireless Technology Architecture and Applications", Electronics Projects Focus (Online)

ZigBee Mesh

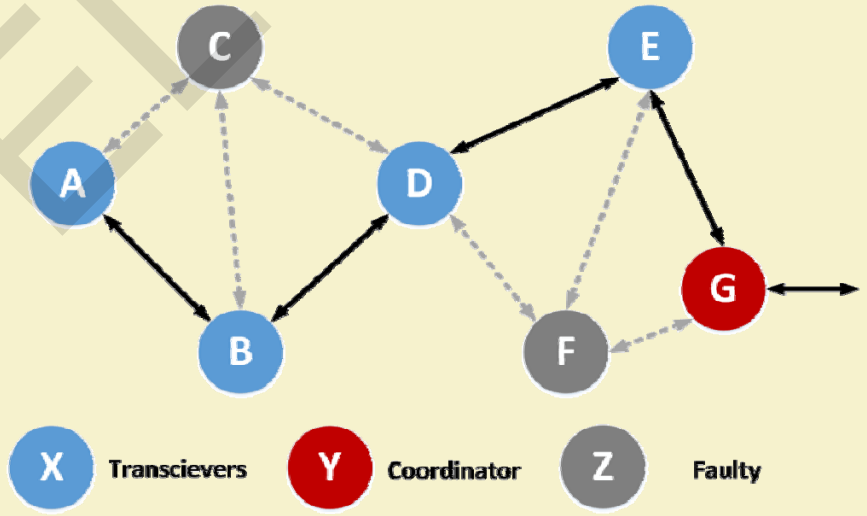
- ✓ In a mesh, any node can communicate with any other node within its range.
- ✓ If nodes are not in range, messages are relayed through intermediate nodes.
- ✓ This allows the network deployment over large areas.



Source: L.Fenzel, "What's The Difference Between IEEE 802.15.4 And ZigBee Wireless?", Electronic Design (Online), Mar. 2013

ZigBee Mesh (Contd.)

- ✓ Meshes have increased network reliability.
- ✓ For example, if nodes C and F are down, the message packets from A can still be relayed to G via B and E.
- ✓ ZigBee mesh networks are self-configuring and self-healing.



Source: L.Fenzel, "What's The Difference Between IEEE 802.15.4 And ZigBee Wireless?", Electronic Design (Online), Mar. 2013

ZigBee Types

- ✓ *ZigBee Coordinator (ZC)*:
  - The Coordinator forms the root of the ZigBee network tree and might act as a bridge between networks.
  - There is a single ZigBee Coordinator in each network, which originally initiates the network.
  - It stores information about the network under it and outside it.
  - It acts as a Trust Center & repository for security keys.

Sources:

- *"Wireless Sensor Networks Research Group". Sensor-networks.org. 2010-04-15.*
- *"Wireless Sensor Networks Research Group". Sensor-networks.org. 2009-02-05.*

ZigBee Types

- ✓ *ZigBee Router (ZR)*:
  - Capable of running applications, as well as relaying information between nodes connected to it.
- ✓ *ZigBee End Device (ZED)*:
  - It contains just enough functionality to talk to the parent node, and it cannot relay data from other devices.
  - This allows the node to be asleep a significant amount of the time thereby enhancing battery life.
  - Memory requirements and cost of ZEDs are quite low, as compared to ZR or ZC.

Sources:

- *"Wireless Sensor Networks Research Group". Sensor-networks.org. 2010-04-15.*
- *"Wireless Sensor Networks Research Group". Sensor-networks.org. 2009-02-05.*

ZigBee Network Layer

- ✓ The network layer uses Ad Hoc On-Demand Distance Vector (AODV) routing.
- ✓ To find the final destination, the AODV broadcasts a route request to all its immediate neighbors.
- ✓ The neighbors relay the same information to their neighbors, eventually spreading the request throughout the network.
- ✓ Upon discovery of the destination, a low-cost path is calculated and informed to the requesting device via unicast messaging.

Source: "Zigbee", Wikipedia (Online)

Applications

- ✓ Building automation
- ✓ Remote control (RF4CE or RF for consumer electronics)
- ✓ Smart energy for home energy monitoring
- ✓ Health care for medical and fitness monitoring
- ✓ Home automation for control of smart homes
- ✓ Light Link for control of LED lighting
- ✓ Telecom services

Source: L.Fenzel, "What's The Difference Between IEEE 802.15.4 And ZigBee Wireless?", Electronic Design (Online), Mar. 2013

Thank You!!