

**ECGR-6185**  
**Advanced Embedded Systems**

**ZIGBEE**  
**802.15.4**

University of North Carolina at Charlotte

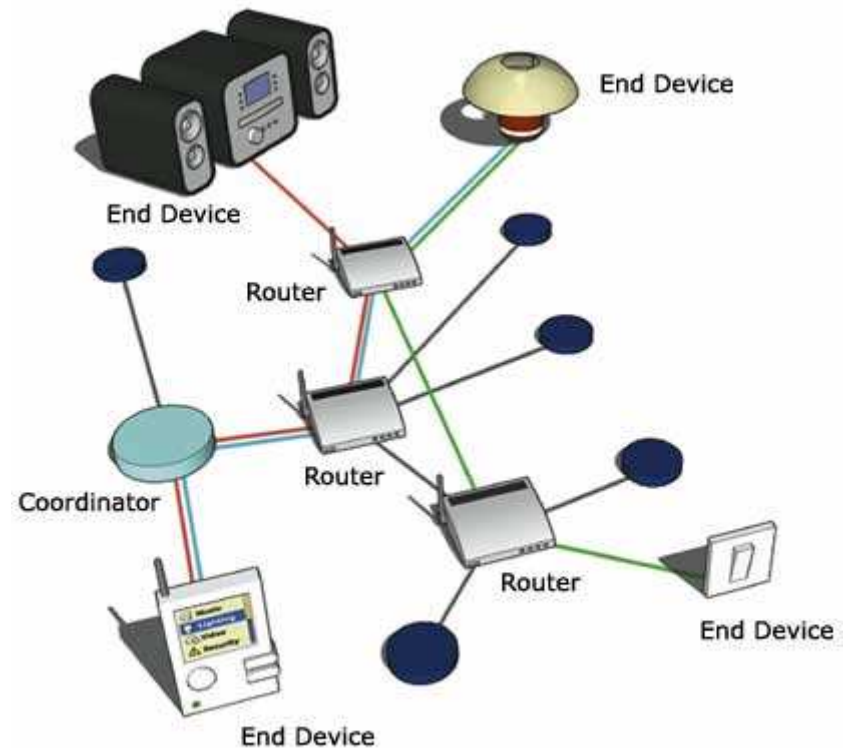
Shikha Tikku

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## IEEE 802.15 WPAN

A WPAN is a wireless personal area network for interconnecting computer devices centered around an individual person's workspace

A wireless PAN consists of a dynamic group of less than 255 devices that communicate within about a 33-foot range



## IEEE 802.15 WPAN

IEEE 802.15 is the 15th working group of the IEEE 802 which specializes in Wireless PAN standards.

It includes five task groups

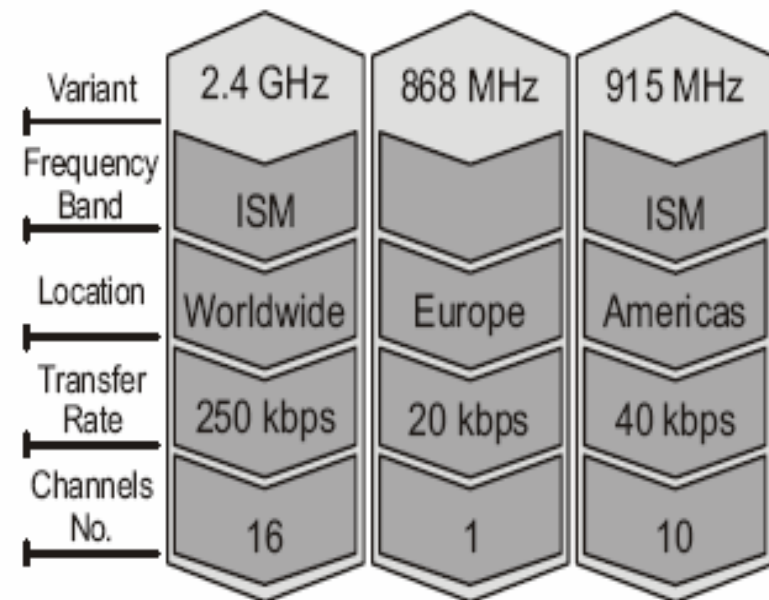
- Task group 1 (WPAN/Bluetooth)
  - Task group 2 (Coexistence)
  - Task group 3 (High Rate WPAN)
  - Task group 4 (Low Rate WPAN)
  - Task group 5 (Mesh Networking)
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## ZigBee

- Established set of specifications for wireless personal area networking (WPAN)
  - Builds on IEEE 802.15 Task group 4 (Low Rate WPAN)
  - First version of Zigbee specification was released on December 16, 2004
  - The name "ZigBee" is derived from the erratic zigging patterns many bees make between flowers when collecting pollen
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## ZIGBEE operates in ISM

- Global use: ISM 2.4 GHz band with 16 channels and data rate of 250 kb/s
- Europe: 868 MHz band with single channel and data rate of 20 kb/s
- USA and Australia: 915 MHz band with 10 channels and data rate of 40 kb/s



## Features of ZigBee

- Extremely low power consumption
  - Short-range operations
  - The ability to sleep for a long time
  - Message acknowledgement
  - CCA (Clear Channel Assessment)
  - Multiple levels of security
  - Simplicity
  - Low cost
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## IEEE 802.15.4 Specifications

- Data rates of 250 kbps, 40 kbps, and 20 kbps
- Two addressing modes; 16-bit short and 64-bit IEEE addressing
- Support for critical latency devices, such as joysticks
- CSMA-CA channel access
- Automatic network establishment by the coordinator

## Specifications

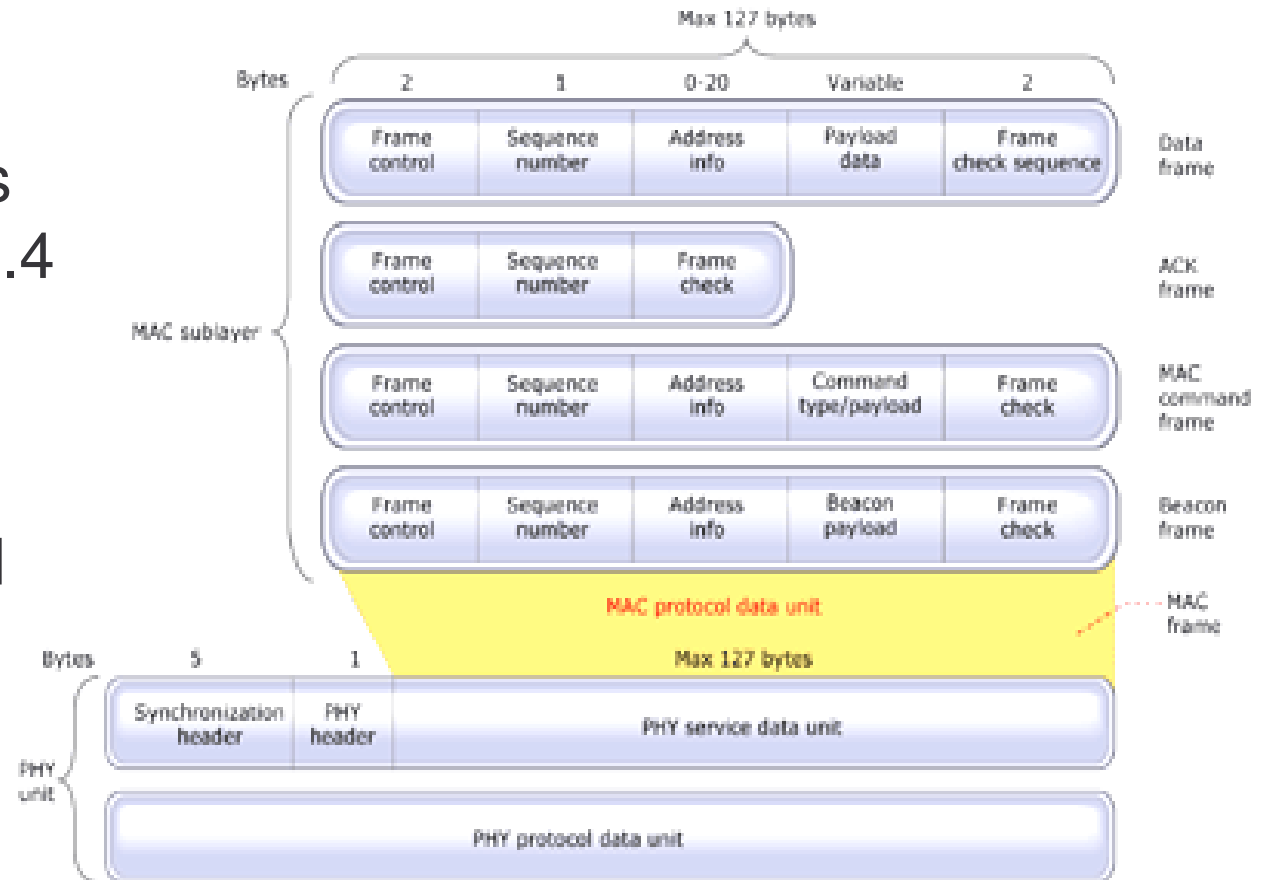
- Fully handshaked protocol for transfer reliability
  - Power management to ensure low power consumption
  - 16 channels in the 2.4GHz ISM band, 10 channels in the 915MHz and one channel in the 868MHz band
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# Frame Structure

There are four basic frame types defined in 802.15.4

- Data
- ACK
- MAC Command
- Beacon



## Ø **Data Frame**

- Payload of up to 104 bytes
- Frame is numbered- tracking
- Frame-check sequence – Error free reception
- Improves reliability in difficult conditions

## Ø **Acknowledgment (ACK) Frame**

- Feedback
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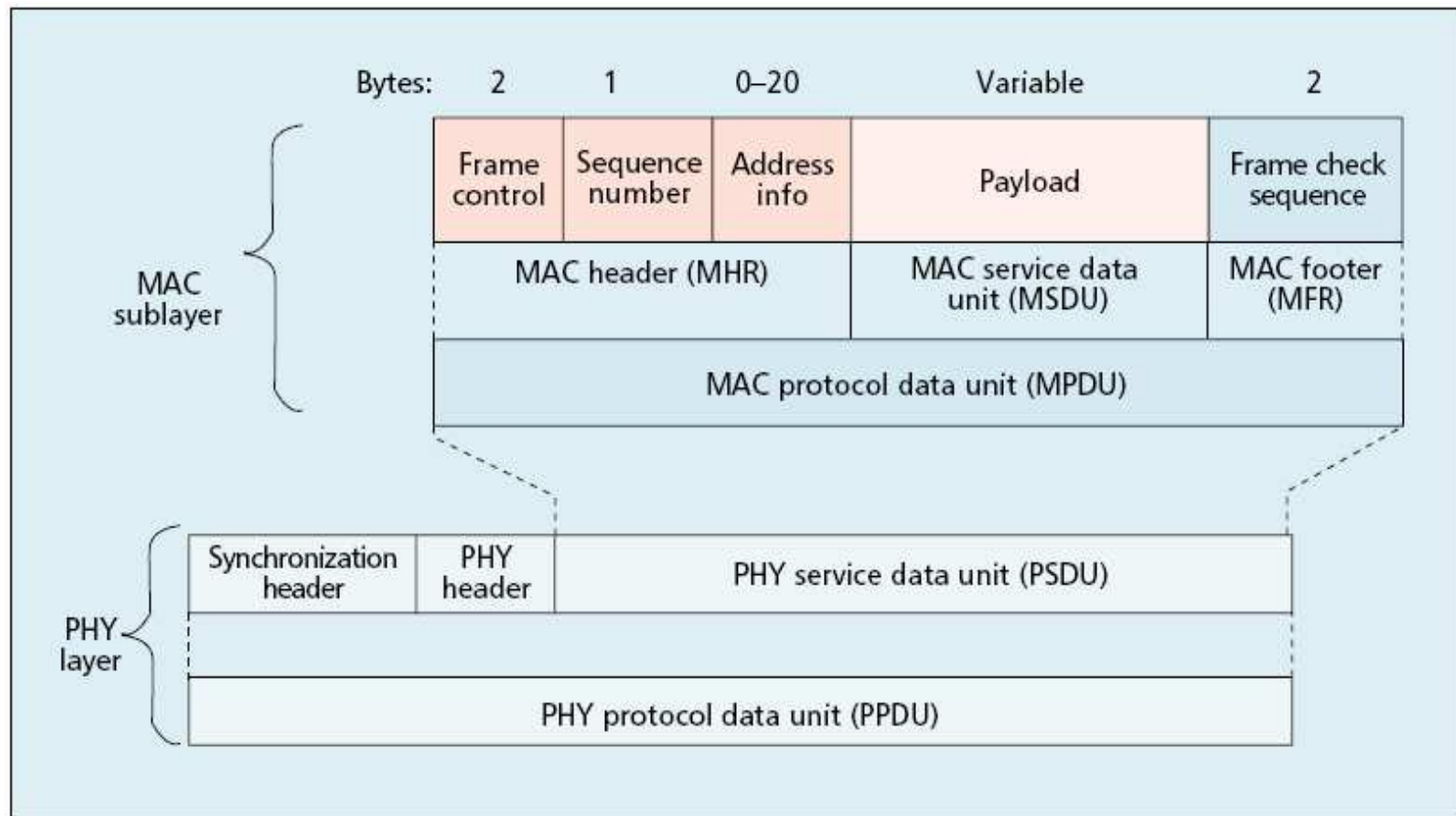
## ∅ **MAC Command Frame**

- Mechanism for remote control
- Configure client nodes

## ∅ **Beacon Frame**

- Wakes up client devices, which listen for their address and go back to sleep if they don't receive it
  - Nodes synchronization
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# Frame Structure



## Physical Layer

- Contains the radio frequency transceiver
- Controls the activation and deactivation
- Channel selection
- Channel assessment
- Transmission and reception of data packets
- Medium access using DSSS and O-QPSK

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## MAC Layer

Employs 64 bit IEEE & 16 bit short addresses

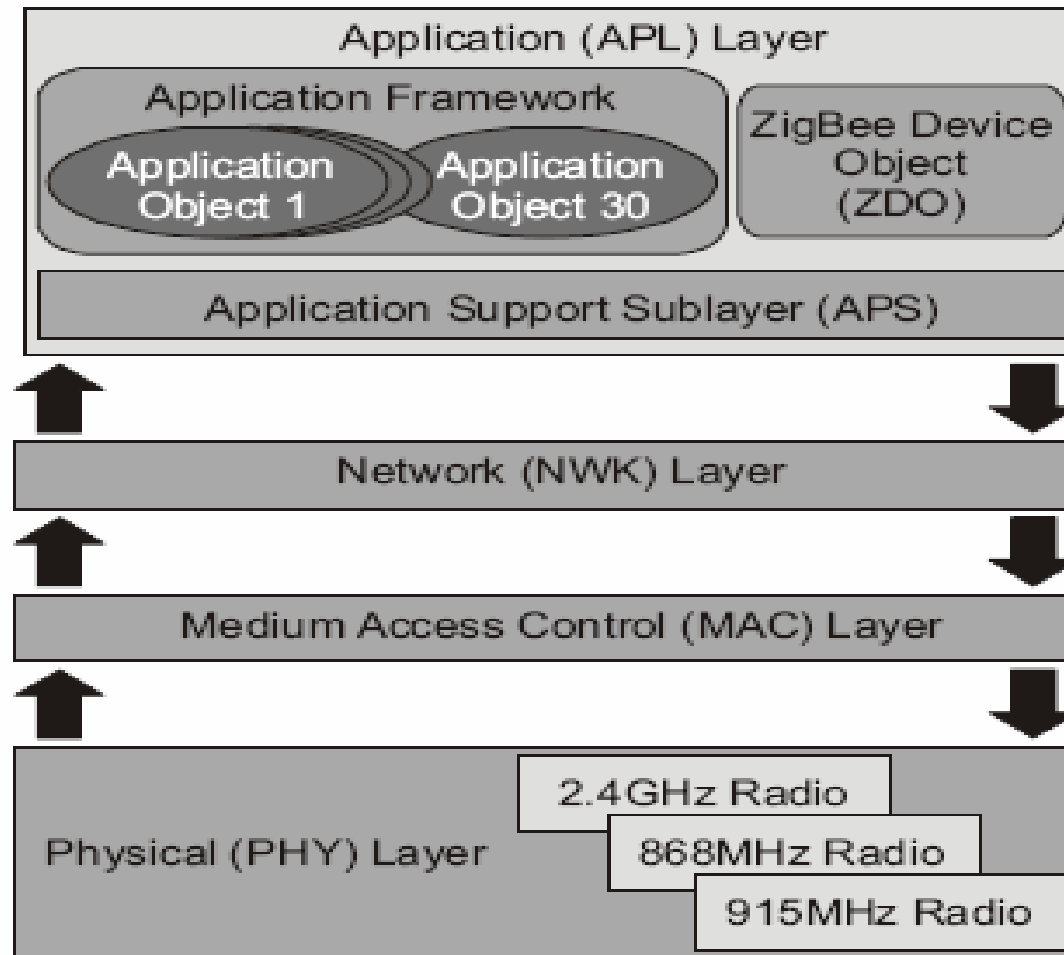
### **Services**

- MAC data service and MAC management service

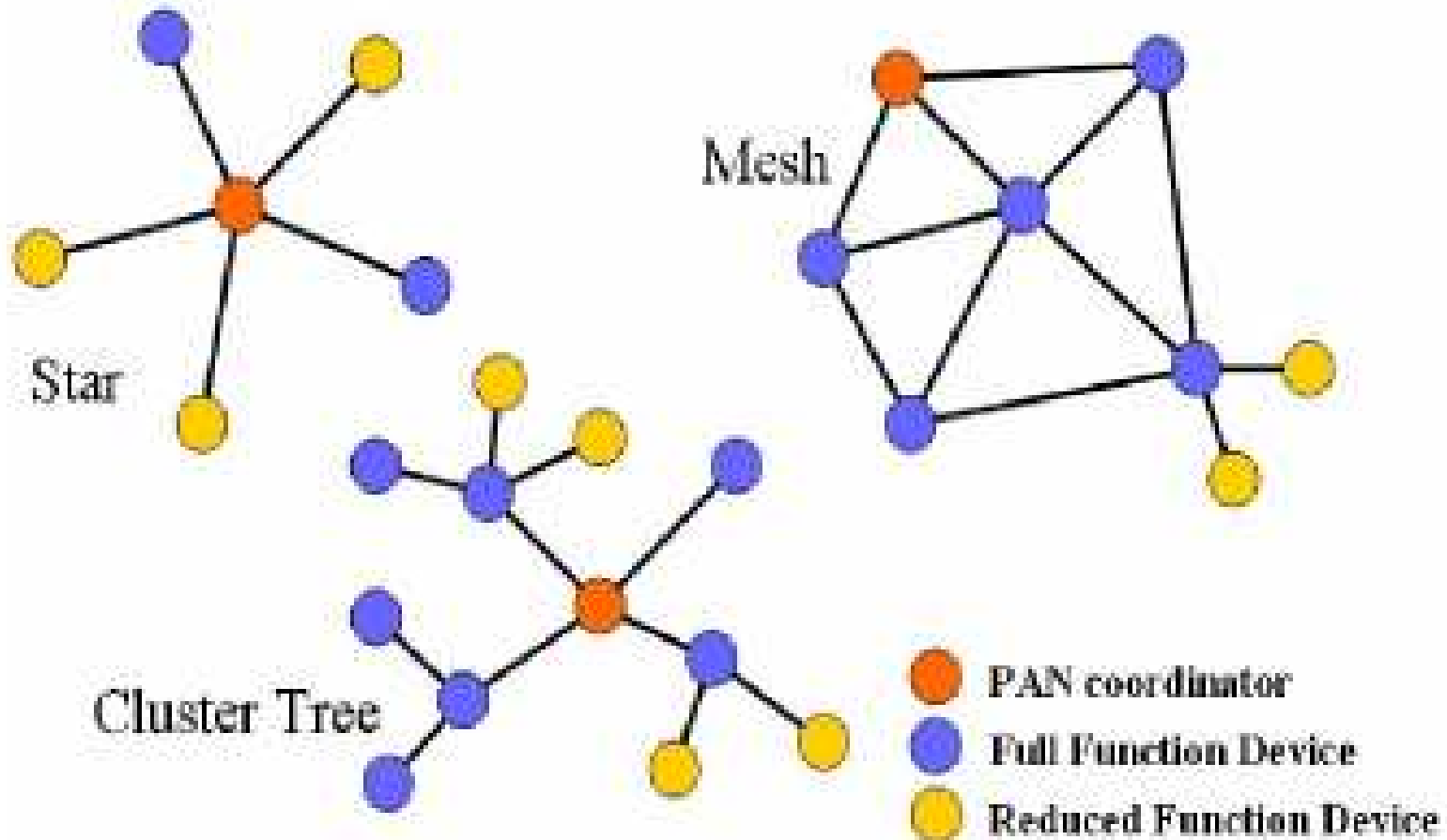
### **Functions**

- Enabling the transmission and reception of MPDUs
  - Beacon management
  - Channel access
  - Frame validation
  - Acknowledged frame delivery
  - Security certification
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# ZigBee Protocol Stack



# ZIGBEE NETWORK ARCHITECTURE





## DEVICE TYPES AND NETWORK TOPOLOGIES

### ∅ Network Coordinator

Most sophisticated of the three types

Maintains overall network knowledge

Requires the most memory and computing power

### ∅ Full Function Device (FFD)

Can function in any topology

Capable of being the network coordinator

Can talk to any other device

## DEVICE TYPES AND NETWORK TOPOLOGIES

### Ø **Reduced Function Device (RFD)**

Cannot become a network coordinator

Talks only to a network coordinator

Very simple implementation

## Traffic Types

ZigBee/IEEE 802.15.4 addresses three typical traffic types. IEEE 802.15.4 MAC can accommodate all the types

- ∅ Data is ***periodic***
  - The application dictates the rate
  - Sensor activates
  - Checks for data
  - Deactivates
  - Example: Sensing Temperature

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## Traffic Types

∅ Data is *intermittent*

- Application/stimulus determines the rate
  - Device is connected to the network only when communication is necessitated
  - Optimum saving on energy
  - Example: Smoke Detectors, Light Switch
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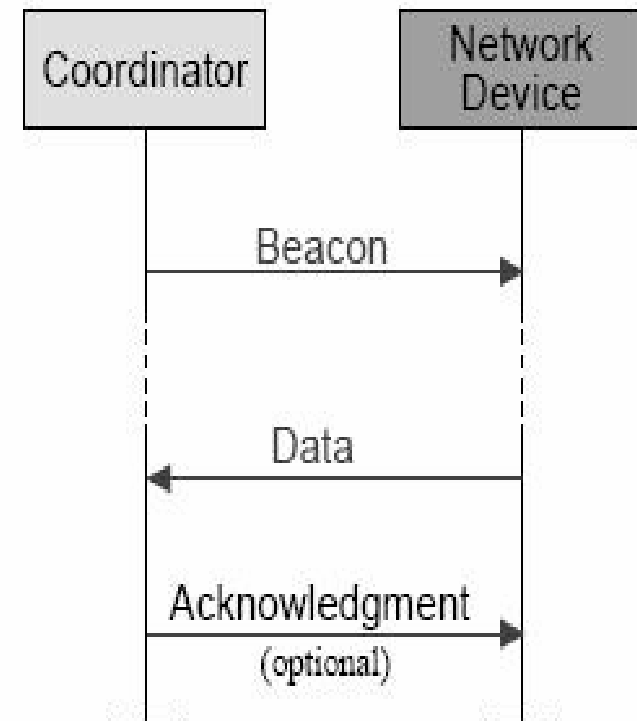
## Traffic Types

- ∅ Data is *repetitive*
  - Rate is fixed
  - Depending on allotted time slots, called GTS (guaranteed time slot), devices operate for fixed durations
  - Example: Mouse
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## Data Transfer Model

### ∅ Beacon mode

- Coordinator runs on batteries
- Offers maximum power savings
- Device watches out for the coordinator's beacon
- Locks on and looks for messages addressed to it
- Coordinator dictates a schedule for next beacon



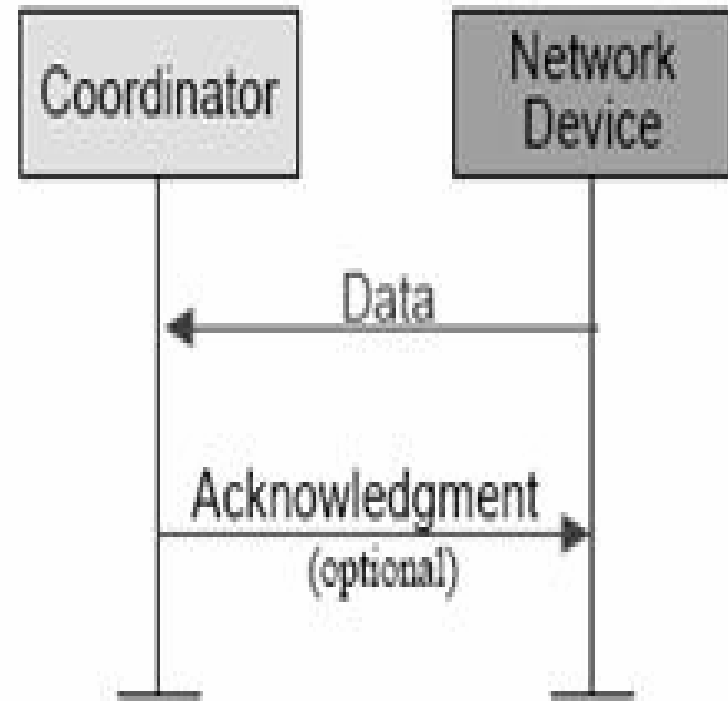
## Beacon Mode Features

- All the devices in a mesh network know when to communicate with each other
  - Timing circuits have to be quite accurate, or wake up sooner to be sure not to miss the beacon
  - Increase in power consumption by the coordinator's receiver, entailing an optimal increase in costs.
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## Non- Beacon Mode

### ∅ Non- Beacon Mode

- Coordinator is mains-powered
- Devices are 'asleep' nearly always





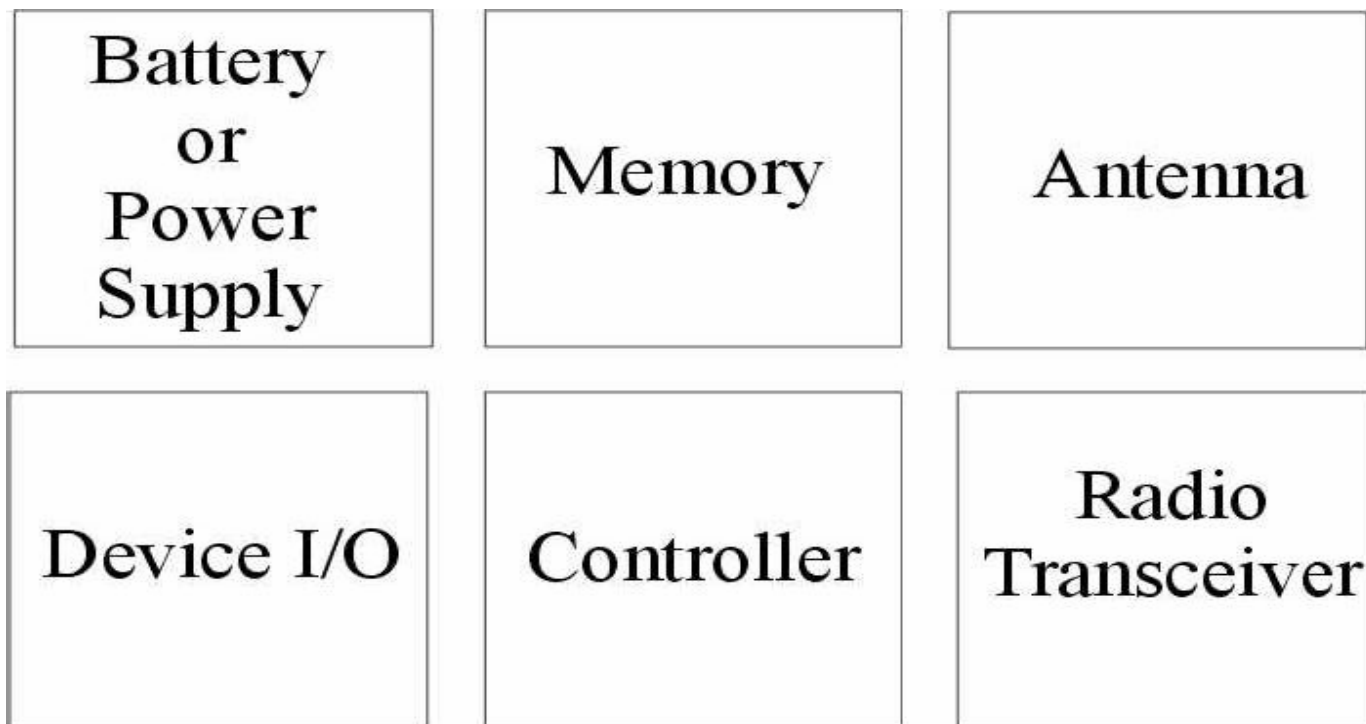
## Non- Beacon Mode

- Devices wake up to confirm their continued presence in the network at random intervals
  - On detection of activity, transmit to the ever-waiting coordinator's receiver
  - If channel is busy, receiver would miss a call
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## ZigBee Alliance

- Association of companies working together to enable reliable, cost effective, low power, wirelessly networked monitoring and control products based on an open global standard
  - Specify minimum firmware features for compatibility between devices from different manufacturers, and the compliance to the IEEE 802.15.4 standard
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## Architecture of a ZigBee device



## Security

Security Model of the IEEE 802.15.4 MAC sublayer specifies four security services

- Access control
- Data encryption
- Frame integrity
- Sequential freshness to reject data frames that have been replayed

## Application of ZigBee devices

- Wireless home security
- Remote thermostats
- Remote lighting
- Draper controller
- Personal healthcare



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## Application of ZigBee devices

- Advanced tagging
  - Automated meter reading
  - Wireless smoke detectors
  - Call button for elderly and disabled
  - Universal remote controller
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## Wireless Standard Comparisons

<b>Standard</b>	<b>ZigBee 802.15.4.</b>	<b>Bluetooth 802.15.1.</b>	<b>Wi-Fi 802.11b</b>	<b>GPRS/GSM</b>
<b>Application</b>	Monitoring & Control	Cable replacement	Web, video, e-mail	WAN, voice/data
<b>System resource</b>	4 kb-32 kb	250 kb+	1 Mb+	16 Mb+
<b>Battery life (days)</b>	100-1000+	1-7	0.1-5	1-7
<b>Nodes per network</b>	256/65 k+	7	30	1000
<b>Bandwidth (kbps)</b>	20-250	720	11000+	64-128
<b>Range (m)</b>	1-75+	1-10+	1-100	1000+
<b>Key attributes</b>	reliable, low power, cost effective	cost, convenience	speed, flexibility	reach, quality

## **Bluetooth is best**

For

- Ad-hoc networks
- Handsfree audio
- Screen graphics, pictures...
- File transfer

## **ZigBee is better**

If

- The Network is static
  - Lots of devices
  - Infrequently used
  - Small Data Packets
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Thank you

Any  
Questions?

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