

Wireless Sensor Networks

WSN is a network to cooperatively monitor physical or environmental conditions.

Networks of small, battery powered, wireless devices.

WSN needs to adapt to Human IoT and machine IoT.

→ MAC

Sensor networks are deployed in ad-hoc where individual nodes are inactive for a long time.

MAC needs to be different to traditional wireless MAC (energy conservation and self-config).

↳ solutions:

- carrier sensing
- RTS - CTS only during high traffic load
- Backoff

S-MAC (Sensor-MAC) is designed for WSN, nodes periodically sleep when others transmit. Trades energy efficiency for latency and lower throughput.

→ 802.15.4 and Zigbee

Zigbee? Designed for wireless controls and sensors. Operates in PANs and devices are small.

... and end devices, other packet devices.

low power, low cost, small packet, low throughput, almost no QoS services.

How Zigbee works?

Star, Cluster tree or Mesh network, routers and end devices, active or sleep states of operation, beacon and non-beacon modes of operation, different traffic-types.

↳ Traffic types:

- **periodic** data (sensors)
- **intermittent** data (stimulus dictate rate)
- **repetitive** data (guaranteed time slot)

↳ Traffic modes:

- **Beacon mode** (sent periodically, low energy consumption, precise timing, coordination and device can go to power save)
- **Non-beacon mode** (no beacon sent, coordination (routers have to stay awake, asymmetric power, heterogeneous network).

↳ Node types

- **Coordinator** ^{layer 2 BC} (only one, initiates network,

stores info, all communicate with it, routing, bridge to other networks)

- **Router** (ZBR, optional, routes between nodes, extends nw coverage, manages local addresses)
- **End Device** (ZBE, low power, cheapest)

→ 802.15.4 / ZigBee Architecture

↳ 802.15.4 basics

- 802.15.4 simple packet data protocol for lightweight wireless networks.
- Channel access via Carrier Sense Multiple access with collision avoidance.
- multi-level security
- message ack and optional beacons
- maximum battery life.

↳ PHY frame structure

- Packet fields :
- Preamble (32 bits)
 - Start of packet delimiter (8 bits)
 - PHY header (8 bit)
 - PSDU → data field (0-127 bytes)

↳ 802.15.4 MAC Design Drivers

- low cost
- ease of implementation

- reliable data transfer
- short range operation
- low power consumption

2 classes : FFD \rightarrow full function device
(talks to any device)

RFD \rightarrow reduced function device
(only talks to coordinator)

4 types of MAC frames :

- data
- beacon
- ACK
- MAC command

is transmitted by the network coordinator to inform other devices about the existence and parameters of the network

is sent by the recipient of a Data Frame to confirm successful reception.

\rightarrow **Superframe** (used by coordinator)

Divided into 2 parts:

- Inactive: all devices sleep (including itself)
- Active: active period divided into 16 slots (each has contention access period and contention free period)

Beacons are used to start superframes, sync with associated devices, announce PAN.

In beacon enabled network, devices use slotted **CSMA/CA** mechanism to contend for channels

Structure of superframe is controlled

by beacon order (BO) and superframe order (SO).

↳ GTS concepts

A guaranteed time slot (GTS) allows a device to operate on the channel within a portion of the superframe, only allocated by PAN coordinator, up to 7 GTS at a time, based on requirements and availability.

GTS can be deallocated and data frame transmitted in allocated GTS use only short addressing.

Before GTS starts, has to be specified as either transmit or receive, and each device must only request one transmit GTS and/or one receive GTS. If it loses connection (sync), loses all GTS allocations.

↳ Channel access mechanism (CSMA/CA)

2 types:

- in non-beacon network → unslotted CSMA/CA
- in beacon enabled net → slotted CSMA/CA

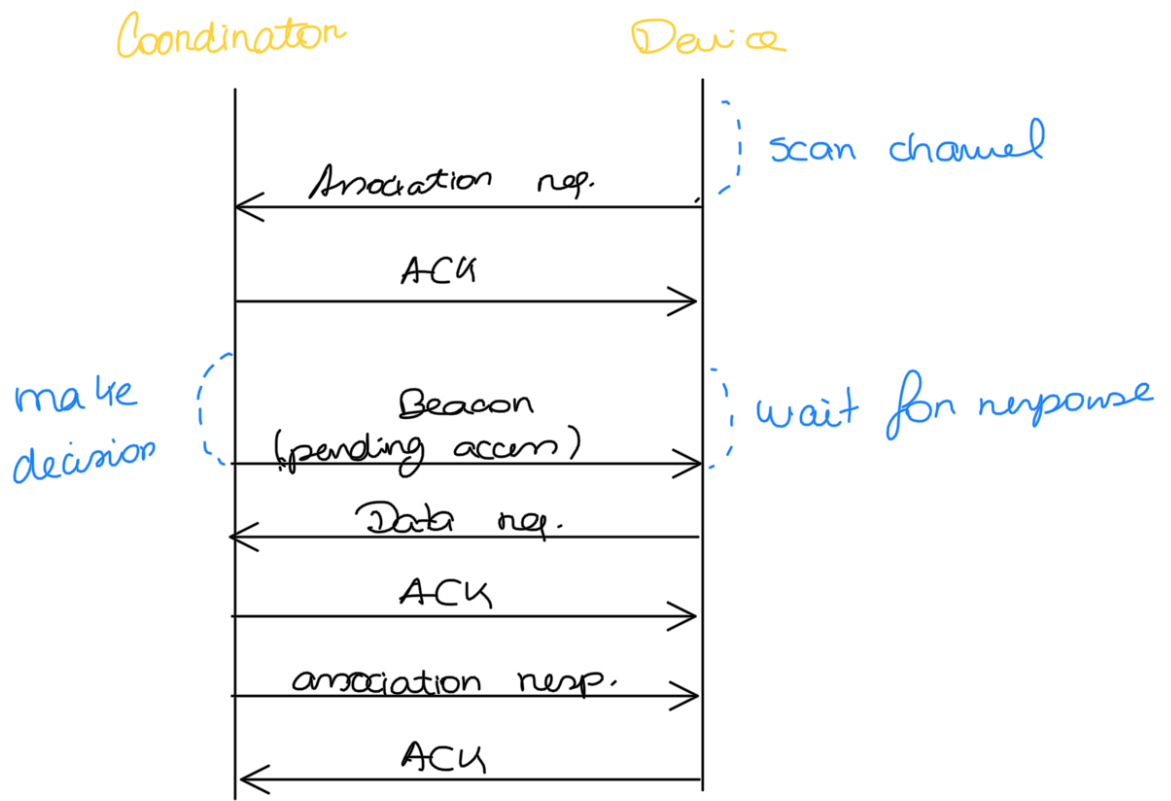


backoff periods need to be aligned with superframe slot boundaries

PHY layer commences all transmissions on the boundary of a slot

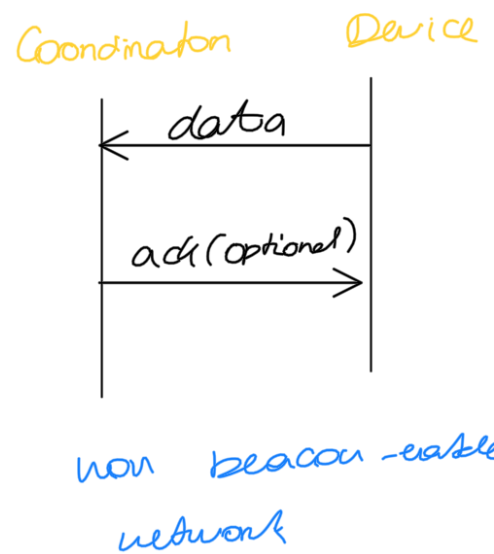
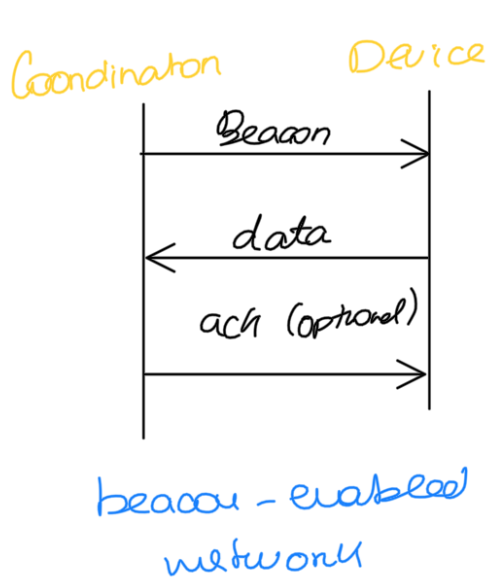
duration of a busy period.

↳ Association procedure



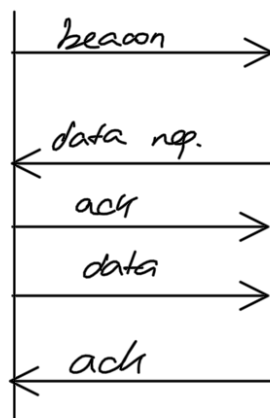
↳ Data transfer model

→ Device to coordinator



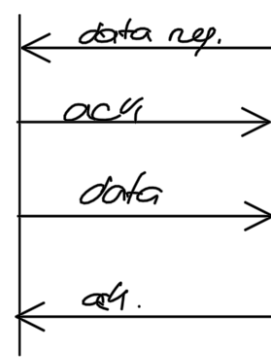
→ Coordinator to device

Coordination Device



beacon - enabled

Coordination Device



non beacon - enabled.