Medium Access Control for Wireless Sensor Networks

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Data Link Layer

- Logical Link Control
  - Flow Control

- MAC
  - Control access to the shared medium
  - Avoid interferences between transmissions
  - Basic Mechanisms
    - Carrier Sense (Contention)
    - Time Division (Schedule)
Contestion-Based MAC Protocols

  - Send when ready
  - If message collides, retransmit
  - Sub-optimal channel utilization

- **CSMA (Carrier Sense Multiple Access)**
  - “Listen before talk”
Hidden Terminal Problem
CSMA/CA

CS
RTS
CTS
DATA
ACK
Blocked
Time
Schedule-Based MAC Protocols

- Time-Division Multiplexing
  - Communication is scheduled by a central authority (Access Point)
  - No contention, no overhearing
  - No direct communication between nodes
  - Access point broadcasts Traffic Control map
  - New nodes request frames in Contention Period

<table>
<thead>
<tr>
<th>Frame 1</th>
<th>Frame 2</th>
<th>Frame 3</th>
<th>Frame 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC</td>
<td>Downlink</td>
<td>Uplink</td>
<td>CP</td>
</tr>
</tbody>
</table>
MACs for Sensor Networks

- **Nodes**
  - Limited hardware resources
  - Powered by *batteries*
  - Energy efficiency is the main objective
    - Turn off the radio whenever possible!

- **Main sources of overhead**
  - Idle listening
  - Collisions
  - Overhearing
  - Protocol overhead
  - Traffic fluctuations
Comm. Hardware: Orinoco S (802.11)
Comm. Hardware: ZV4002 (802.15.1)
Comm. Hardware: CC2420 (802.15.4)
Comm. Hardware: CC1000

Data Rate (kbps) vs. RX Power (mA) vs. TX Power (mA) vs. Standby Power (uA)

TX Power (mA) 12

RX Power (mA) 4 6 16 256

Data Rate (kbps) 106 1092 11250

Standby Power (uA) 3
Comm. Hardware: TR1000

- TX Power (mA)
- RX Power (mA)
- Standby Power (uA)
- Data Rate (kbps)
Communication Hardware

- TX Power (mA)
- RX Power (mA)
- Standby Power (uA)
- Data Rate (kbps)

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Communication Hardware: CC1000

- UHF FM Transceiver
  - Variable Frequency
  - Frequency-Shif Keying modulation (FSK)
  - Manchester of NRZ (Non-Return to Zero) encoding
  - Received Signal Strength Indicator (RSSI)
  - Programmable TX Power
EPOS: RF Transceiver Family

```
RF_Transceiver
+ config(int freq, int power): void
+ enable(): void
+ disable(): void
+ int_enable(): void
+ int_disable(): void
+ tx_mode(): void
+ rx_mode(): void
+ put(char c): void
+ get(): char
+ rssi(): int
+ id(): Reg64
```

Diagram:

```
RFM1000
CC2420
CC1000
- init(): void
- calibrate(): void
```
EPOS: CC1000 Mediator

Registers

Parameters

RSSI

+ config(int freq, int power): void
+ enable(): void
+ disable(): void
+ int_enable(): void
+ int_disable(): void
+ tx_mode(): void
+ rx_mode(): void
+ put(char c): void
+ get(): char
+ rssi(): int
+ id(): Reg64
  - frequency(int f): void
  - calibrate(): void
  - init(): void

CC1000

Serial_ID

+ id(): Reg64

SPI

+ get(): char
+ put(char c): void
+ int_enable(): void
+ int_disable(): void

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MACs for Sensor Networks: LPL

- Low Power Listening
  - Long preamble
  - Short sample

```
TX ___________________________ Preamble | Message
```

```
RX
```

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Low Power Listening: State Machine
EPOS: Low Power Radio