An IoT-oriented Monitoring System for Smart Agriculture Applications

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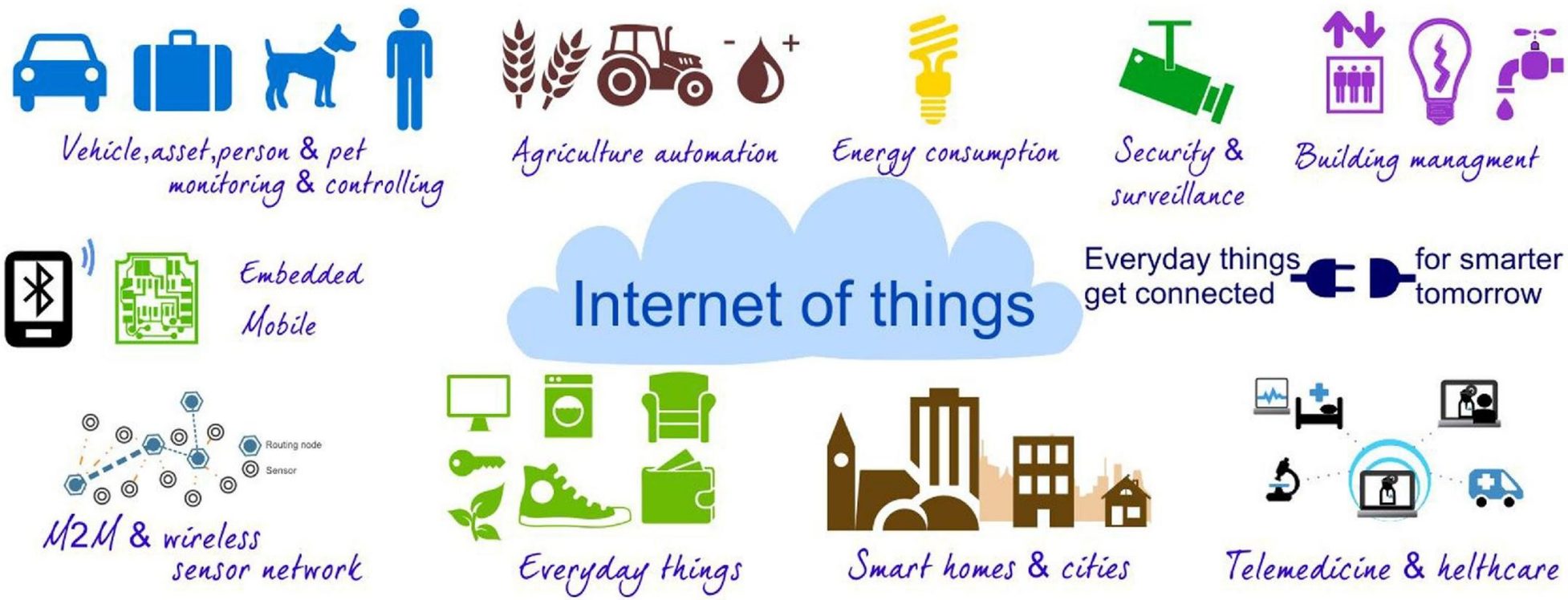
Outline

- Introduction on IoT in the context of Smart Farming
- Wireless Sensor Networks (WSNs)
- Proposed architecture
- Future developments

Introduction

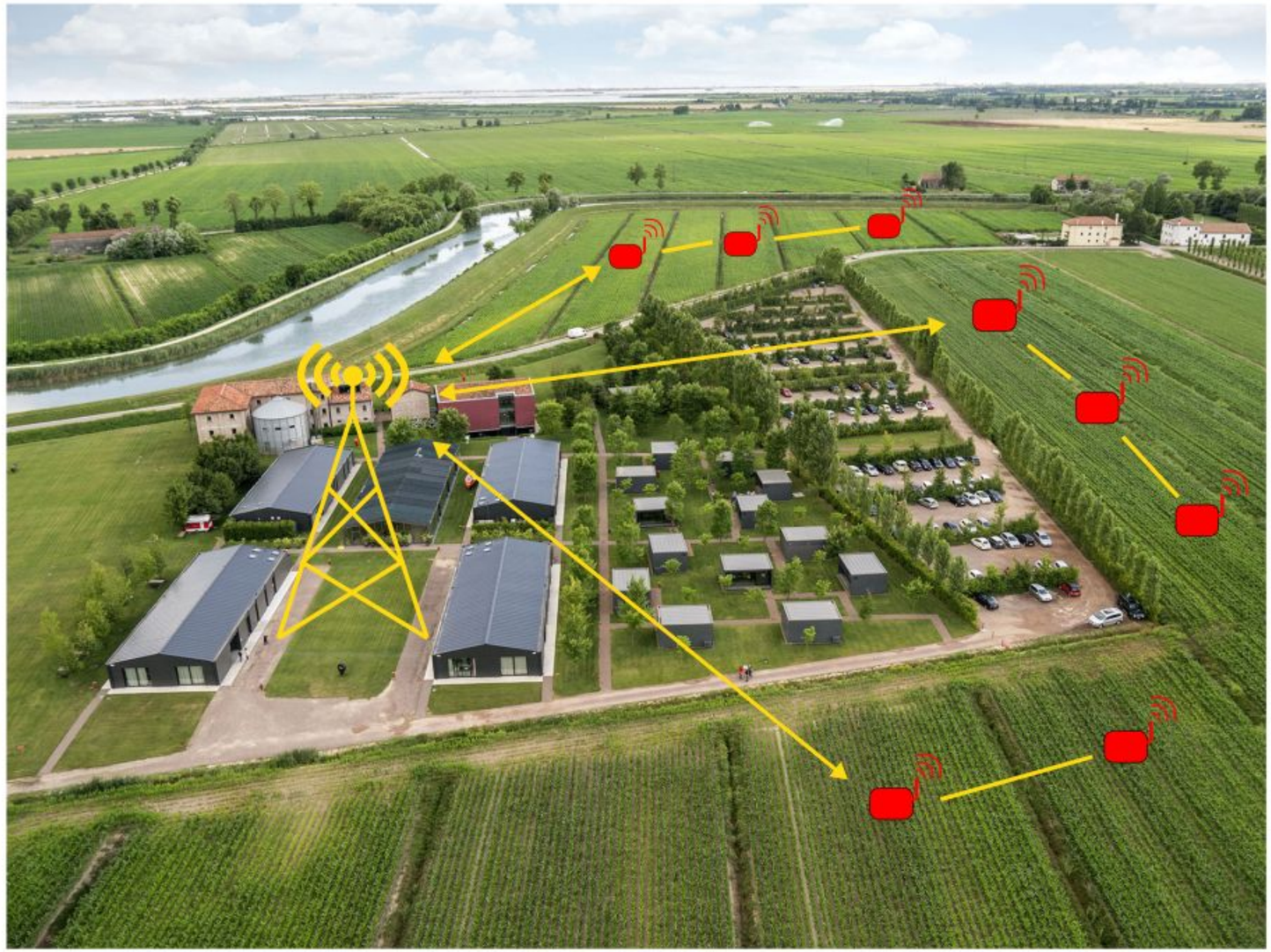
Highest opportunities in:
Smart Cities, Healthcare and Smart Agriculture



Farmers operate with sensors, drones, ….

Necessity of a dedicated IoT infrastructure

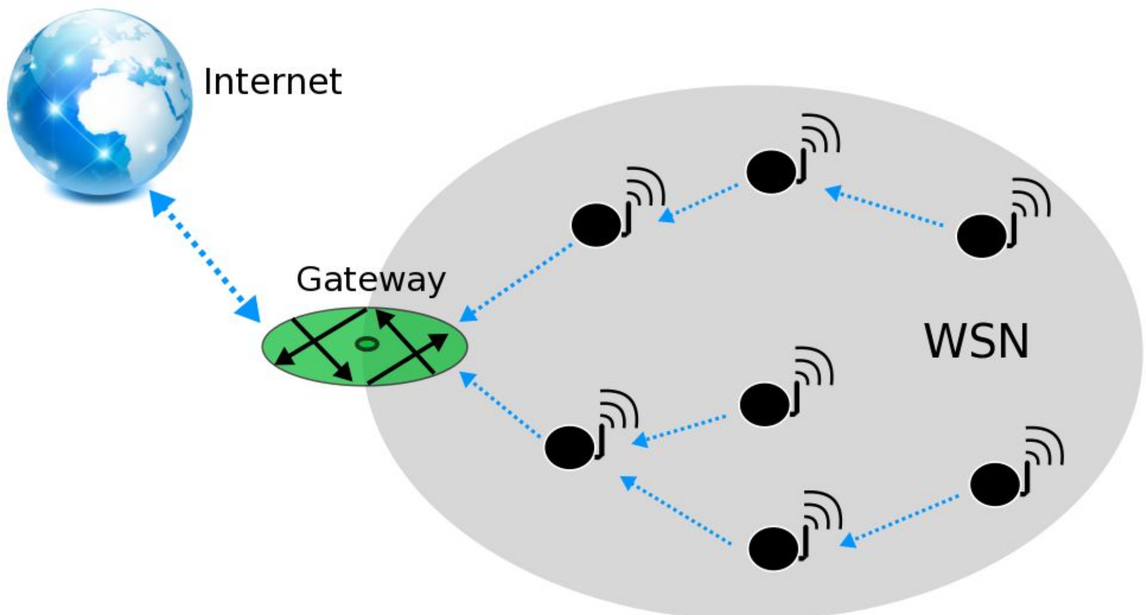
Smart Farming



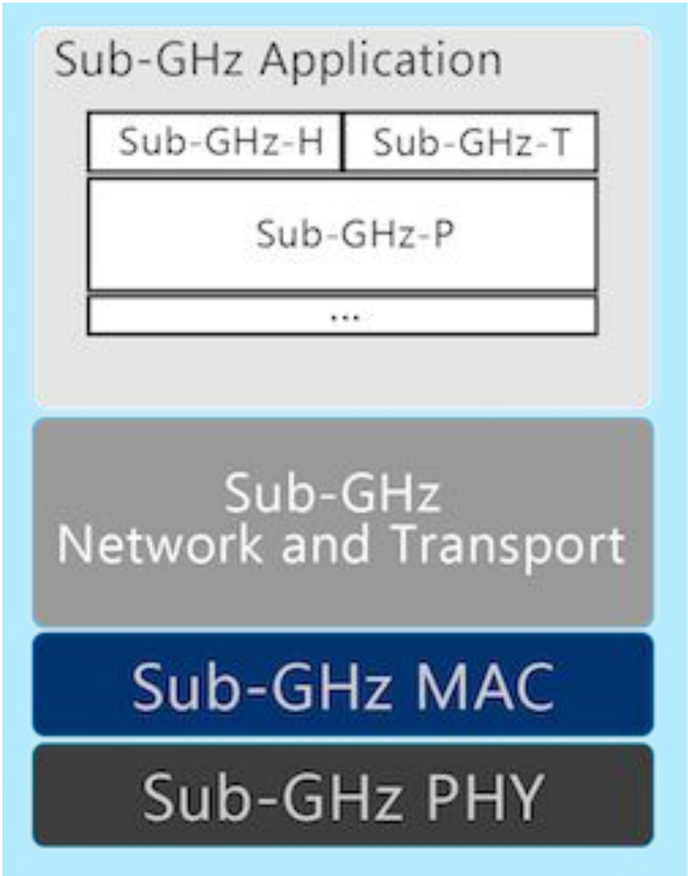
Agriculture is the field of study that is more suited to the implementation of these technologies and the one that will benefits more from them in the next years.

Wireless Sensor Network (WSN)

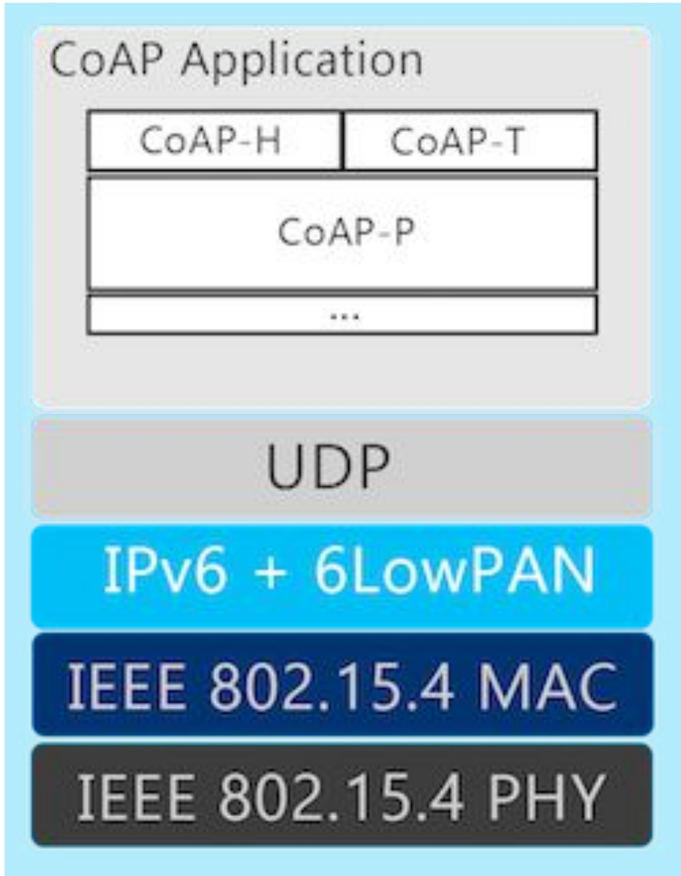
- Highly distributed networks of small, lightweight wireless nodes
- May be composed of hundreds or thousands devices
- Node
  - Sensing
  - Processing
  - Communication
- Monitors the environment or system by measuring physical parameters



WSN Stack



Sub-GHz stack



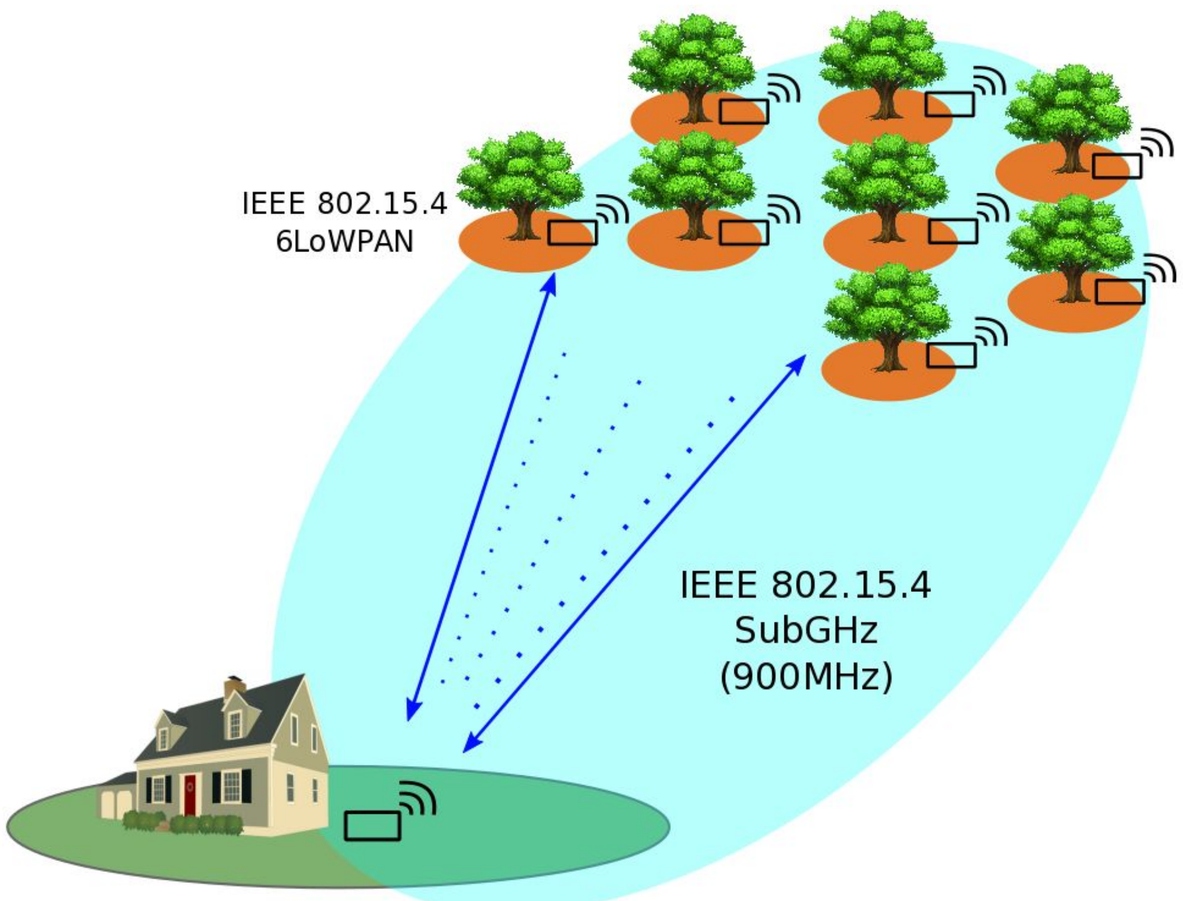
IEEE 802.15.4 stack

Requirements

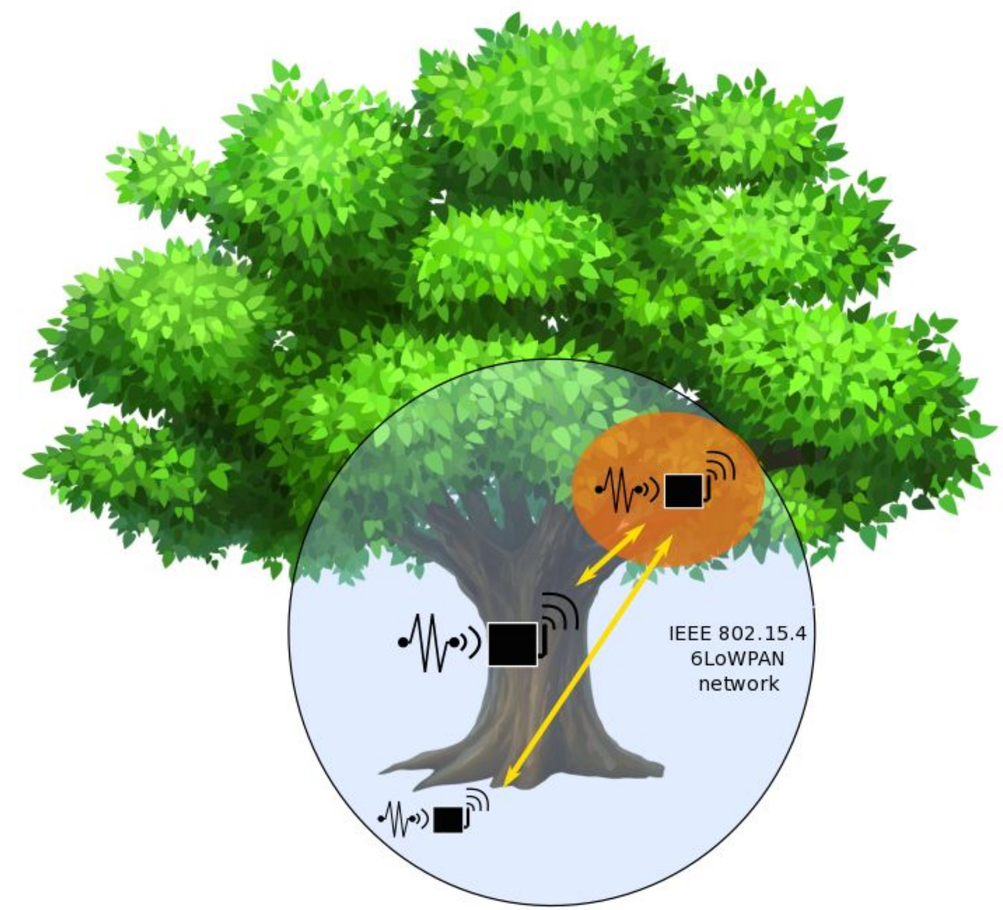
- Weather resistant
- Reduced intrusiveness
- Open source
- Modularity
- Scalability (storage)
- Real-Time
- Inexpensive

IoT Network Structure

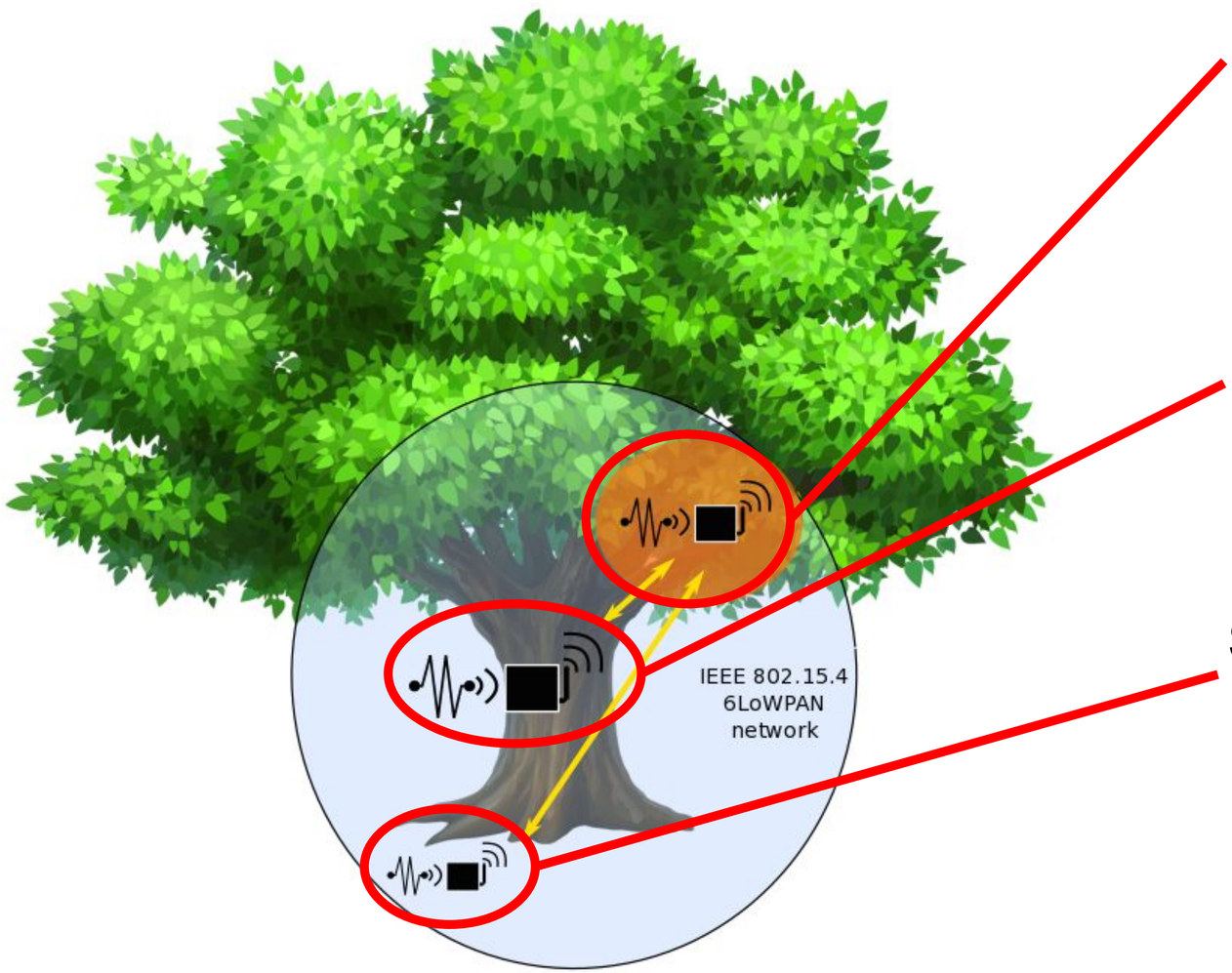
Sink ↔ crops network



WSN on a single tree



Local WSN



Sink and wind sensor

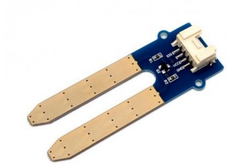
- Parallax MMA7455

Air temperature / humidity sensor

- DHT 22

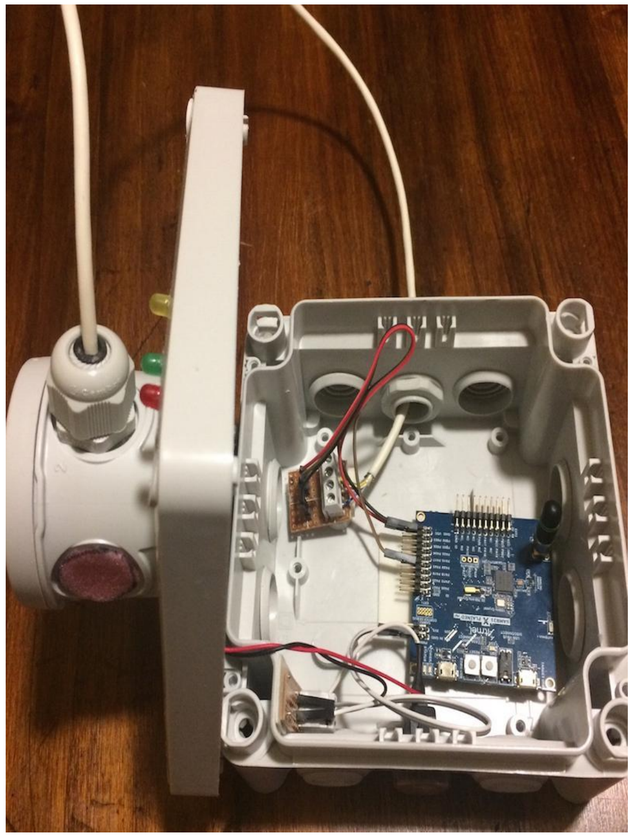
Soil moisture sensor

- SeeedStudio Grove



WSN - Temperature/Humidity Node

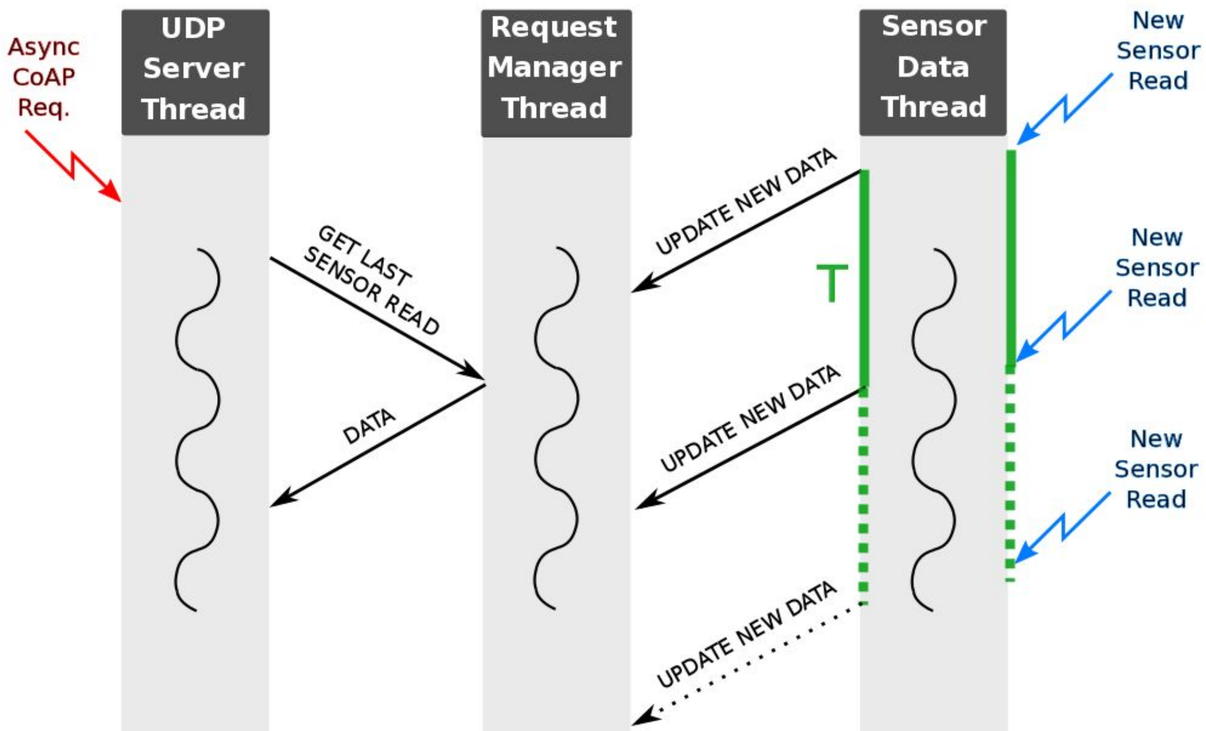
- Based on Atmel SAM R21 XPro board
- Compliant with IEEE 802.15.4
- Running RIOT operating system
- Sampling at regular intervals from DHT22 sensor
- Different processing threads
  - **Request Manager Thread** responsible to initialize the board and generate secondary threads



WSN - Temperature/Humidity Node

- **Sensor Data Thread**
  - Retrieve data from sensors (16-bits temperature, 16-bits humidity, 8-bits checksum)
  - BIN-to-DEC conversion and adaptation

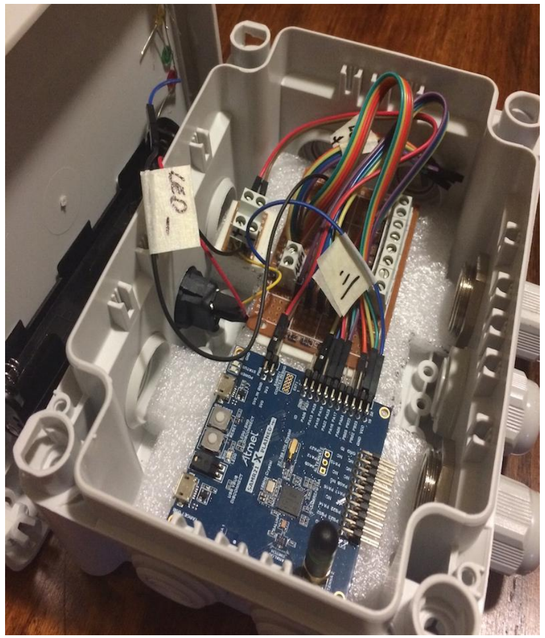
- **Request Manager Thread**
  - Request dispatcher distinguishing:
    - Incoming messages from the UST, with NULL content, asking for the last sensor data
    - Messages originated by the SDT, containing the last values read from the sensor → Local cache for speeding up the response



WSN - Soil Moisture Node

- Based on Atmel SAM R21 XPro board
- Sampling from SeeedStudio Grove sensor

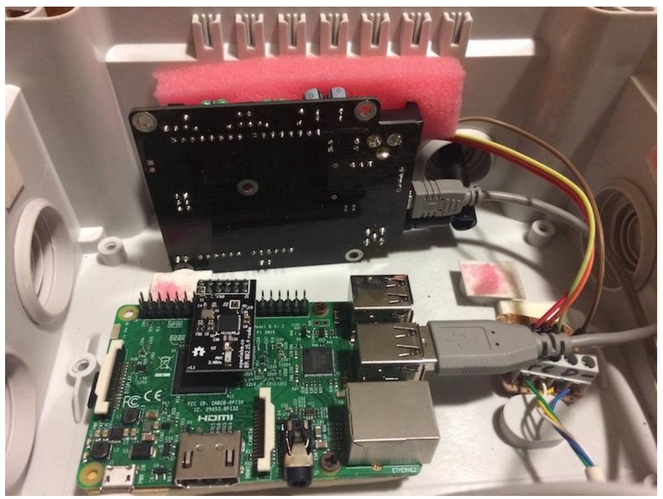
- Visual feedback system based on 3 blinking led colors
  - ***Red***: initializing mode
  - ***Green:*** board initialized, starting the control loop
  - ***Yellow:*** reading sensor



WSN - Local Sink and Wind Intensity Node

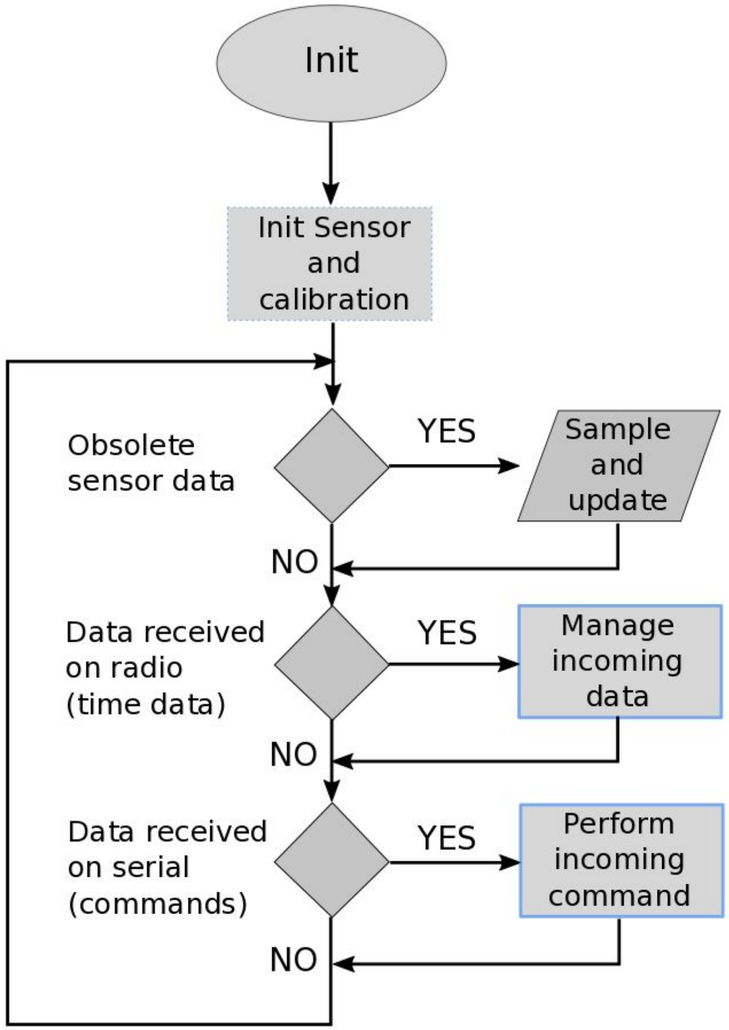
- Dual function
  - Border router for the local IEEE 802.15.4-based network
  - Gateway for interactions with remote sink (through the Sub-GHz network interface)

- Based on Raspberry Pi3 board
- NoSQL MongoDB database instance
- OpenLabs IEEE 802.15.4 transceiver
- Freakduino 900LR Sub-GHz node
- Sampling from 3-axis Freescale MMA7455 accelerometer sensor



WSN - Local Sink and Wind Intensity Node

- Accelerometer sensor initialization
- Control loop initialization
- Sensor data updating
- Incoming data from Sub-GHz channel handling
  - Command *T*: synchronization request to farmer's sink, in order to obtain the updated timestamp (chronological order of sensed data)
- Manage incoming data from serial channel (as local sink node)
  - Command *D*: request for latest 3-axes wind samples (through the Freakduino interface)



Remote Sink Node

- Gathers all crop-related data coming from each WSN
- Placed at the farmer's house

- Based on Raspberry Pi3 board
- Freakduino 900LR board, providing Sub-GHz communication

- CoAP server
  - List of the monitored plants, through service and resource discovery mechanisms
  - Enables external CoAP clients to request information on each monitored plant on different WSN

Future developments

- Adoption of a routing protocol for local WSNs (e.g., RPL)
- Heterogeneity of sensors data
- Data visualisation
- Data analysis (Big Data, Business Intelligence, ….)
- Alternative long-range communication protocols (LoRA, Sigfox, ….)
- Alternative boards
- Business analysis on the proposed IoT architecture

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