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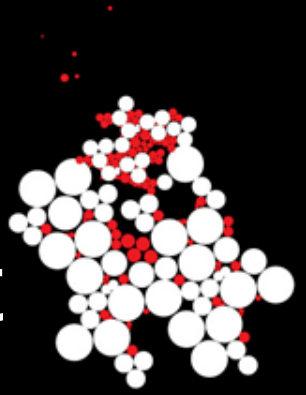

Evaluation of DECT-ULE for Robust Communication in Dense Wireless Sensor Networks

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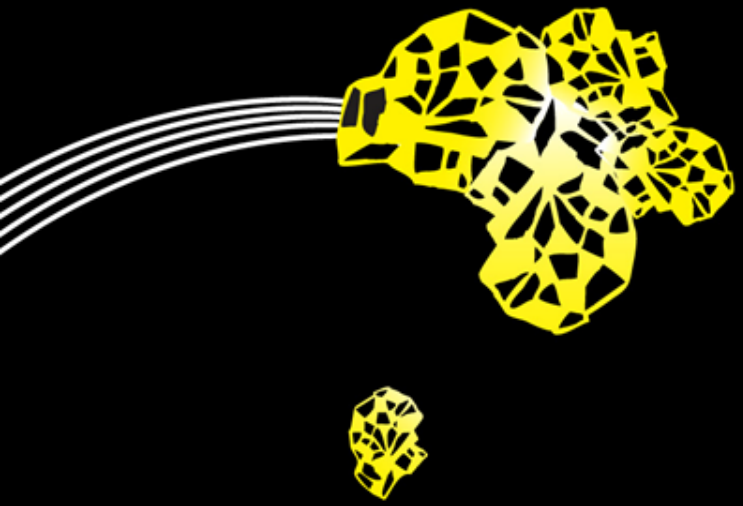

Internet of Things: Our context

Distributed sensing
Wireless control
Localization

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Challenges

- Cover a large area
- Communication reliability
- Real-time communication

Challenges

- Cover a large area
  - Star/tree network (long range communication)
    - High transmission power
    - Infrastructure
  - Mesh network (multiple hops)
    - Introduce additional delay
    - Scheduling technique

Challenges

- Communication reliability
  - Choosing a less crowded frequency band
  - Dynamic channel allocation
  - MIMO

Challenges

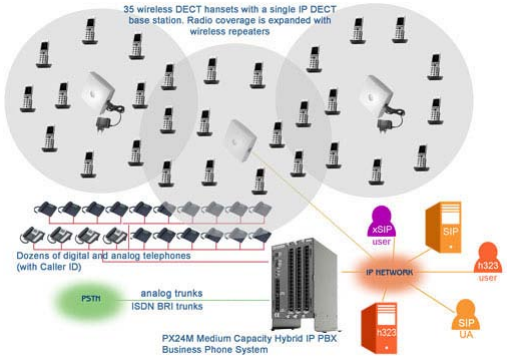
- Real-time communication
  - Scheduling

Conventional standards for WSN communication

- IEEE 802.15.4
  - ZigBee, WirelessHART (on top of PHY & MAC), ISA 100.11a
- Use 2.4 GHz unlicensed band
  - High interference
- CSMA based
  - Delay in the packet reception
- Star or mesh topology
- Low transmit power
  - Low communication range (10-30 m)

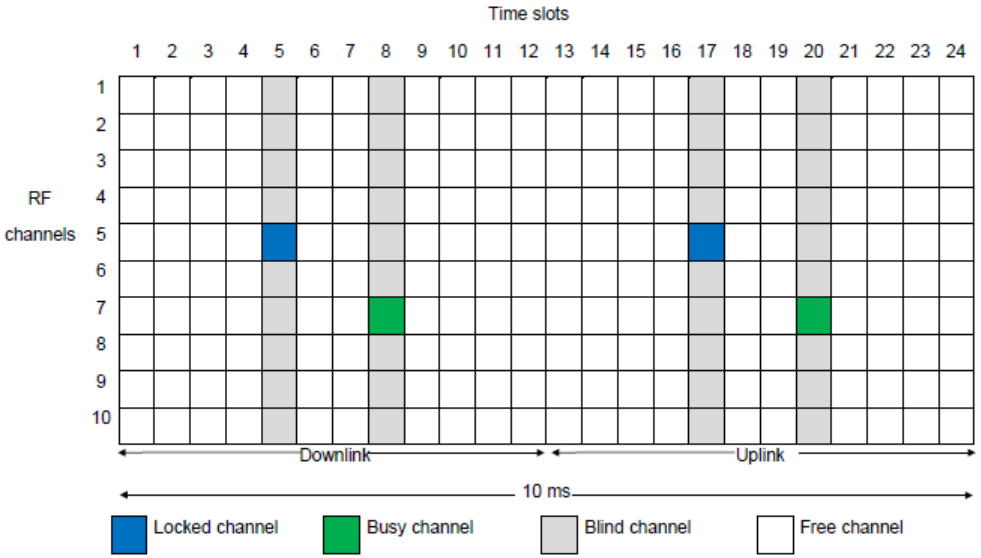
What is DECT and why?

- Digital Enhanced Cordless Telecommunications (DECT)
  - Primarily used in cordless voice communication
  - DECT PHY uses the different frequency band in different parts of the world
    - In Europe- 1.9 GHz licensed and royalty free
    - In US- 1.92 GHz-1.93 GHz



Features of DECT

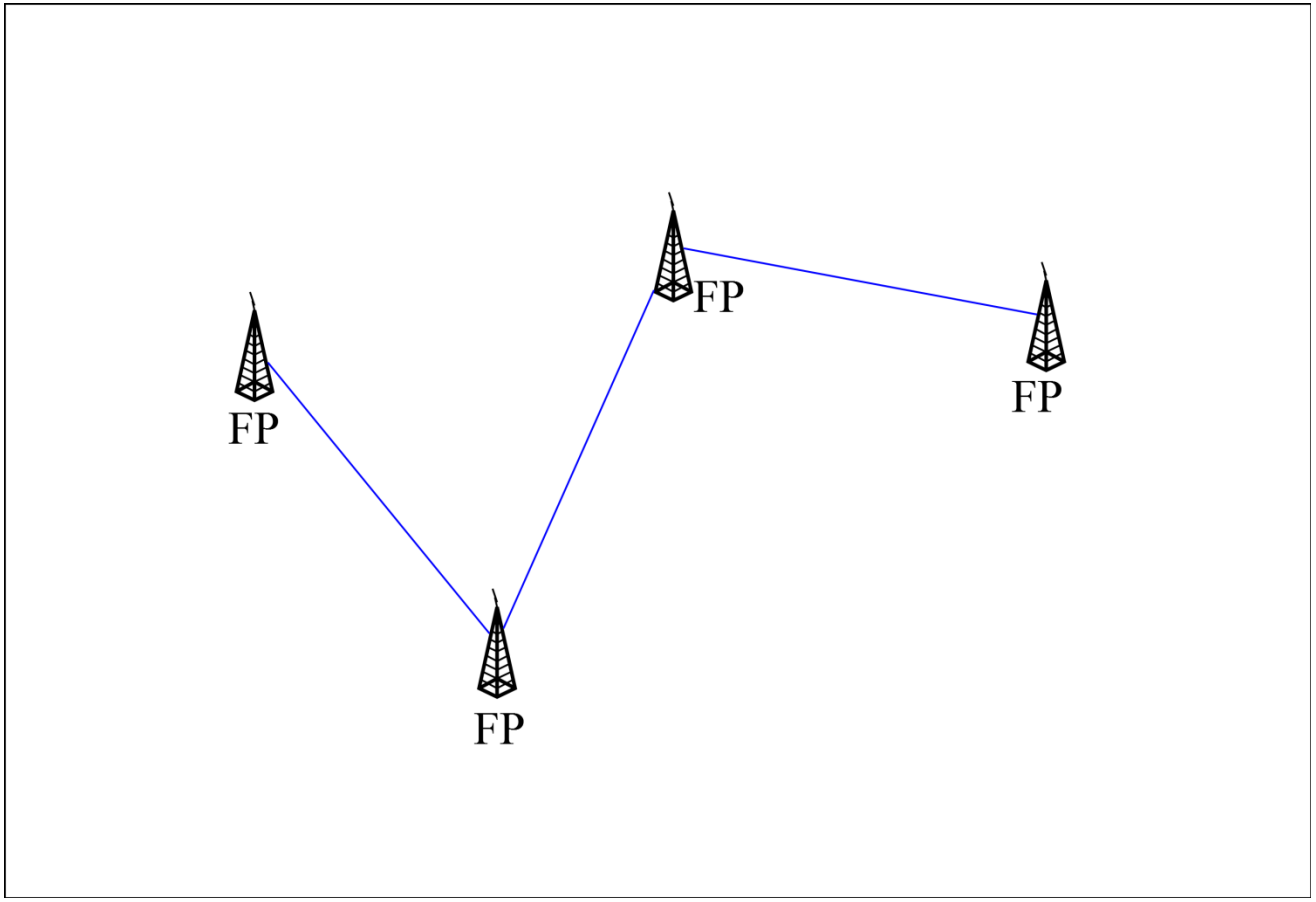
- DECT frequency / time spectrum
  - o Use same frequency channel for uplink & downlink
  - o 120 channels for communication
  - o Max data rate 1152 kbps
  - o Can handle 12 simultaneous call per base station



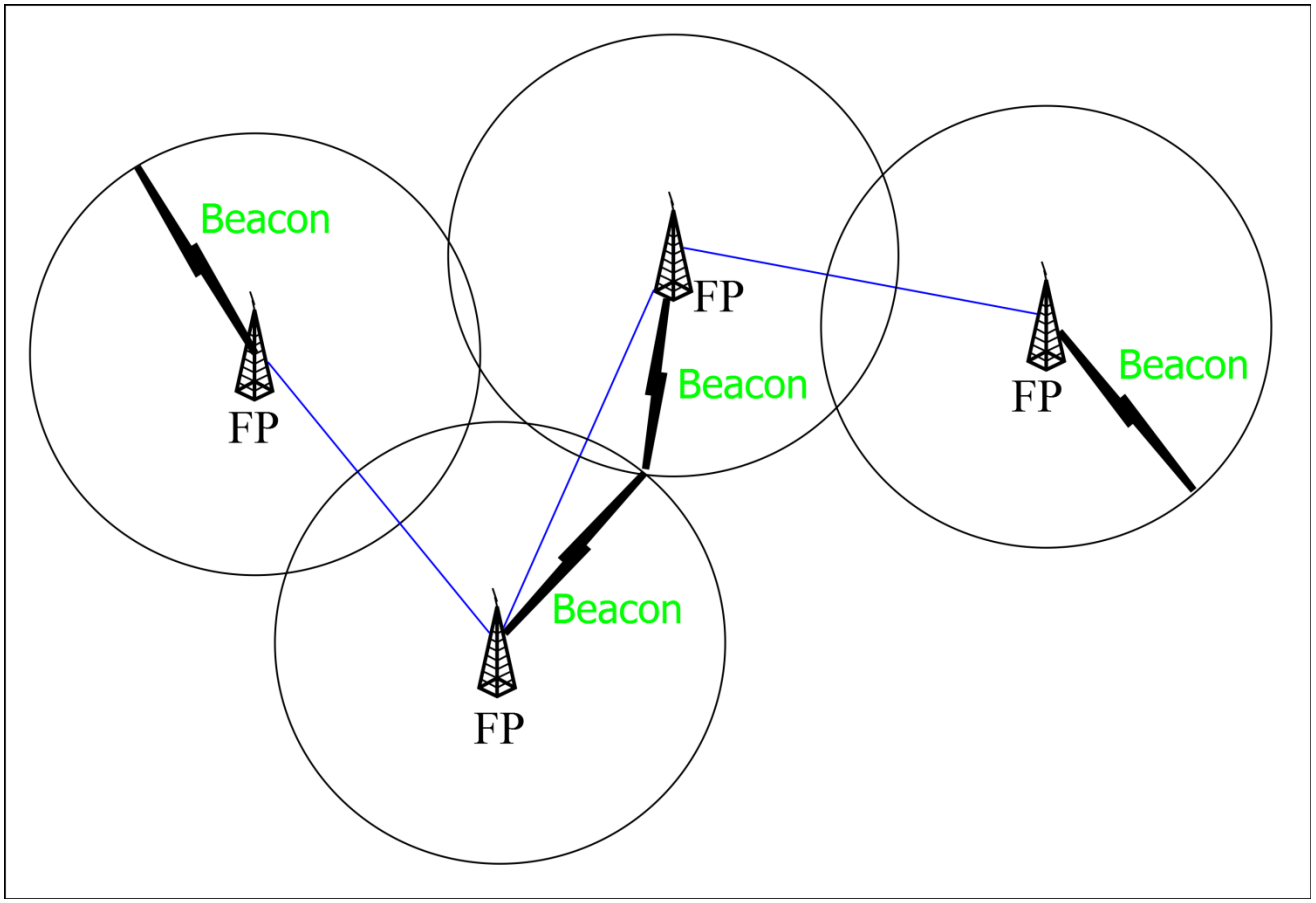
DECT ULE : The low power version of DECT

- Capable to go into long sleep mode without losing synchronization (upto 20 seconds)
- Low sleep current consumption (~3 μA)
- Can operate years (typically 5-10 years) on a single battery (considering 20 sec of sleep time)
- Force wake up mechanism in case of urgency

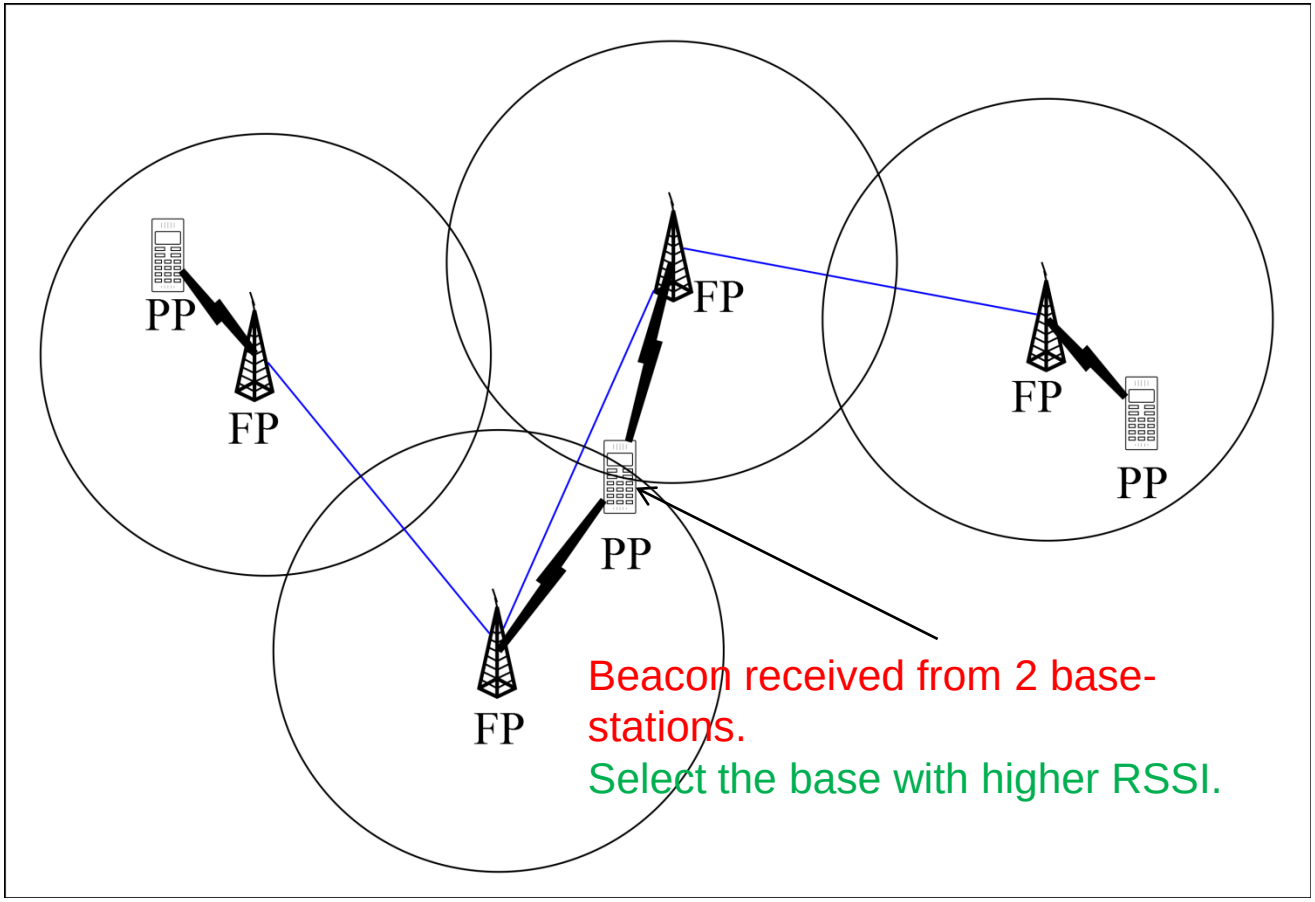
DECT operation principle



DECT operation principle



DECT operation principle



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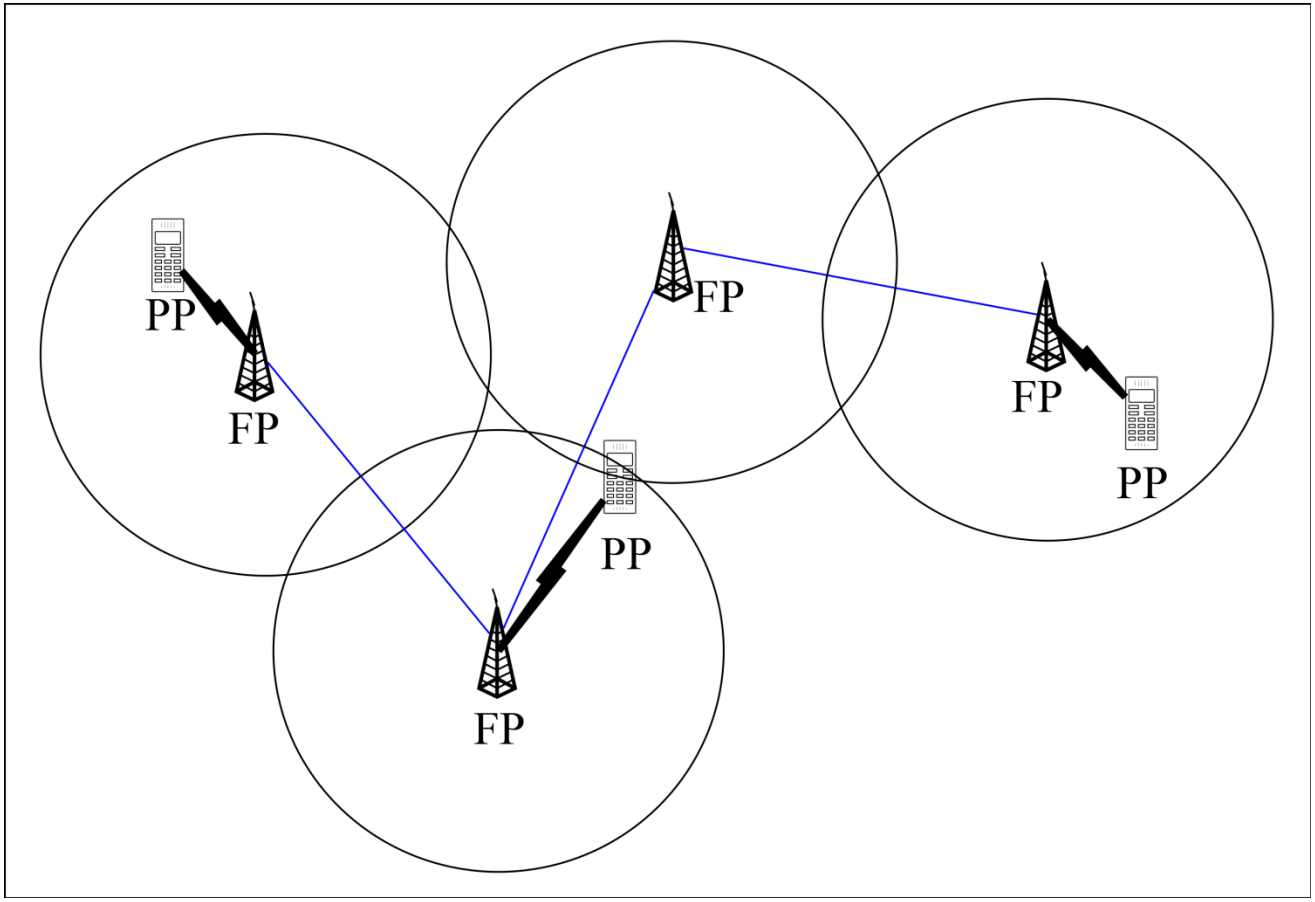
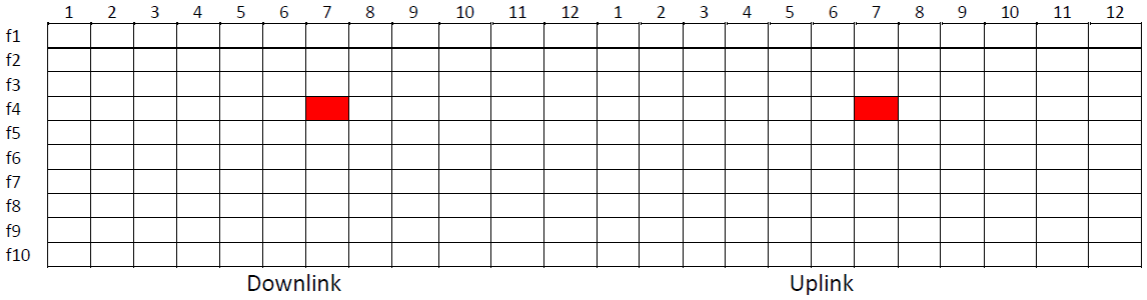


Dynamic channel allocation of DECT

We refer the connection attempt from a PP to base as a call



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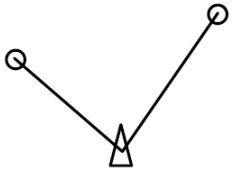

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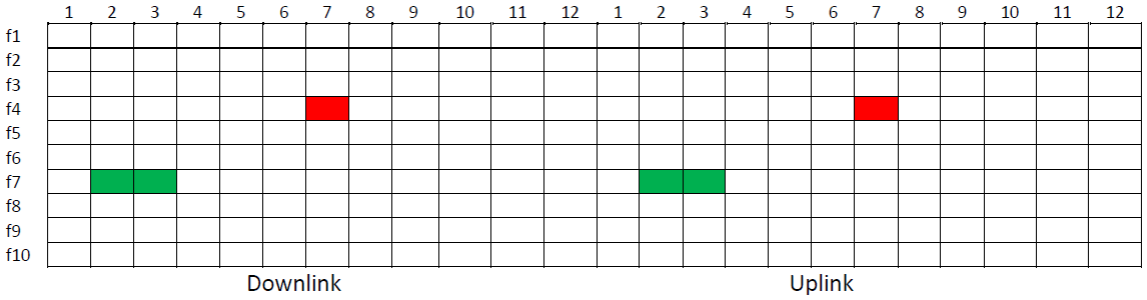

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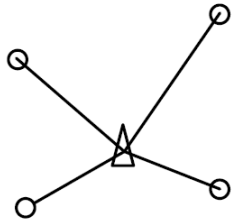

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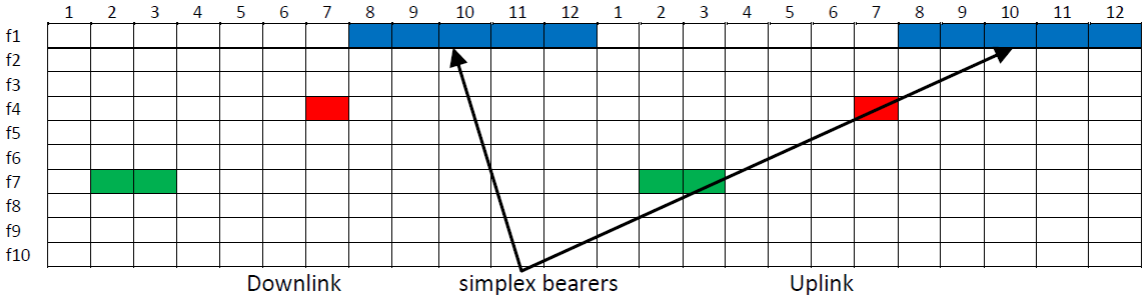

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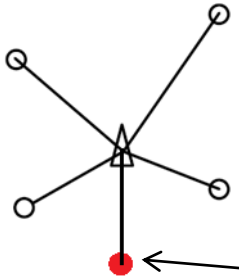
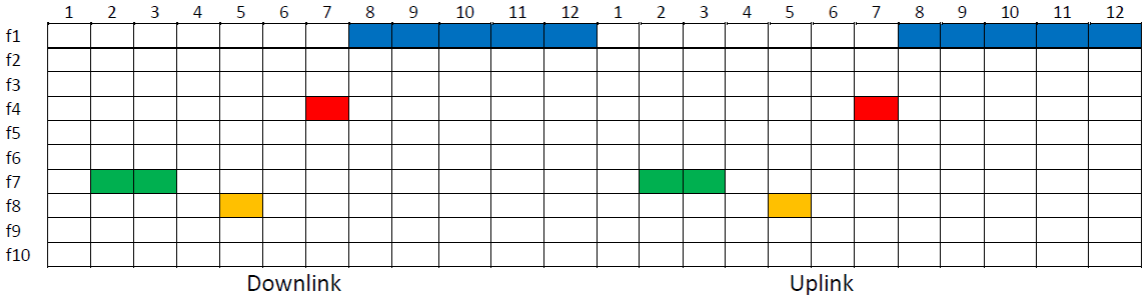


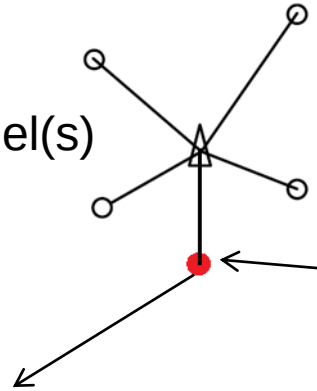
We refer the connection attempt from a PP to base as a call

This new PP needs 2 slots for communication



Dynamic channel allocation of DECT

Can try to select another channel(s) on the same or other base



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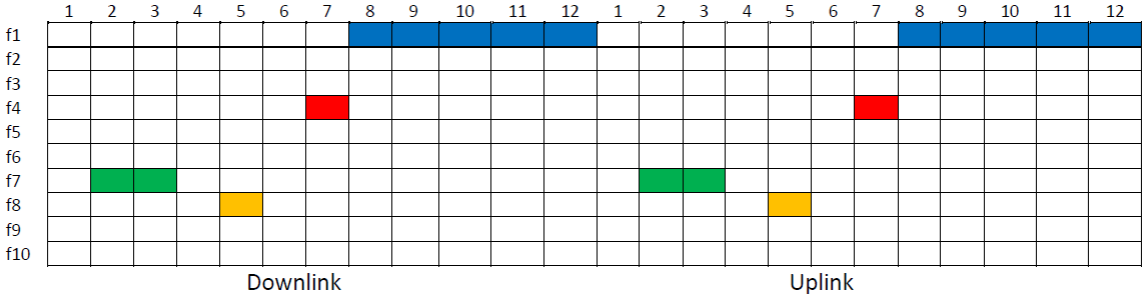
Channel selection failure



Dynamic channel allocation of DECT

If it fails after trying 3 bases, the call will be dropped.

If still failed, the PP may try to resend the data during next scheduled time, the call will be lost after trying certain retransmissions.

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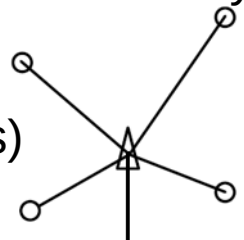

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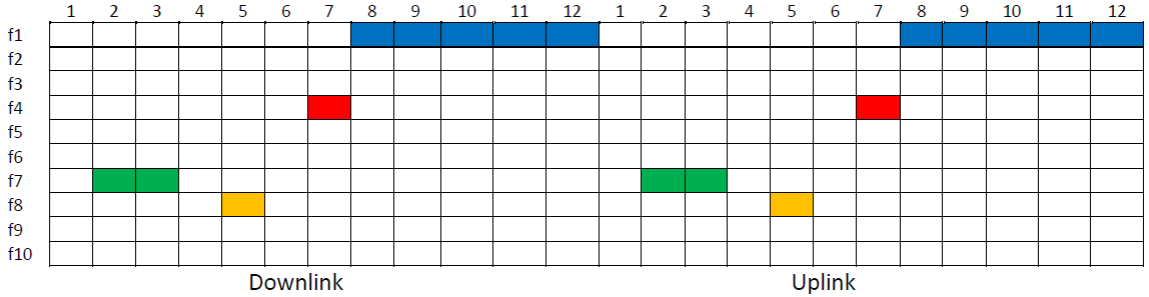
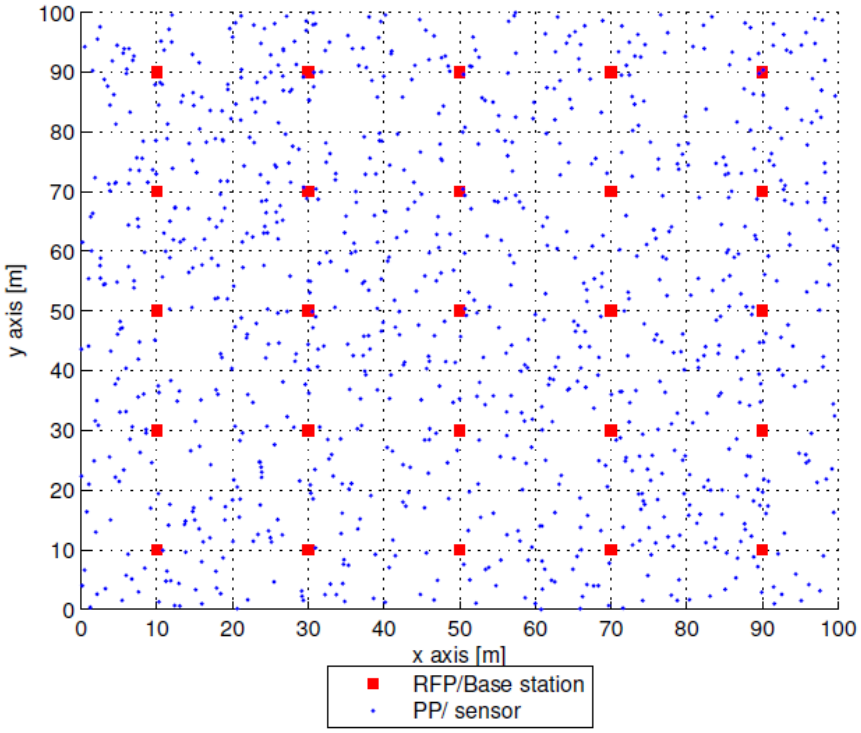


Evaluation of DECT-ULE for dense WSN

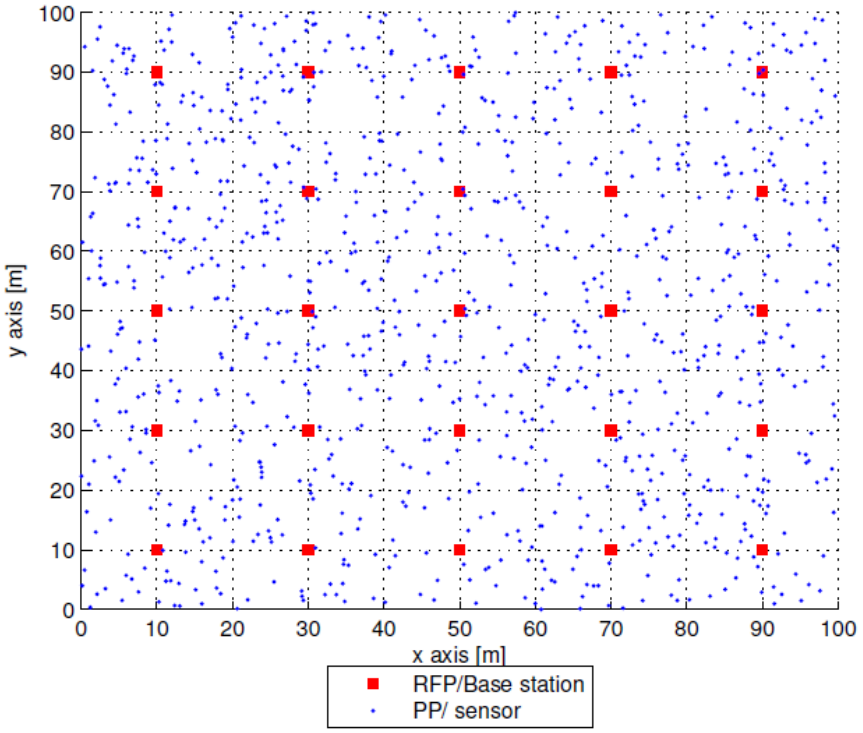
- Dense network
- Diverse traffic pattern
- Performance matrices
  - Channel selection failure
  - Lost call probability
  - Channel quality
  - Average traffic per base
  - Latency (call setup delay)

Evaluation of DECT-ULE for dense WSN



- 100m X 100m area
- 25 Base stations
- 1000 randomly placed sensor nodes

Evaluation of DECT-ULE for dense WSN



Up to 10 and 100 sensors may try to call at a time in low and high traffic case respectively

The duration of a call can be up to 500 ms.

Each sensor will send the data in a regular interval (from 1 to 60 seconds)

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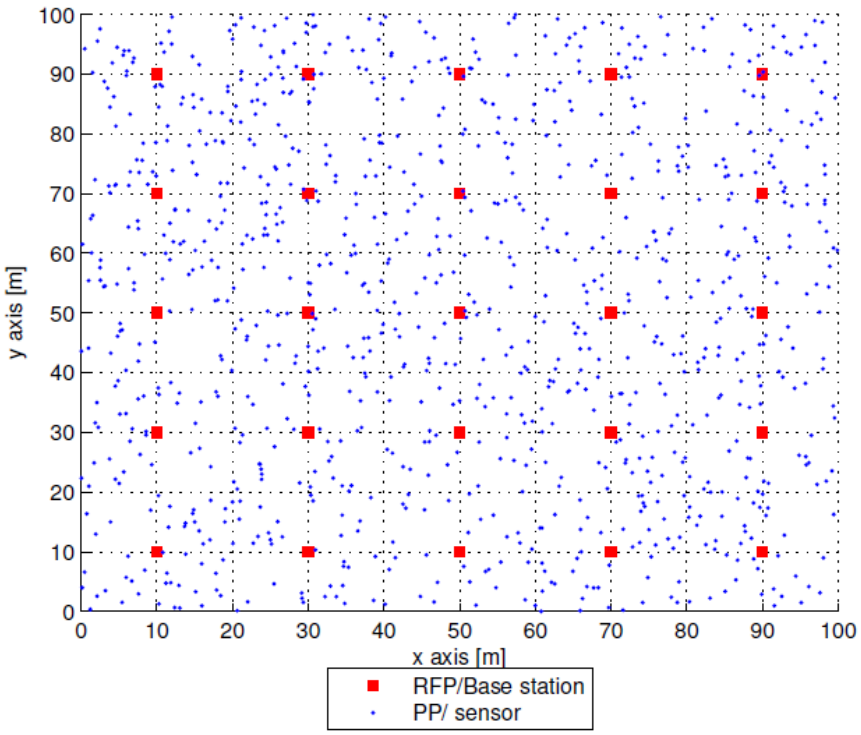
Evaluation of DECT-ULE for dense WSN



Interference reduction
- handover
- channel reuse

Energy efficiency

- 100m X 100m area
- 25 Base stations
- 1000 randomly placed sensor nodes

Evaluation results

- Channel selection failure
  - 1.42% (for low traffic)
  - 17.05% (for high traffic)
- Lost call
  - 0.0442 % (for low traffic)
  - 0.4173% (for high traffic)

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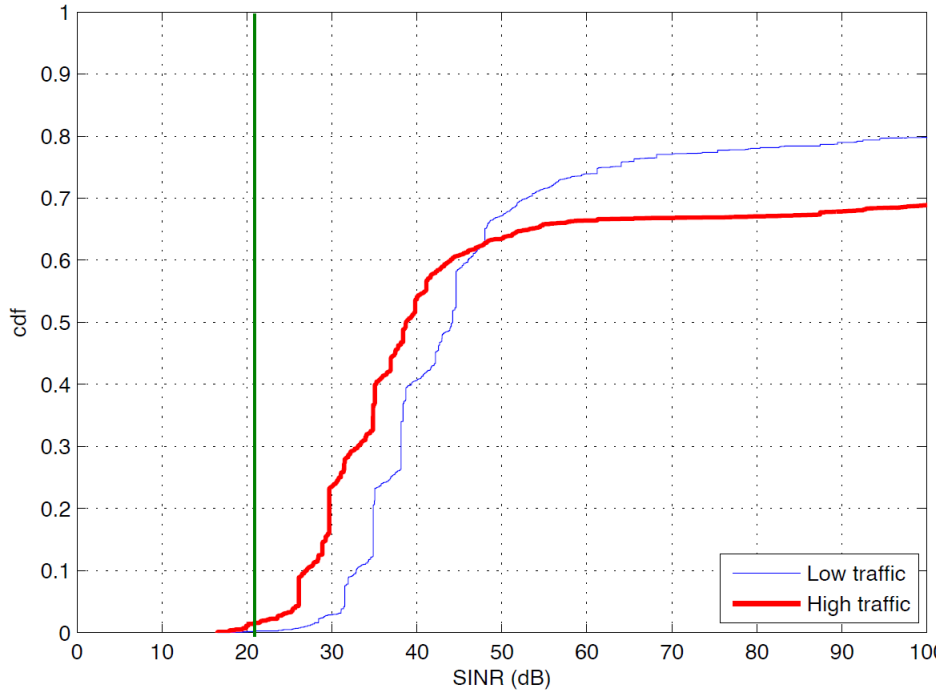

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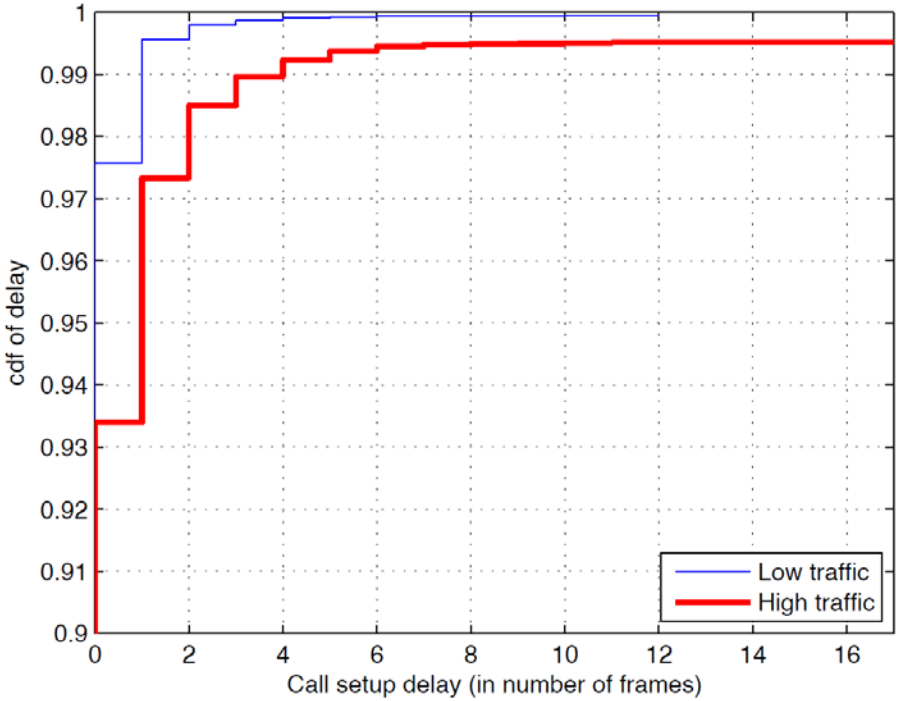

- About 30 ms end to end delay can be guaranteed due to this small call setup delay ☺
- A typical WirelessHART network may have 100 ms end to end delay.

Open issues

- Free channel map update in every 30 sec
  - Suitable for voice communication
  - Not suitable for sensor networks
- Multi-hop network
  - Effective throughput of the system will be reduced
- Infrastructures
  - Unsuitable for adhoc-network applications (e.g., disaster management)

Conclusion

- DECT ULE
  - Can handle dense WSNs by providing
    - Reliable communication channel
    - Low latency
  - Mature standard
    - Available kits
  - Possibly can combine sensor applications with existing voice communication infrastructure
    - Reduce the implementation cost
    - Attractive for many business organizations

Acknowledgement

- This project is supported by the EU FP7-ICT Project **WiBRATE** (Wireless, self-powered vibration monitoring and control for complex industrial systems). http://wibrate.eu/

Questions and Contact

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