Wireless Challenges

What can go wrong with wireless communication and experiments?

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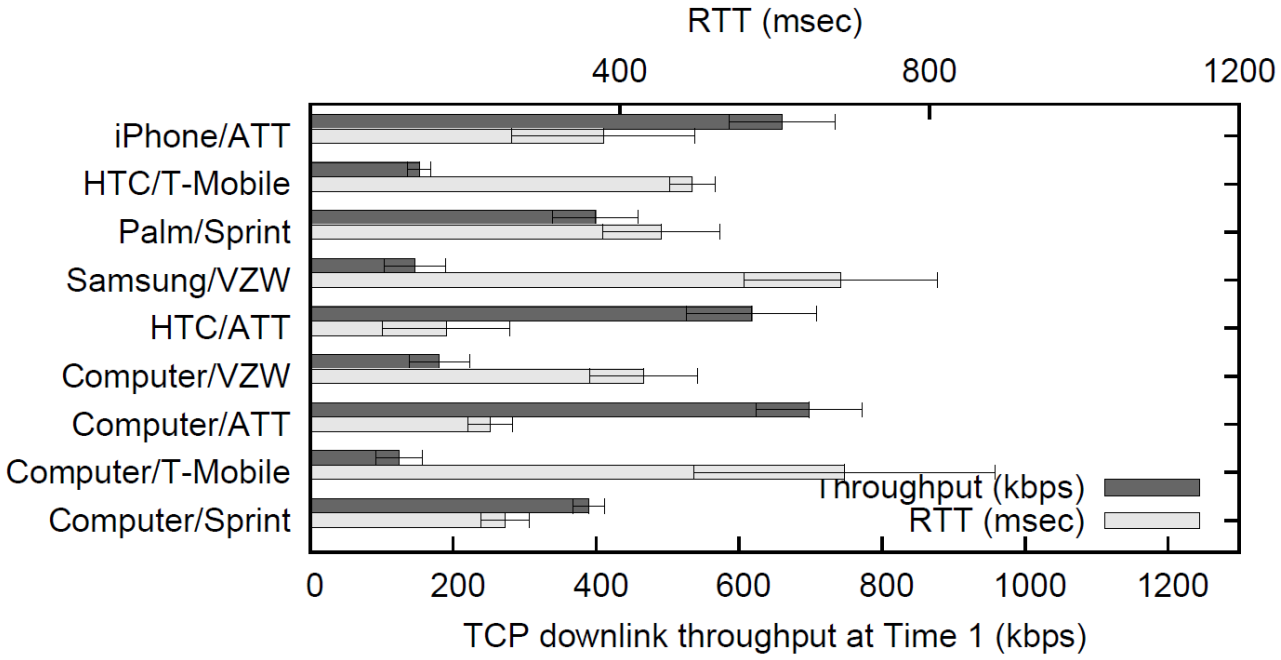
The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 258301 (CREW project).

The spectrum scarcity problem

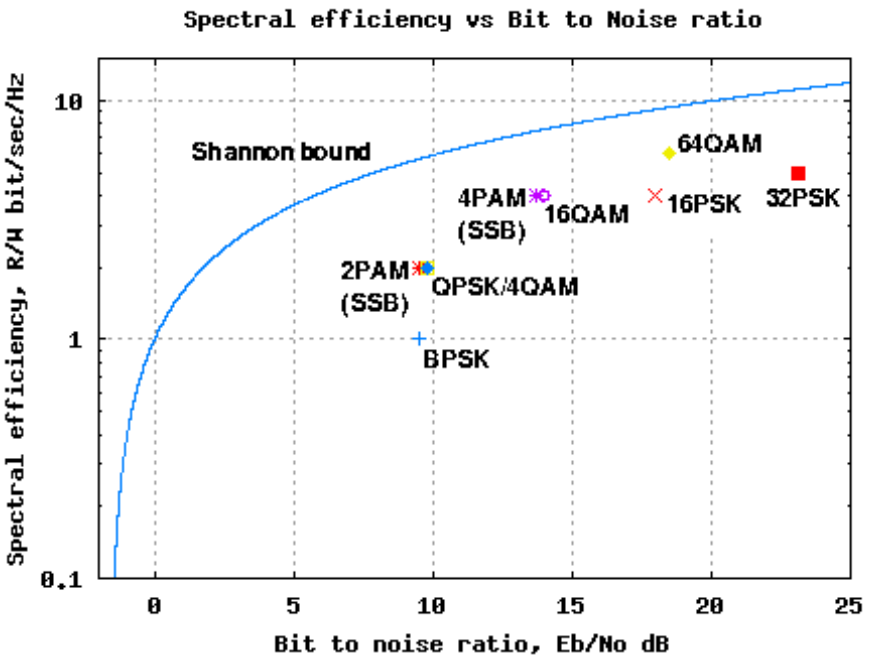
- **Usage of wireless access is going up**
  - Wireless use is on the rise
  - Consumption of data per user is going up
  - Next generation of applications and terminals
- **Throughput & Latency not sufficient for next generation applications supported by new terminals**



Capacity is finite!!!

- **Shannon's law sets a limit to what is achievable**

$$C / B = \log_2(1 + SNR)$$



- **Engineering innovations**
  - Turbo codes
  - Increased receiver sensitivity
  - MIMO, Cooperative MIMO, Massive MIMO
  - Network coding
  - MAC and transport protocols
  - Small cells & increased spatial reuse (network densification)
  - …

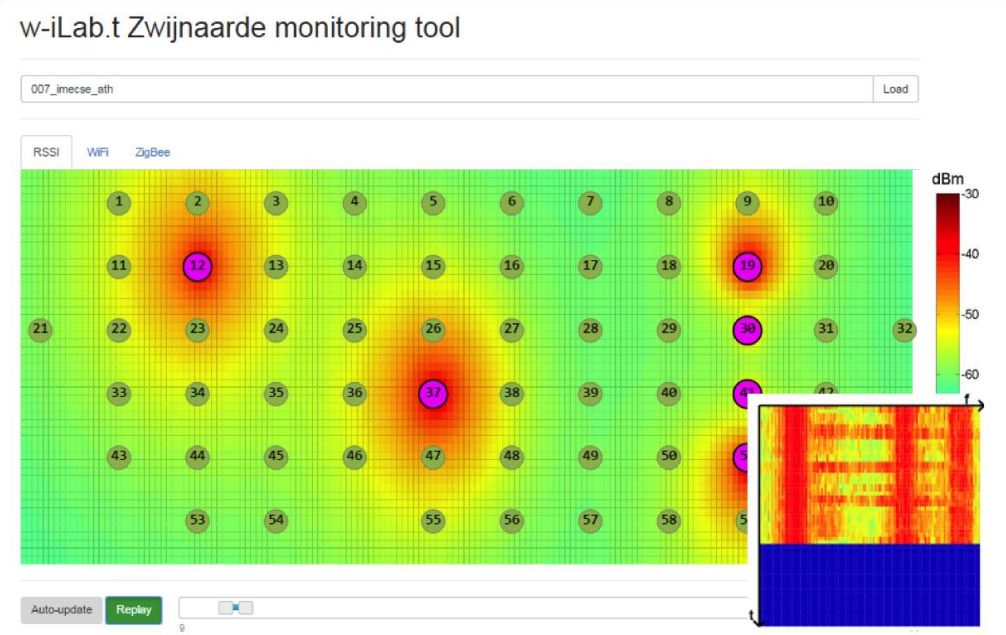
- **But the limit still exists!!!**
  - → more bandwidth
  - → higher bands
  - → more efficient use of lower bands
  - → smaller cells

How CREW is dealing with the scarcity problem?

Wireless Experimentation

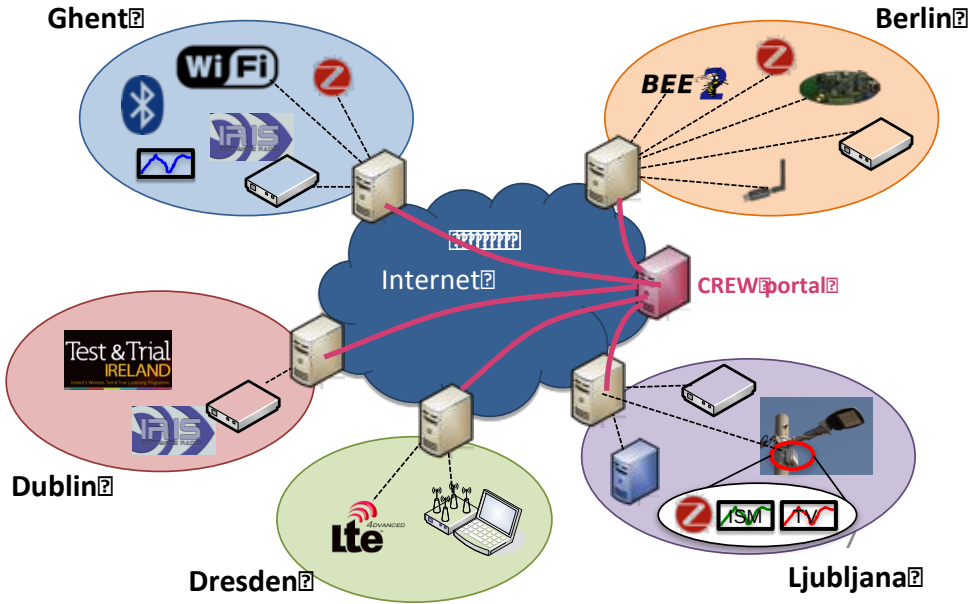
Motivation

- **Simulations are not realistic**
  - Oversimplification of wireless environment
  - Consider ideal hardware
    - Perfect synchronization
    - Same sensitivity
  - Interference is hard to simulate
- **Experimentally-supported research is crucial for validation**



Challenges

- **Setting up testbeds is difficult**
  - Small scale tests are often not enough
- **Need for controlled interference**
  - Knowledge on what is a root of the problem
- **Support for various hardware**
- **Replication of experiments can be difficult**
  - Uncontrolled interference



Wireless Testbeds Experimentation

- **Hands on: Learn how to**
  - Get access to a remote wireless testbed
  - Set up and run a wireless experiment
  - Test and evaluate wireless solutions
- **Possibilities**
  - Demo
  - Wireless Testbed Academy
  - Globecom December 2015 San Diego
    - TT-15: Hands-on experimentation with cognitive radio enabled systems

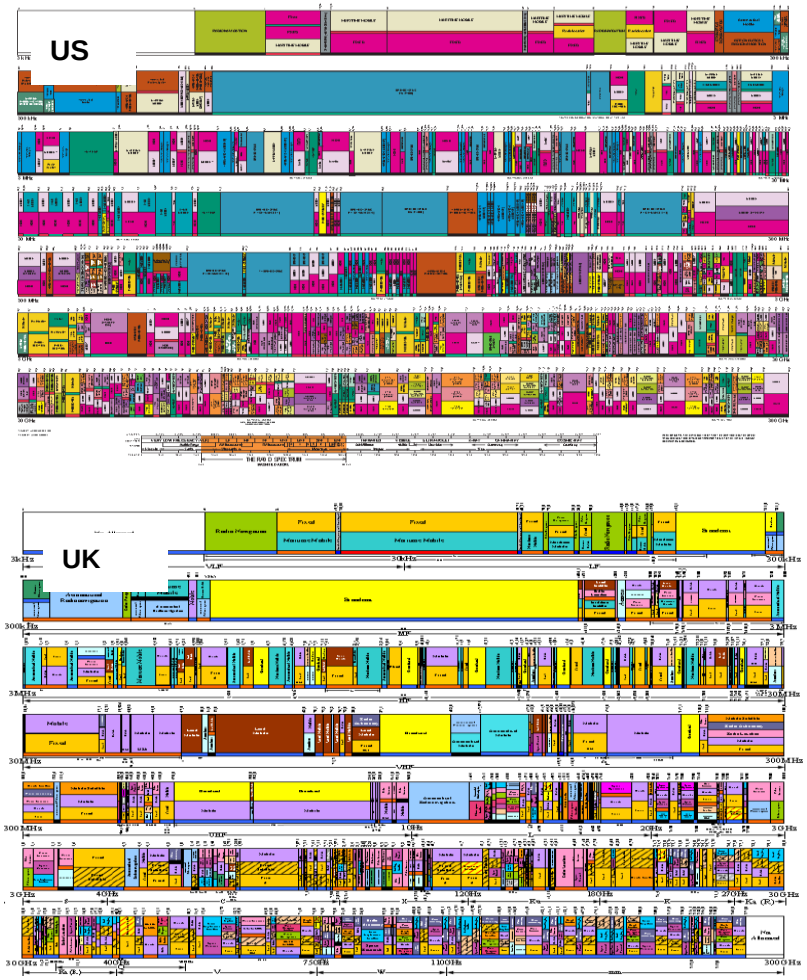
Code examples: https://github.com/WirelessTestbedsAcademy

Utilization problems in using licensed bands

Spectrum occupancy

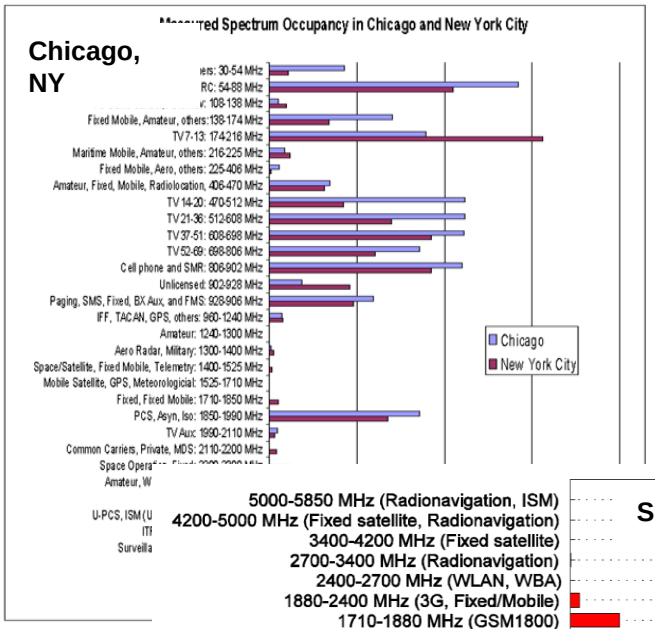
Frequency allocations tables

- "we have a problem"

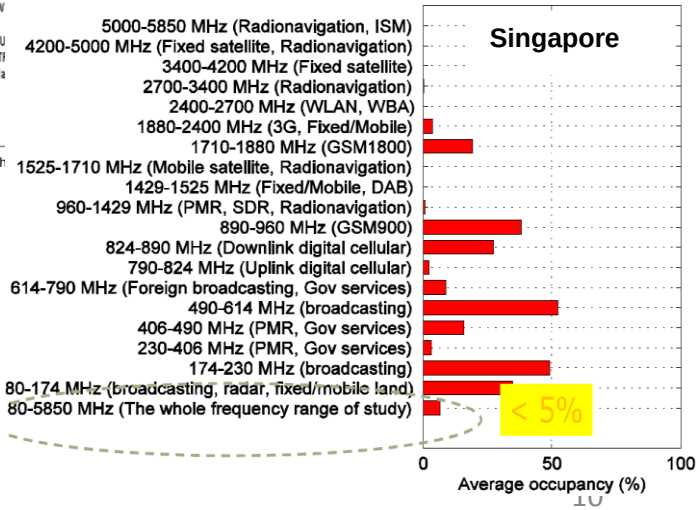


RF spectrum measurements

- "we have an opportunity"



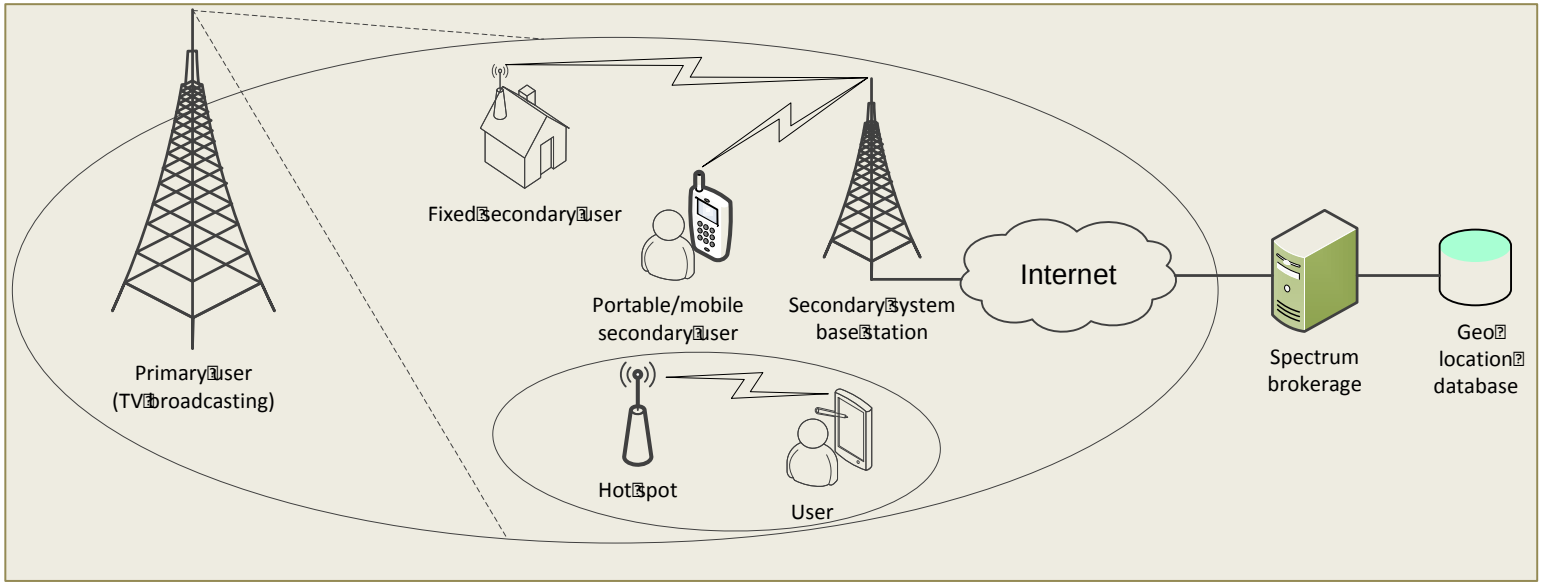
M. A. McHenry et al., Ch



M. Habibul, et al, Spectrum Survey in Singapore: Occupancy Measurements and Analyses, presented in CrownCom 2008, May 15 – 17, 2008, Singapore.

White spaces in licensed bands

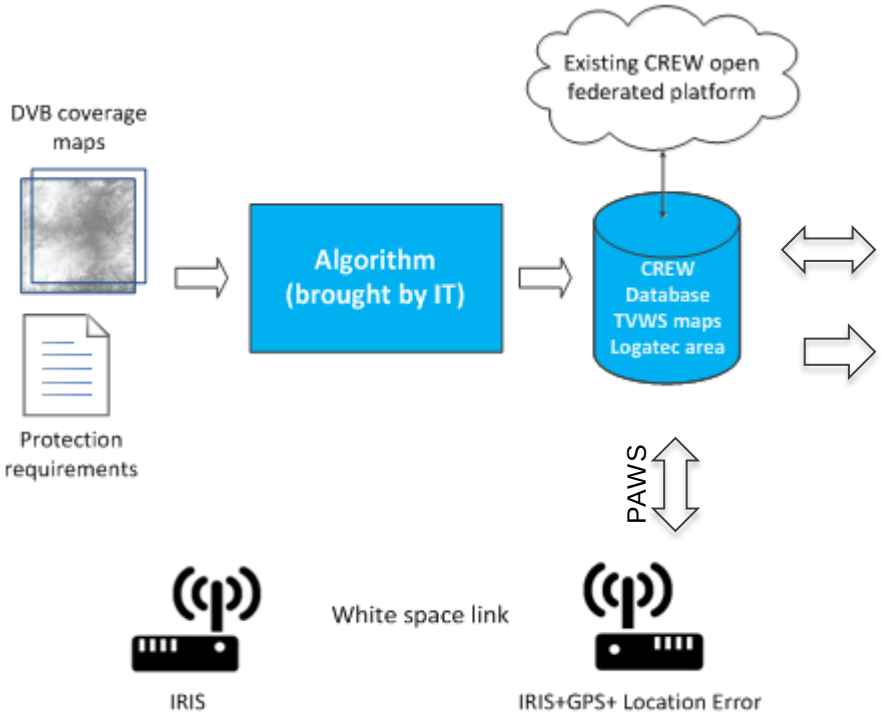
- **From exclusive access by primary (licensed) user (PU) only…**
  - ***Problem***: underutilized spectrum in temporal and spatial domain
    → white spaces or spectrum holes
- **… to dynamic spectrum access by secondary users (SU)**
  - increased spectrum utilization by using white spaces



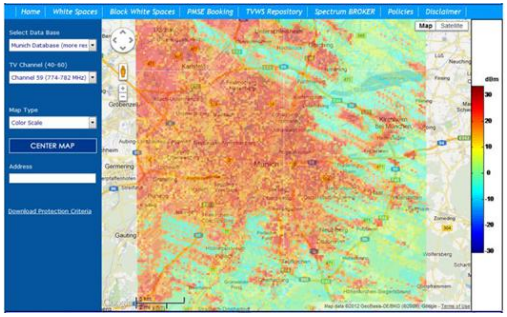
- **Research questions**
  - How SUs can use white spaces without degrading PU performance?
  - How can SU sense PU activity?

Adding dynamic content to TVWS DB

- **Experiment by Instituto de Telecomunicações and CMSF-Sistemas de Informação (CREW Open Call 2)**
  - geolocation database assisted by a low-cost densely deployed spectrum monitoring network
  - to protect dynamic incumbent systems, such as wireless microphones that are not registered in the database



LOG-a-TEC testbed



Logatec TVWS maps

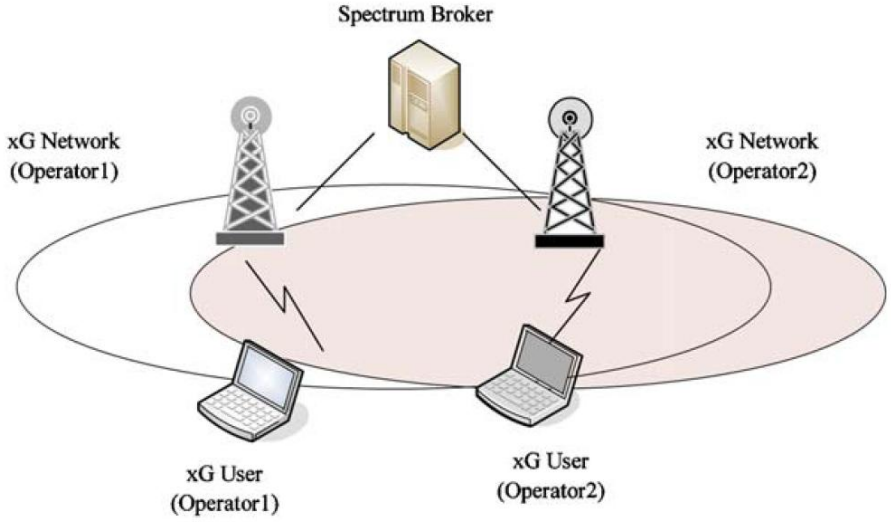
instituto de telecomunicações

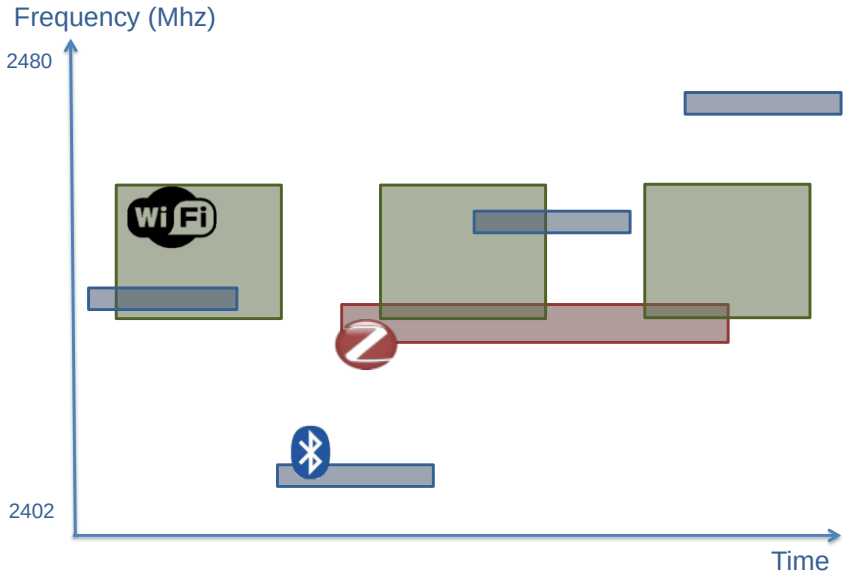
CMSF Sistemas de Informação

Coexistence problems in using unlicensed (ISM) bands

Spectrum sharing in unlicensed band

- **Open spectrum access (horizontal spectrum sharing)**
  - All networks/users coexist in the same band
  - Spectrum sharing methods between (heterogeneous) networks (network operators) to improve spectrum efficiency
  - Users compete with each other for the same unlicensed band

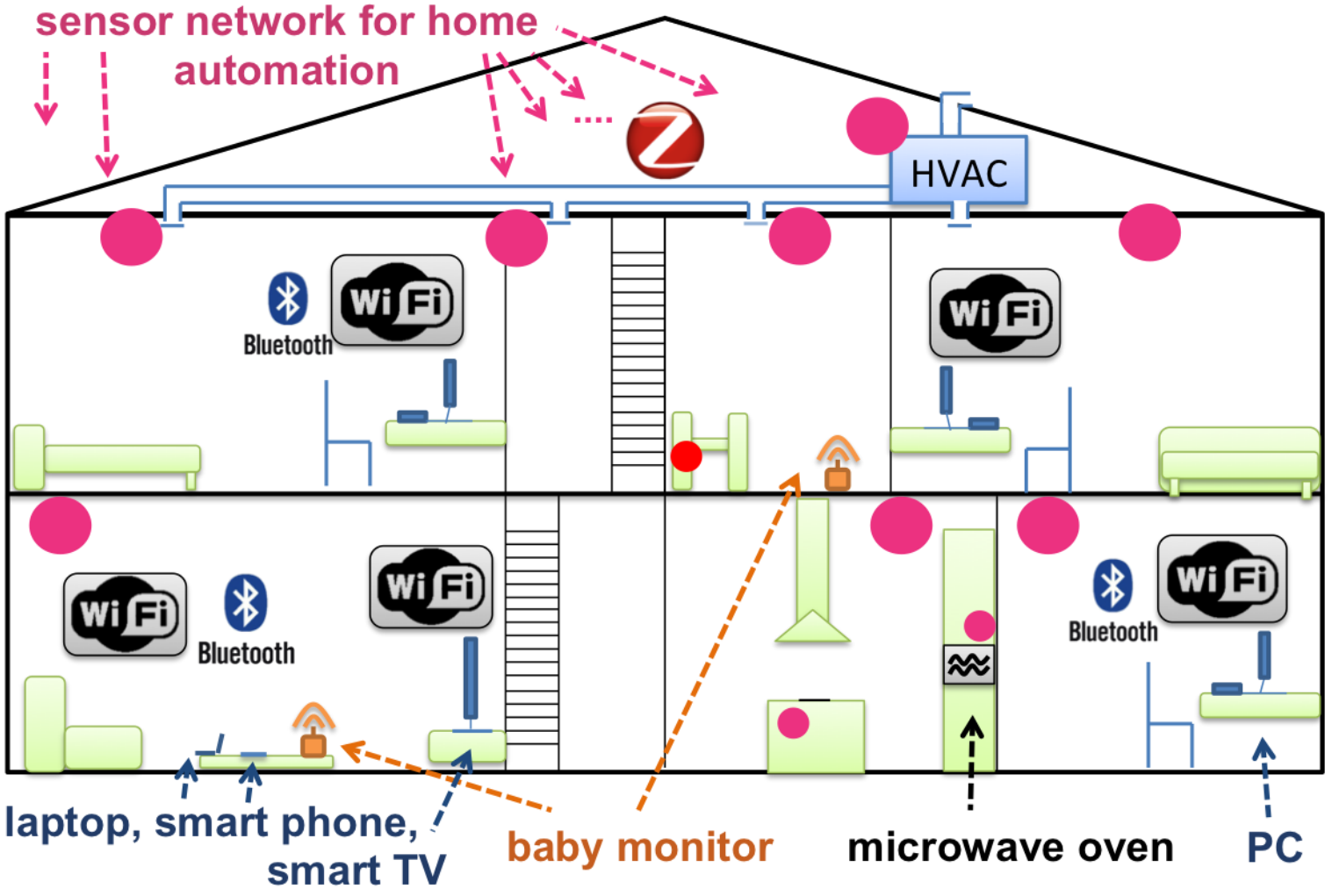




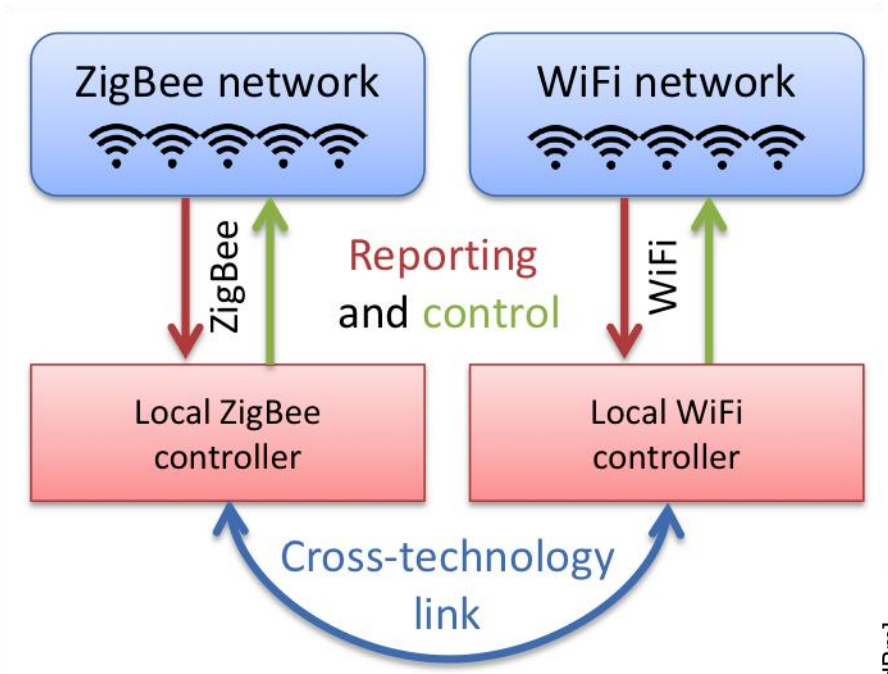
I. Akyildiz et al., "Next generation/ dynamic spectrum access/cognitive radio wireless networks: a survey", Computer Networks, vol. 50, no. 13, pp. 2127–2159, Sep. 2006.

Coexistence in ISM bands

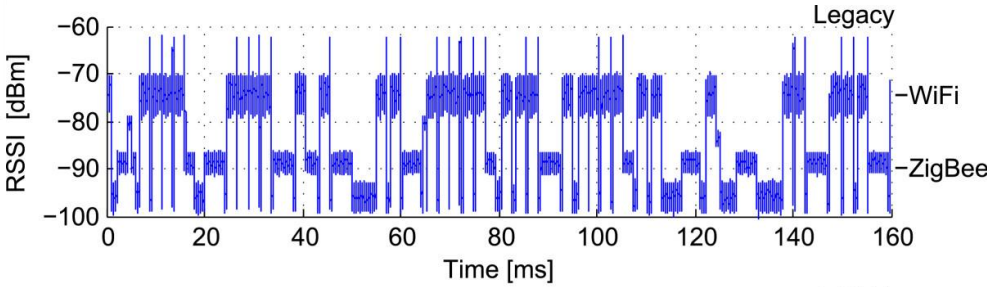
- **Coexistence problem in unlicensed (ISM) bands**
  - ISM bands are heavily used (lots of interference!)
  - Suboptimal use of the scarce spectral resources in ISM bands



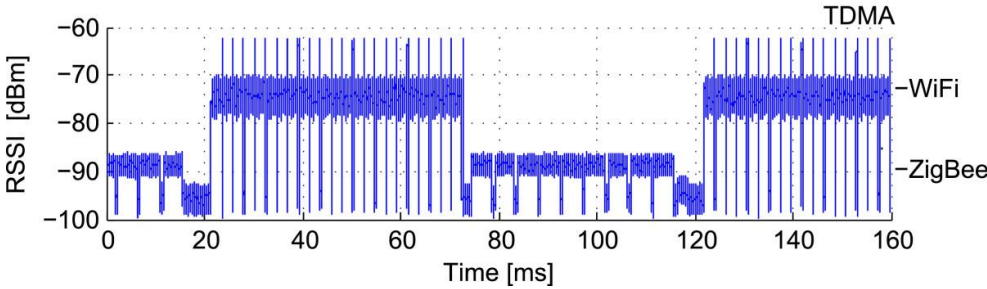
Cross-technology TDMA in 2.4 GHz ISM band



Legacy (CSMA/CA) operation: collisions between Wi-Fi and ZigBee (ZigBee normalised throughput reduced from 80% when no interference to 20% in case of Wi-Fi interference)



Cross-technology TDMA: Efficient airtime sharing (no more packet loss, more efficient channel usage, 35% normalized throughput within 50% of airtime)



De Valck, Peter, et al. "Exploiting programmable architectures for WiFi/ZigBee inter-technology cooperation." EURASIP Journal on Wireless Communications and Networking 2014.1 (2014): 1-13.

Cognitive Radio Experimentation World
Wireless Challenges

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