Radio Diversity for Wireless Sensor Networks

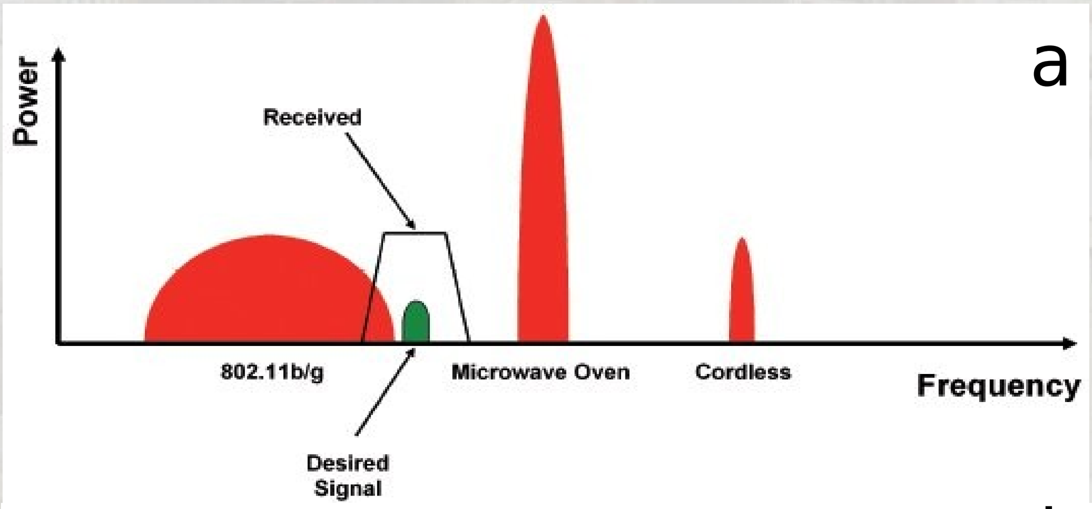
Claro Noda

Advised by: S. Prabh†, J. A. Afonso*, M. Alves†

†CISTER/ISEP, Instituto Politécnico do Porto. *Departamento de Electrónica Industrial, Universidade do Minho.

Introduction

ISM bands are increasingly shared among different standardized communication devices and networks (e.g Wi-Fi, Bluetooth and ZigBee) which may suffer from and cause interference to each others [1], as shown in figure 1. However, providing ***reliable*** and ***time bounded*** package delivery is critical for correct operation in a relevant group of sensor network applications. We are interested in **highly mobile** systems which provide a significant challenges, since the Wireless Channel, the interference situation and the topology can change rapidly. Examples: **mobile robots**, **mobile body sensor networks** and vehicular networks, among others. See figure 2 for performance analysis in an urban environment [2].



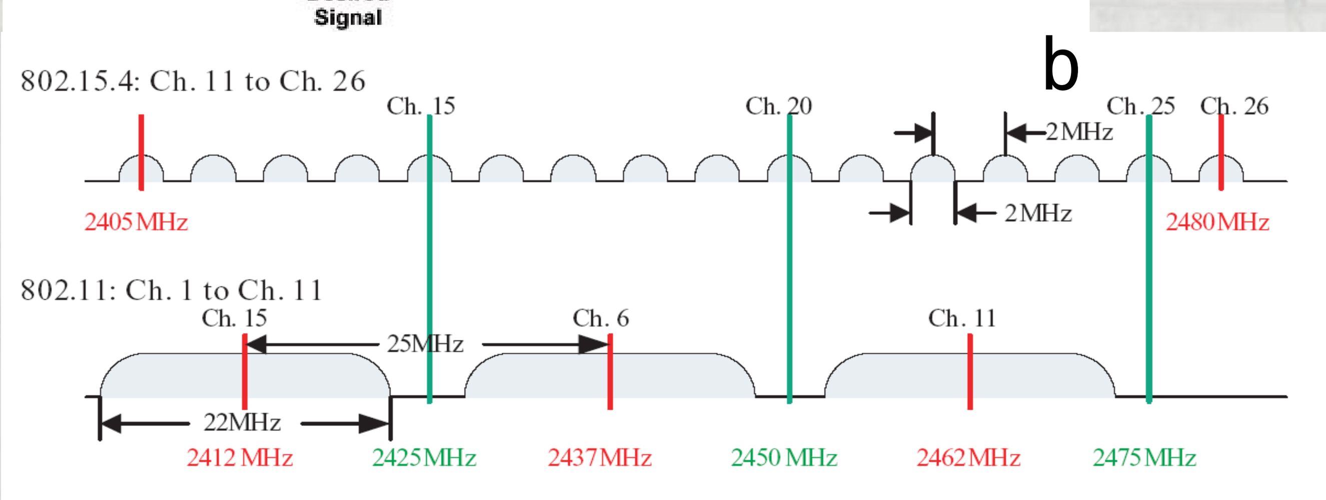


Figure 1. Spectrum of the globally available 2.4 GHz ISM band:
a) coexisting signal footprints, b) 802.11 and 802.15.4 channel allocation.

We are concerned about using **IEEE802.15.4** radios to enable communication among a variety of embedded computing devices equipped with sensing or actuation capabilities that are able to cooperate and organize themselves autonomously into networks to achieve a common task. We refer to these devices as ***cooperating objects*** (COs) [3]. The COs may also profit from available network infrastructure that may aid in achieving their collective goals.

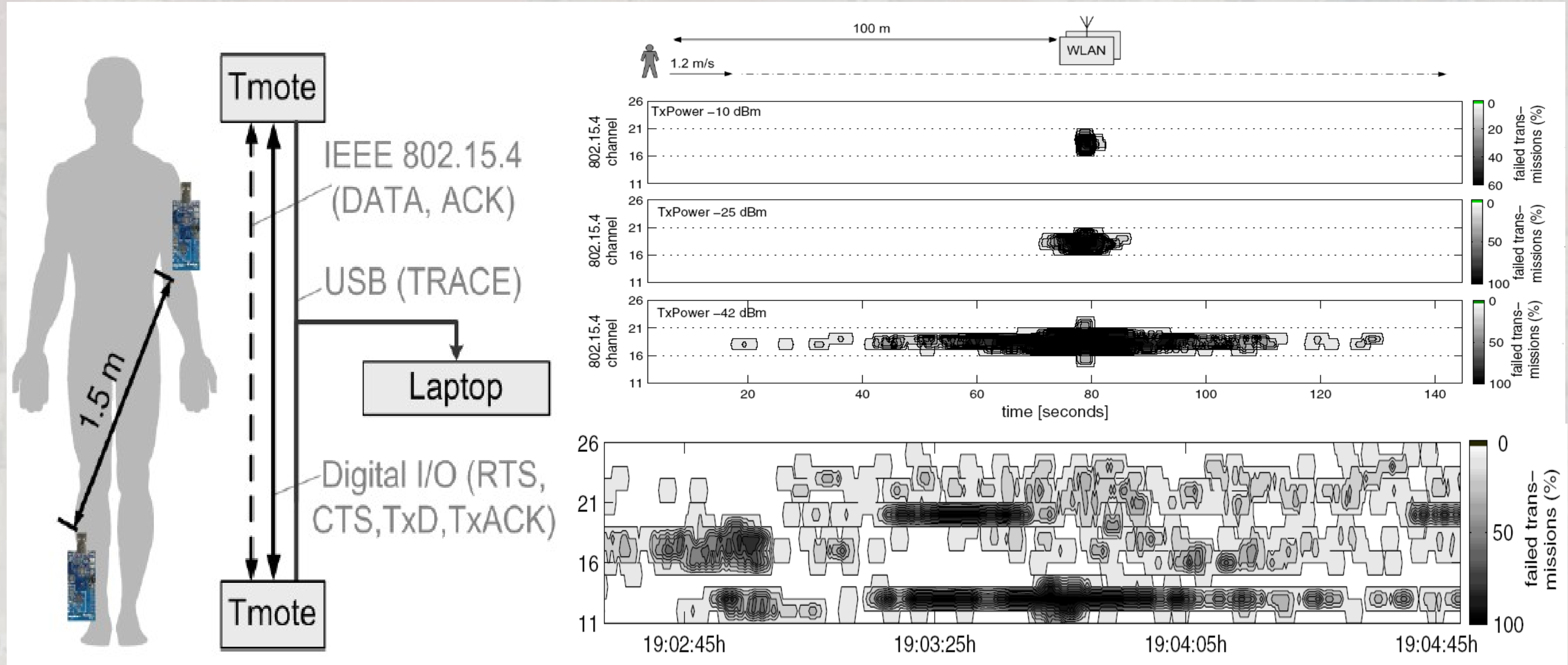


Figure 2. Measurements showing the interfering effects of 802.11 on a 802.15.4 link during a walk around a WLAN AP. Motes are attached to the body, as shown in the left, and a Laptop (WLAN client) is carried in a backpack. Experiments conducted by Hauer et al [2] in downtown Berlin. EWSN 2009

Related Work

IEEE-802.15.4 implies ***low cost*** and ***low power operation***, which limit the options to mitigate interference and radio propagation inconveniences like multi-path fading and shadowing. Radios are based in inexpensive architectures with low transmission power for short range links (typically less than 30 m), usually between mobile and energy constrained nodes (e.g. battery operated). Coexistence issues between IEEE-802.11 and 802.15.4 have received the community attention for years. Given the complexity involved, some remedies leverage from specific scenarios assumptions to soften the problem [4]. There are recent publication addressing the need of **frequency agility** [5, 6, 7]. These studies are not conclusive, not applicable to large scale mobile scenarios, nor they address implications for routing, relevant for space diversity opportunities.

Problem Statement

An instantaneous view of the spectrum band in a given location consistently shows enough opportunity for communications. We are interested in improving reliability of radio links for supporting COs networks. This instantaneous view may change rapidly in real scenarios, depending on how crowded is the band. Therefore, the problem that we address could be defined as learning from the spectrum dynamics in the area where the network is formed and integrate that information into algorithms that enable efficient resource management to offer guarantees of ***reliable*** and ***time bounded*** message exchanges network-wide.

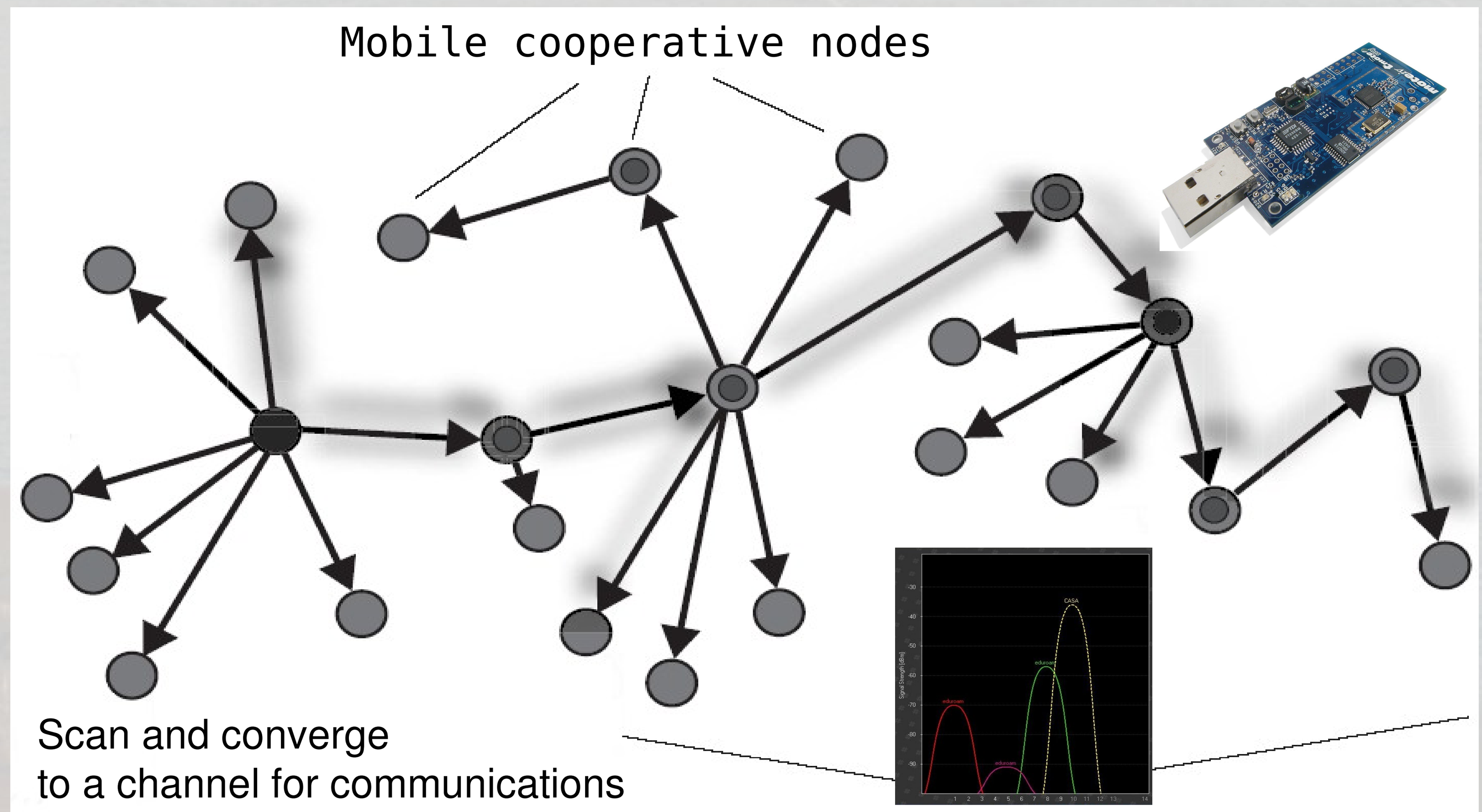


Figure 3. Network of *mobile* sensor nodes cooperating to sense the spectrum and converge to best channels for communication. Arrows indicate direction of movement.

We will look into **cognitive radio concepts** that could be adapted for low power and inexpensive radio infrastructures and provide mechanism to **effectively avoid external interference**. Also lightweight and quick estimation schemes for the channel quality indicators will be necessary in order to dynamically assess the interference situation in a given link.

References

1.- Compatibility of IEEE-802.15.4 (Zigbee) with IEEE802.11 (WLAN), Bluetooth, and Microwave Ovens in 2.4 GHz ISM-Band. A. Sikora. Technical report, Steibeis-Transfer Centre, Sep 2004

2.- Experimental Study of the Impact of WLAN Interference on IEEE 802.15.4 Body Area Networks. J. Hauer, V. Handziski and A. Wolisz. EWSN 2009

3.- CONET Research Roadmap. June 2009 (available online)

4.- Dynamic Multi-channel MAC Protocol for LR-WPAN Based on Interference Learning. Kwang-il Hwang. FGCN08

5.- Y-mac: An energy-efficient multi-channel mac protocol for dense wireless sensor networks. Y. Kim, H. Shin, and H. Cha. IPSN 2008

6.- A practical multi-channel media access control protocol for wireless sensor networks. H. K. Le, D. Henriksson, and T. F. Abdelzaher. IPSN 2008

7.- Spectrum Agile Medium Access Control Protocol for Wireless Sensor Networks. J. Ansari, T. Ang and P. Mahonen. SIGCOMM 2009

Further Information

For more information please contact: cand@isep.ipp.pt or visit:
http://www.cister.isep.ipp.pt
http://www.cooperating-objects.org
Poster available at:
http://www.complexperiments.net/noda/MAPTele/WS/Poster.pdf