Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Wireless coexistence for industrial automation]
Date Submitted: [10 November 2013]
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Re: [Call for contributions by IEEE802.15 SG-SRU on 21 Oct., 2013]

Abstract: [The document provides the requirements and views of industrial automation applications for wireless devices and a vision of how automatic / collaborative coexistence management can be standardized]

Purpose: []

Wireless coexistence for industrial automation

(2nd SRU presentation)

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Topics

- Recap Jan 2013 presentation
- Understandings from ETSI TG11 #35
- Activities of WiRIA & first results
- Hypothesis and bottom line findings
- Basic idea to improve EN 300 328 v1.9.1

Recap

- 15-13-0056-00-0sru-ig-sru-January-2013-Wireless coexistence for industrial automation_LW_02

Recap: Coexistence, Coexistence management

- Coexistence is a key problem which has to be solved in order to provide reliable (best effort is not enough!) wireless communication in industrial automation.

- Coexistence management is independent of a certain frequency spectrum or a communication technology.

Recap: Definitions of Coexistence

- ## according to IEEE Std 802.15.2-2003:

  The **ability** of one system to perform a task in a given shared environment where other systems have an ability to perform their tasks and may or may not be using the same set of rules.

- ## according to IEC 62657-2:

  state in which all wireless communication solutions sharing a common media fulfill all their application communication requirements
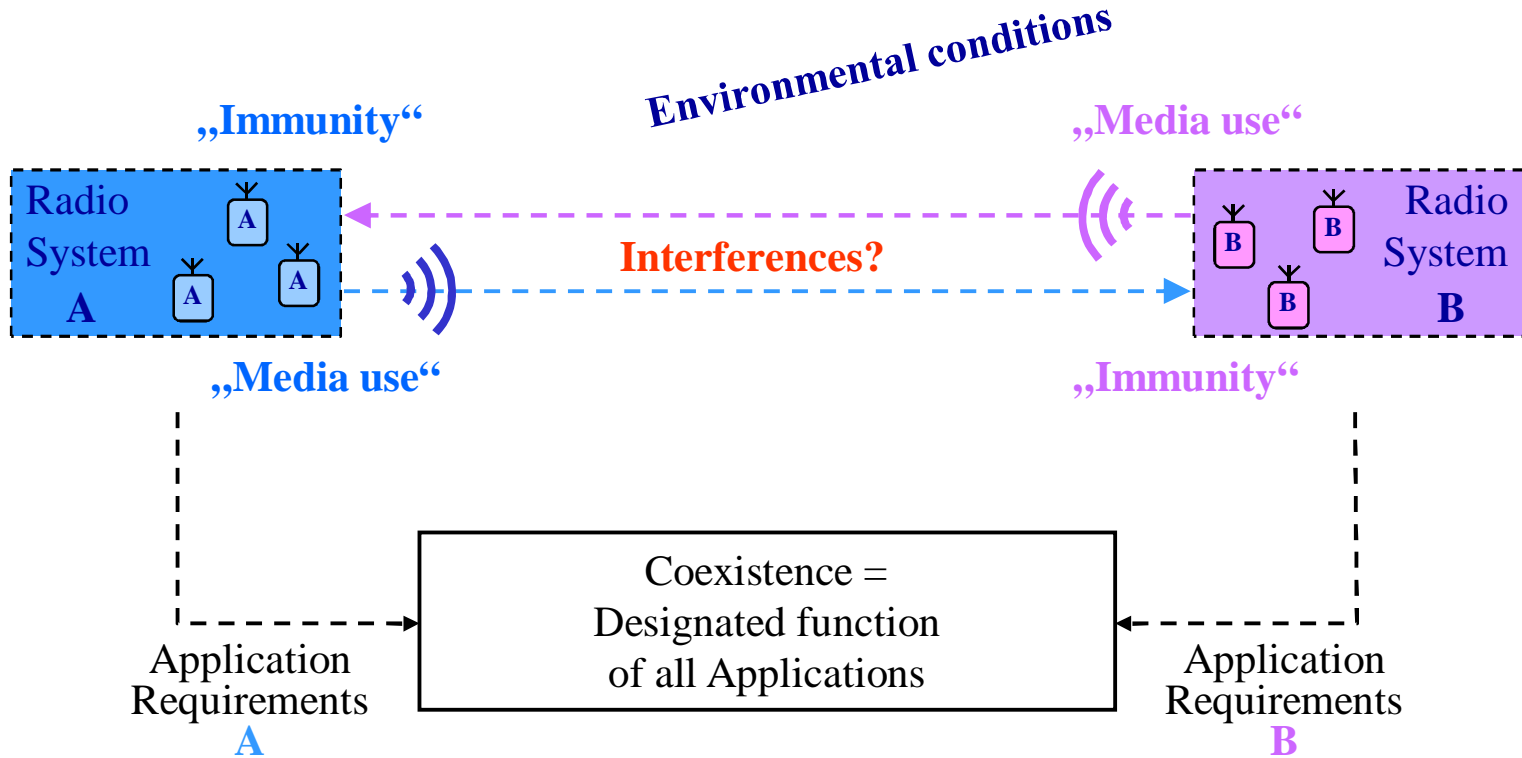
Recap: Coexistence according to IEC62657-2

- ❑ is a **dynamic state** within an environment (not a characteristic of a wireless solution)

- ❑ means that **all wireless solutions** involved fulfil their tasks

- ❑ depends on the requirements of the **application** and the resulting **wireless solution**

- ❑ can be assessed using **characteristic parameters**

- ❑ has to be **planned, monitored and maintained**

Recap: Industrial Automation

- Industrial Automation has an enormous potential for innovations – while wireless solutions are an essential driver for innovations.

- For Industrial Automation there are different, standard-based and complementary wireless solutions existing that fulfill the special industrial requirements since many years (e.g. IEC 62591 using IEEE 802.15.4e; IEC 61784-1, CPF3 using IEEE 802.15.1 and IEEE 802.11.

- The harmonized standard used for 2.4 GHz in Europe is EN 300 328. It has been revised and the current version (EN 300 328 V 1.8.1) does not allow to fulfill all Industrial Automation requirements at time.

Recap: Coexistence management of wireless solutions

IEC 62657-2

Environmental conditions

„Immunity"   „Media use"

Radio System A

„Media use"   „Immunity"

Interferences?

Radio System B

Application Requirements A

Coexistence = Designated function of all Applications

Application Requirements B

Source: www.ZVEI.org*

Recap: IEC TC65 expertise

- 65A: System aspects like Functional safety IEC 61508.
- 65B: Devices used in industrial process measurement and control
- 65C: Network communication incl. Installation, security, safety, coexistence
- 65E: Representation of device properties and functions, methodologies and applications supporting automation of engineering processes.

Recap:Reconfigurable Radio System (RRS)

- New spectrum frequencies and RRS should NOT be construed as alternatives to our industrial presence in 2.4 GHz. They should be in addition to a usage of areas with Coexistence Management (CM) in 2.4 GHz.

- RRS offer unprecedented optimization and propagation possibilities and can extend CM.

- RRS can provide additional mechanisms for a future EN 300328 V1.9.0, assuming that RRS are proper for IA.

- EC mandate **M/512 EN: "***RRS, in particular Software Defined Radio (SDR) and Cognitive Radio (CR) technologies have been investigated in the commercial, public safety and military areas. While each area has specific operational and technical requirements, a consistent approach should bring benefits for all areas.***"**

If this EC mandate has been issued 2012-11-19. It addresses CEN, CENELEC and ETSI to specify harmonized standards.

Recap: Vision

- Devices and / or networks collaborate by using an **<u>automatic coexisting management</u>**
  - Parameters defined in IEC 62657-2 plus ad-ons are distributed
  - An arbiter (central or distributed) will assign spectrum
  - Coexistence is monitored and maintained continuously.

Recap: Possible next Steps

1. In industrial automation plans can be assumed a controlled area for the usage of wireless devices/networks.

    – This makes it easier versus a public area without any information of the wireless devices/networks joining and disappearing.

    – Existing communication networks like PROFInet and tools like EDDL, OPC, FDI, etc. can be used to describe and distribute the information.

    – The challenge is the definition of an arbiter.

Recap: Possible next Steps

2. Generalize the industrial automation approach to public usage of wireless devices/networks.

   ➢ The challenge is the specification of an application requirement of public devices, which are typically unknown without any plan and schedule.

      • A solution for this could be an approach like PROFInet uses for real-time and best effort TCP/IP traffic in a common network:
        time slicing!

        – for those using automatic adaptive mechanisms get access to the scheduled high efficient „real-time slot, and the other have to live with the best effort slot.

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- Activities of WiRIA & first results
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Understandings from TG11 #35 EN 300 328 v1.9.1

To summarize from the last meeting, the main findings from document ERMTG11(13)000019a1r1 will be shown on the next slides.

The references are made to the questions [x] and original text is in italic font.

Understandings from TG11 #35 EN 300 328 v1.9.1

[1] What is the definition of the term "<u>equal access</u>" in the requirement: "…ensure **equal access**…"?

It is understood, that "**access**" is meant purely time wise.

It is the <u>chance</u> for a system within a given time frame to transmit for a certain amount of time and then stay silent for a certain amount of time to enable others to get access to the medium

…

[3]

In the context of EN 300 328, the graceful degradation can only be seen in respect to equal access (time wise) to the spectrum.

Understandings from TG11 #35 EN 300 328 v1.9.1

…

[5]

In respect to the „efficient use" of spectrum TG11 concluded that the term „efficient" is linked to the **avoidance of harmful interference**

refer also to the R&TTE directive:

*(22) Whereas effective use of the radio spectrum should be ensured so **as to avoid harmful interference**; whereas the most efficient possible use, according to the state of the art, of limited resources such as the radio frequency spectrum should be encouraged;*

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Activities of WiRIA & first results EN 300 328 v1.9.1
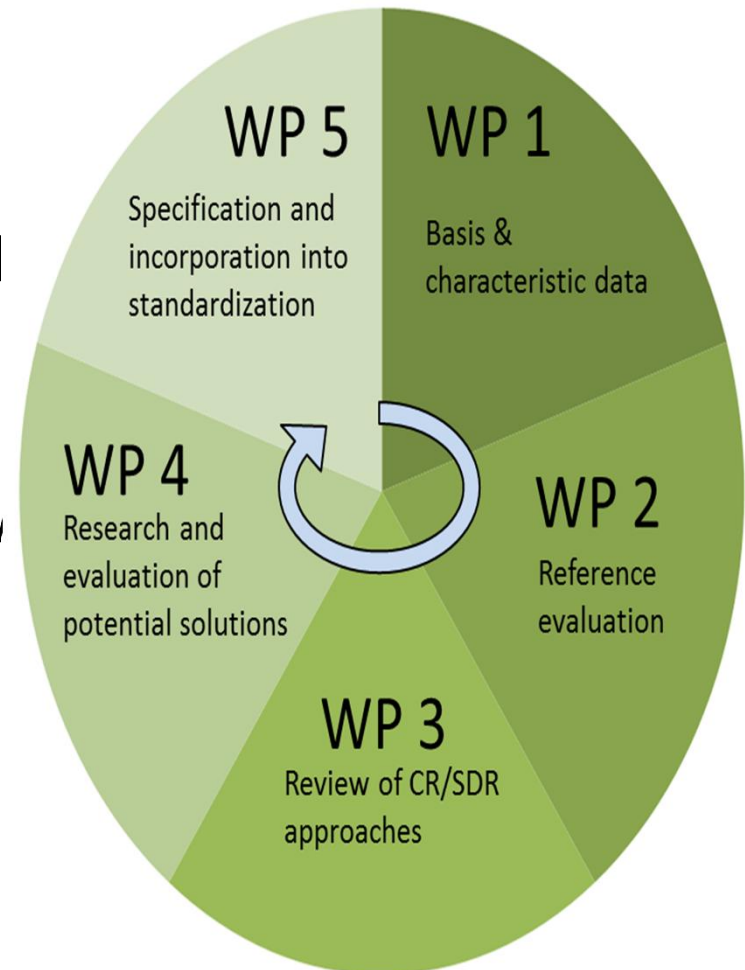
Activities of WiRIA

WP1: done

WP2: first results – to be finished
by end of October 2013

WP3: draft available

WP4: first concept without review

WP5: part of a draft available

WP 5 — Specification and incorporation into standardization

WP 1 — Basis & characteristic data

WP 4 — Research and evaluation of potential solutions

WP 2 — Reference evaluation

WP 3 — Review of CR/SDR approaches

Ludwig Winkel, Siemens AG

Activities of WiRIA & first results EN 300 328 v1.9.1

Work Package 2

In this WP media access mechanisms were analyzed to outline the status quo and to work out a neutral basis for comparability.

The analysis is conducted by MAC level simulations. Two independent research institutes are carrying out the simulations – one by using OMNeT++ and the other one by using NS2. contracting two institutes by using two different tools should exclude tool based or implementation based faults.

First results are available, however they still need two more months until end of October 2013 to finish their work

The simulations are including the media access mechanisms of the following standards:

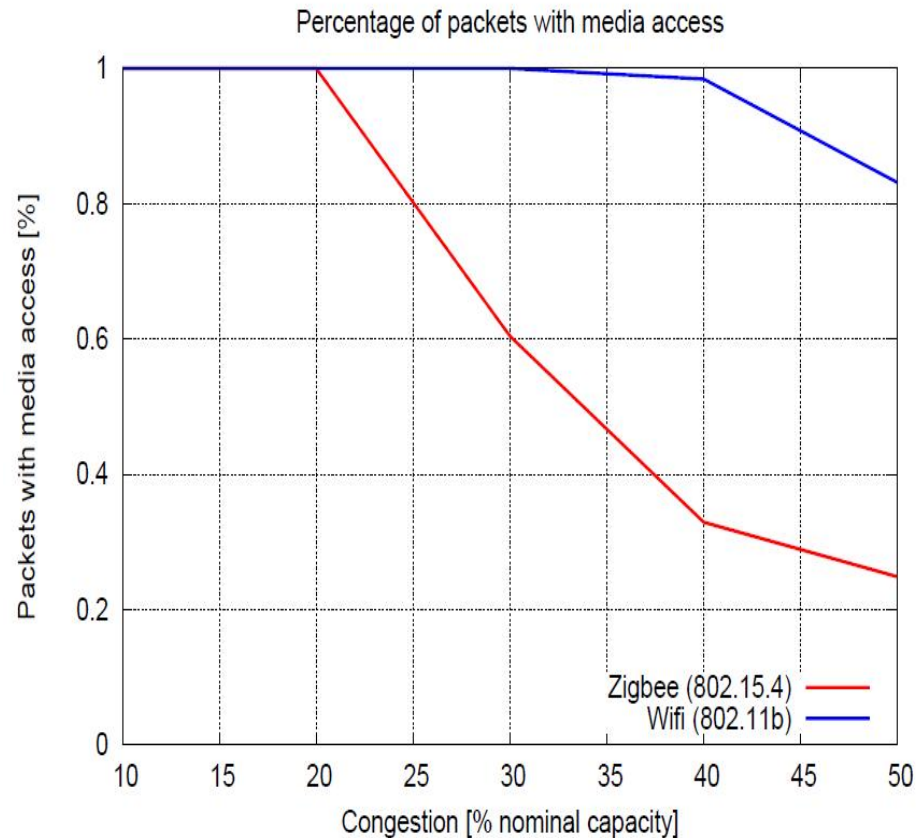# Activities of WiRIA & first results
EN 300 328 v1.9.1

as defined in EN 300 328 V1.8.1

- FH non-adaptive   (e.g. Bluetooth 1.2 w/o AFH)

- FH adaptive, non-LBT based DAA   (e.g. Bluetooth 1.2 with AFH)

- FH adaptive, LBT based DAA

- Non FH non-adaptive   (e.g. WirelessHART, ISA 100.11a)

- Non FH adaptive, non-LBT based DAA

- Non FH adaptive, frame based LBT based DAA   (e.g. IEEE802.15.4 GTS)

- Non FH adaptive, load based LBT based DAA
  (e.g. IEEE 802.15.4 with energy based CSMA/CA and IEEE802.11 with energy based CSMA/CA)

Activities of WiRIA & first results
EN 300 328 v1.9.1

Simulation results: IEEE 802.11b vs. IEEE 802.15.4

Percentage of packets with media access

X-axis: Media requests in percentage of total media capacity

Y-axis: Packets with media access (normalized to 1)

Activities of WiRIA & first results EN 300 328 v1.9.1

Conclusions from the MAC simulations

- Currently specified media access mechanisms from EN300328v1.8.1 do <u>not achieve an equal access</u> and degradation of service to all

- Clear advantage for IEEE802.11 systems compared to other techniques

- Clear advantage for the **fastest** – not for the most friendly / the most polite system

- Overall waste of spectrum resources due to random-type media access mechanisms

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Hypothesis and bottom line findings EN 300 328 v1.9.1

Hypothesis and bottom line findings

- Automatic adaptive, device based media access mechanisms do improve the coexistence in a congested area only in a limited way
  - Due to the random type nature of these media access mechanisms the spectrum and time resources are not used efficiently
  - Due to the different CCA times of the mechanisms the media access is not distributed in a fair and equal way

- A more efficient solution on single device level doesn´t seem to be achievable

Hypothesis and bottom line findings EN 300 328 v1.9.1

Hypothesis and bottom line findings

- To further improve the use of spectrum in all application fields (public, IT or industrial) an additional device should coordinate the spectrum resources like bandwidth, time, etc.

Let´s have a short look to other radio expert groups ….

Hypothesis and bottom line findings EN 300 328 v1.9.1

In IEEE 802.22 the concept for a higher degree of coexistence and spectrum efficiency is based on a so called spectrum manager in a WRAN (wireless regional area network)

- Key functions of the spectrum manager are:
  - Maintain spectrum availability information
  - Channel classification and selection
  - Coexistence with other WRANs
  - Channel set management
  - Accessing the database service
  - Making channel move decisions for one or more CPEs or the entire cell
  - …

CPE = customer premise equipment

IEEE 802.22
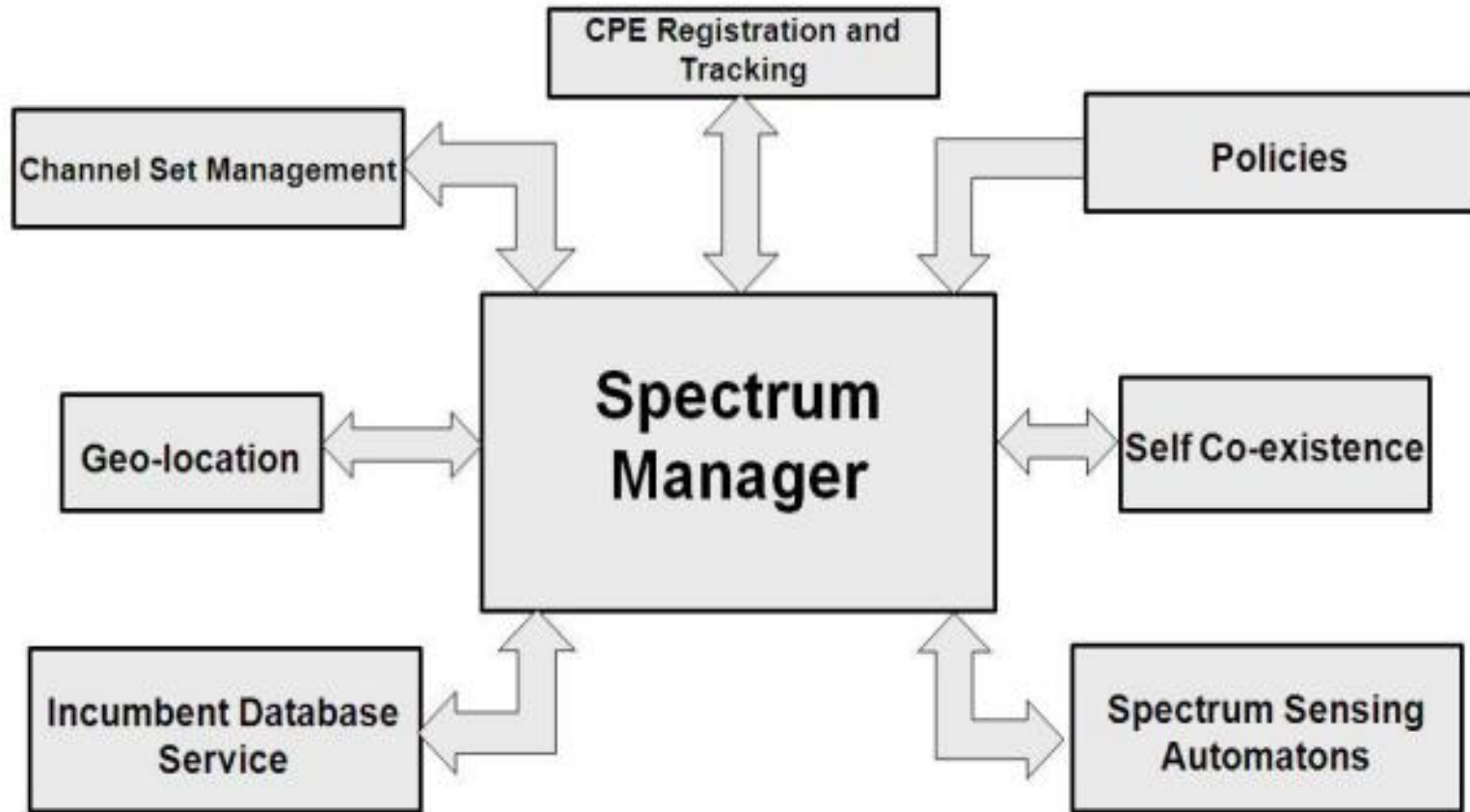
Spectrum Manager from IEEE 802.22

Source: IEEE: IEEE Standard for Information Technology – Telecommunications and information exchange between systems – Wireless Regional Area Networks (WRAN) – Specific requirements Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Policies and Procedures for Operation in the TV Bands. IEEE 802.22-2011

Hypothesis and bottom line findings EN 300 328 v1.9.1

Another example comes from the cellular mobile phone experts. They have already developed different options:

- In ETSI TR 102 683 v1.1.1 the concept of a Cognitive Pilot Channel is described. More details can be found in TR 102 838.

- The target is to achieve an effective coexistence management and an efficient use of spectrum by dynamic (automatic) assignments.

- The different RATs (radio access technology) can easily be compared with multiple radio technologies in 2.4GHz

ETSI TR 102 683 and TR 102 838
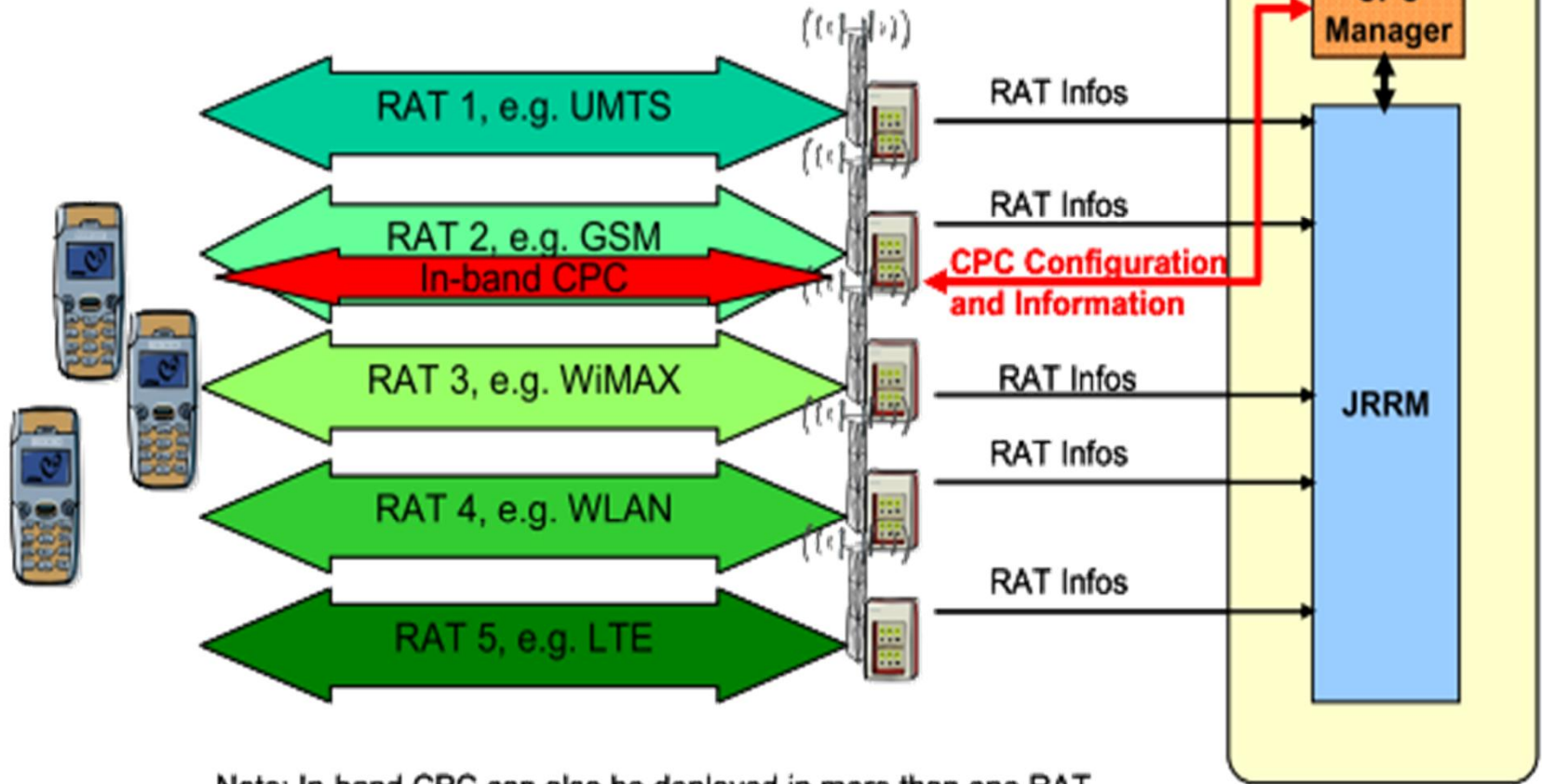
Note: In-band CPC can also be deployed in more than one RAT

RAT   = radio access technology   CPC   = cognitive pilot channel   JRRM = joint radio resource manager

Sources:

ETSI: Reconfigurable Radio Systems (RRS); Cognitive Pilot Channel (CPC). ETSI TR 102 683 V1.1.1

ETSI: Reconfigurable Radio Systems (RRS); Summary of feasibility studies and potential standardization topics. ETSI TR 102 838 V1.1.1

Hypothesis and bottom line findings EN 300 328 v1.9.1

A very similar approach can be found in the feasibility study in ETSI TR 102 684 v1.1.1

- The idea of a central control point (CCP) is to coordinate between multiple networks using single RAT or multiple RATs

- The coordination can be used for:
  - inter-network sensing assistance (e.g. a powered device is scanning the RF environment for a low (battery-) powered device)
  - Network service discovery assistance
  - Location tracking by proxy
  - Network optimization
  - Assistance for network healing

ETSI TR 102 684
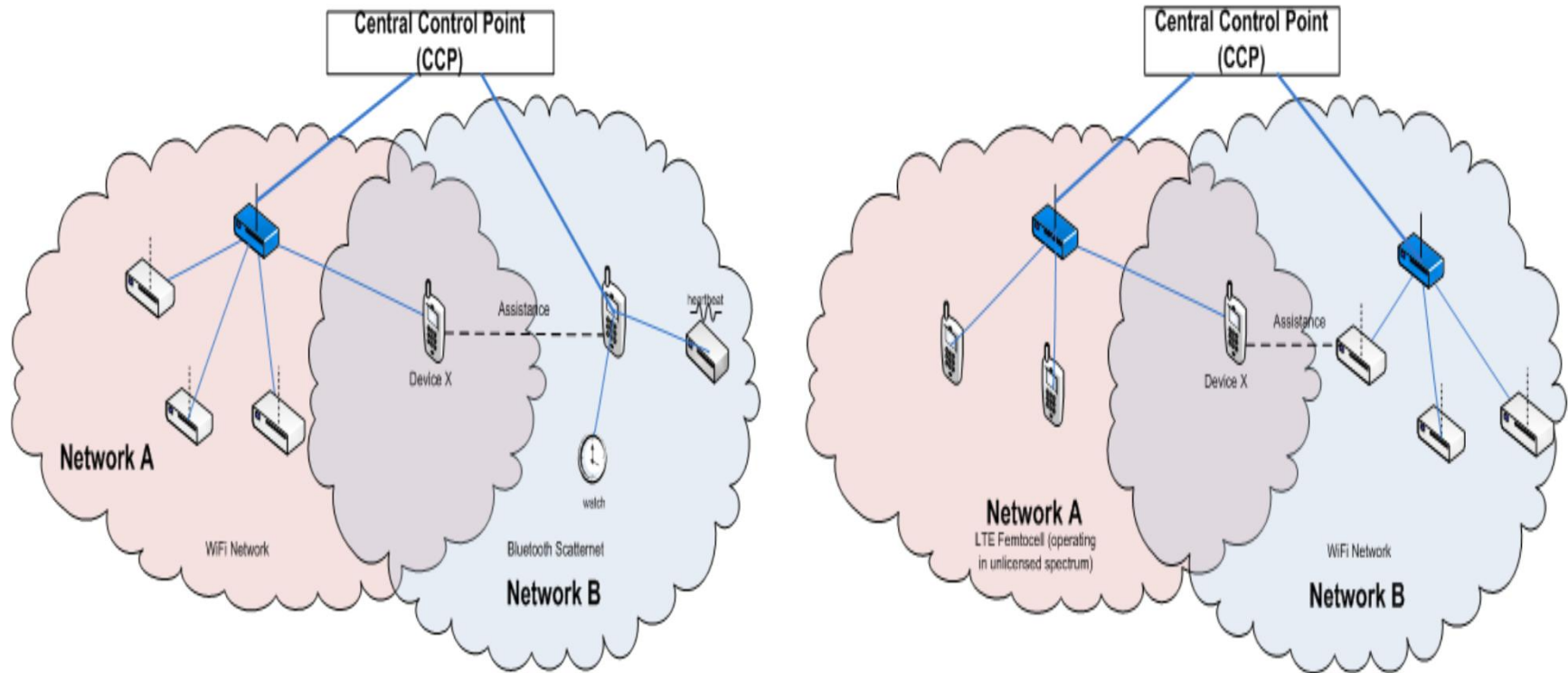
As it is shown above the CCP concept is possible for different kind of RATs (e.g. WiFi and Bluetooth or LTE and WiFI or WiFi and Zigbee etc.

Source: ETSI: Reconfigurable Radio Systems (RRS); Feasibility Study on Control Channels for Cognitive Radio Systems. ETSI TR 102 684 V1.1.1

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Basic idea to improve EN 300 328 v1.9.1
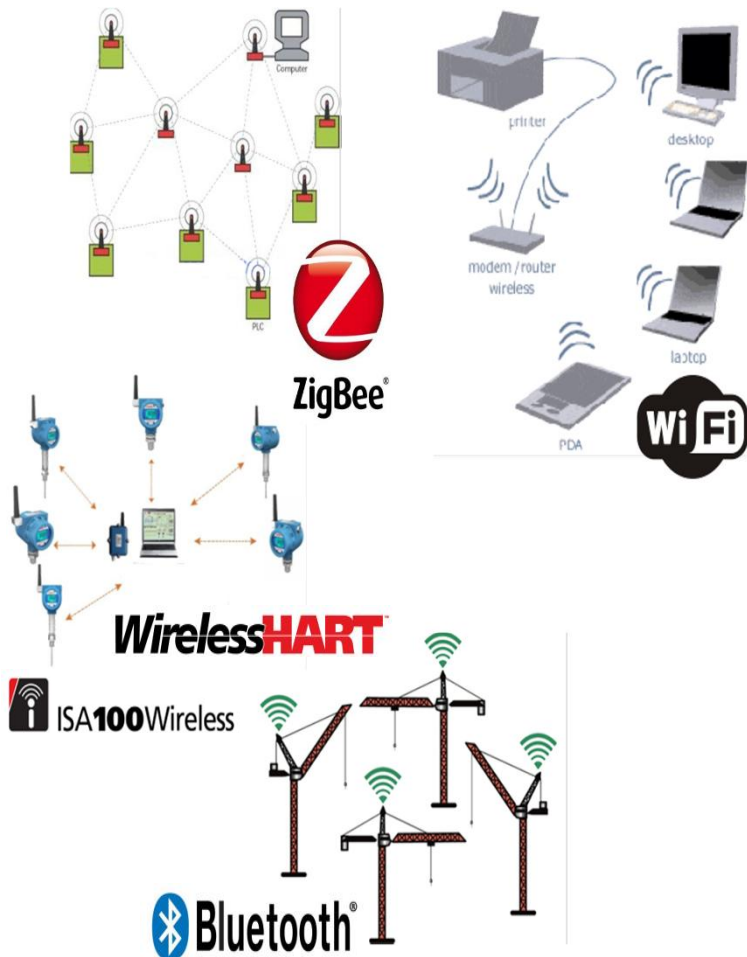
Todays situation in EN300 328v1.7.1

Todays adaptive mechanisms do <u>not</u> focus on coexistence – they focus on best performance for the individual technology (refer to: ERMTG11(23)08a1)

Consequence:
- Interference will occur in congested areas
- Systems behavior = "best effort"

Slide 35 Ludwig Winkel, Siemens AG

Basic idea to improve EN 300 328 v1.9.1

<u>Future situation in EN300 328v1.8.1</u>

Legacy systems (v1.7.1) will coexist with new systems (v1.8.1)

Consequence:
- If interference occurs, legacy systems will succeed in congested areas
- Systems behavior = "best effort" & "should be polite and equal (but isn´t!)"
- In pure v1.8.1 areas, problems are given by 10mW EN300440 systems
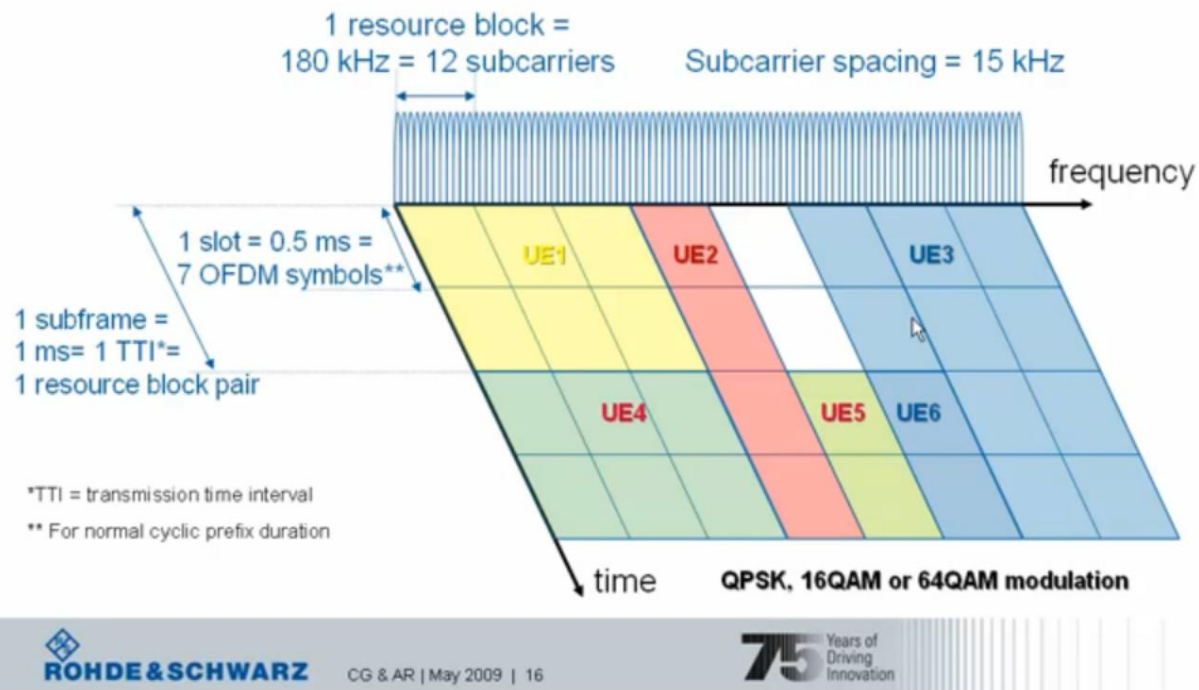
Basic idea to improve EN 300 328 v1.9.1

Idea of a CCP (central control point):

The CCP is scheduling resources to the different wireless systems. This can include single device to CCP communications or an access point to CCP communication, while the access point will then use the CCP information to configure and control it´s own network

CCP

ISA**100**Wireless

WirelessHART

Bluetooth

ZigBee

Wi Fi
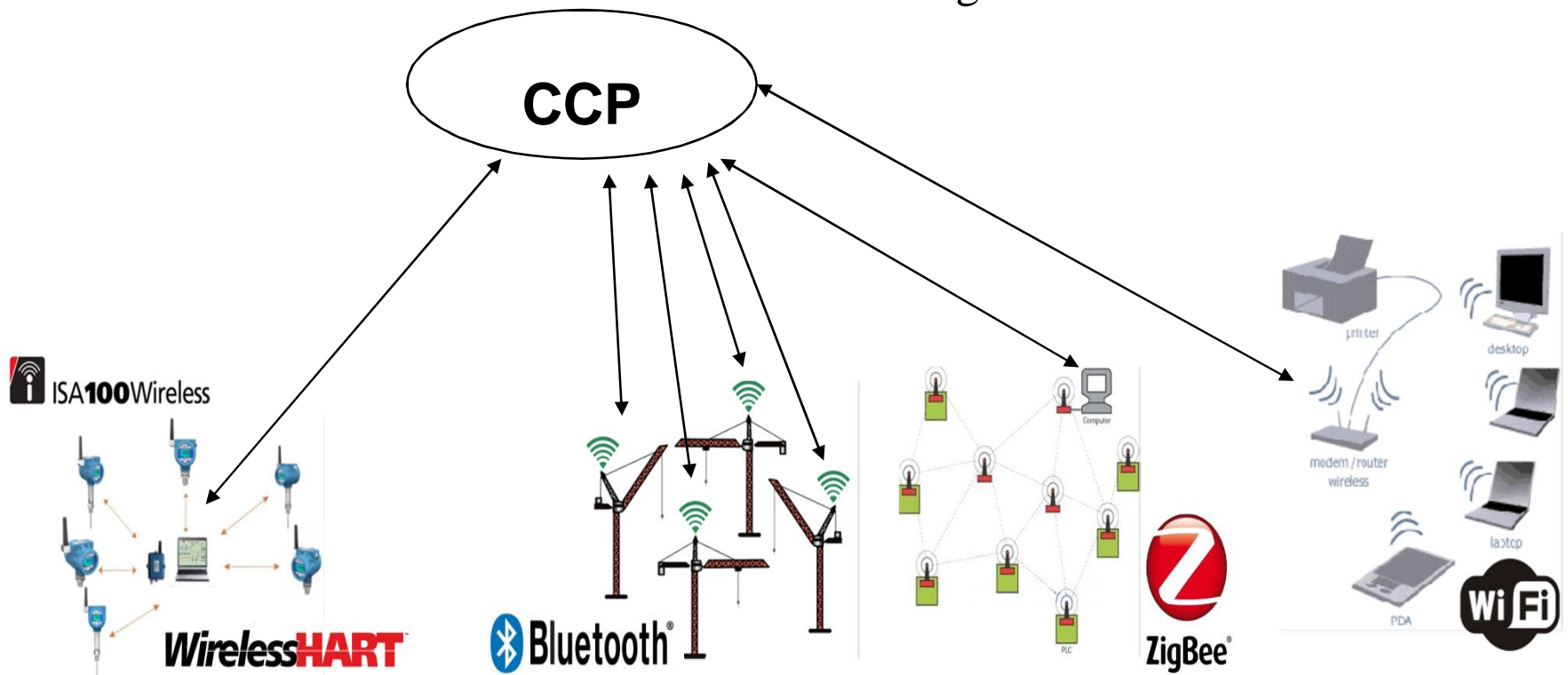
Basic idea to improve EN 300 328 v1.9.1

The resources can be selected in the <u>time</u> and in the <u>frequency</u> domain. Comparable to OFDM based systems like LTE, the CCP can organize the available spectrum resources and assign resource blocks to the different wireless networks (or devices)

Source: http://www.eventhelix.com/lte/tutorial/web-presentation.htm#.UhHrL6BRMtE

Basic idea to improve EN 300 328 v1.9.1

- The CCP is communicating to the different network access points (or the individual wireless devices) via a specified <u>pilot channel</u>.
- This pilot channel is an <u>in-band</u> (2.4GHz) communication channel, which could be realized with different modulation schemes.
- A CCP can support one or more pilot channels with one or more modulation schemes. It can talk multiple "languages".
- The functionality of a CCP shall be described in EN300328v1.9.1

→ always keep in mind: if the device does not find a CCP it will automatically fall back to v1.8.1 behavior !
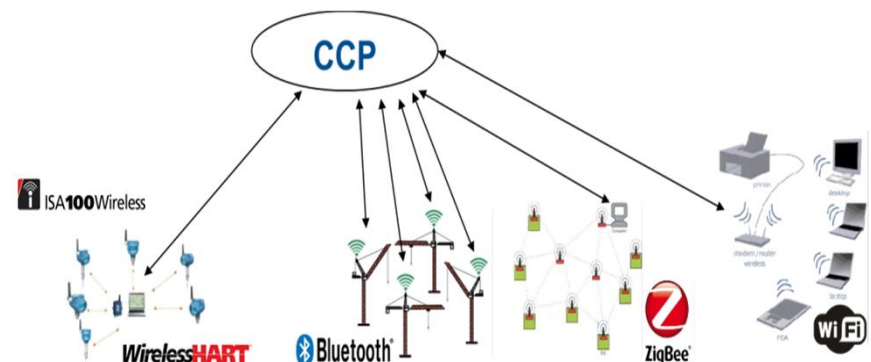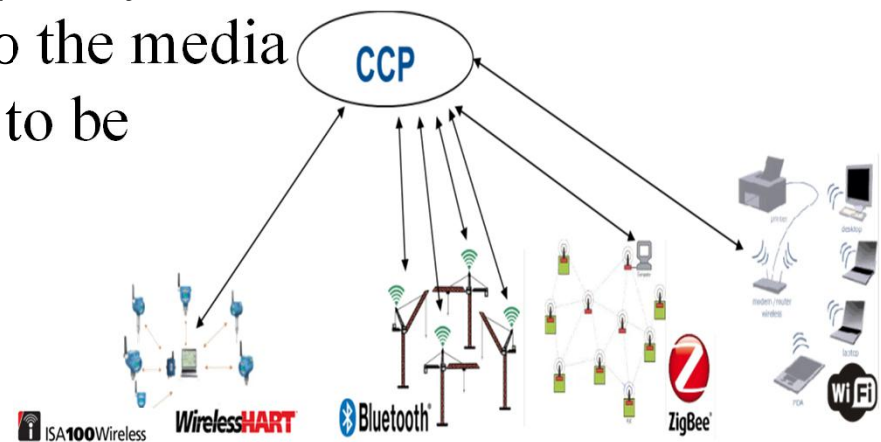
Basic idea to improve EN 300 328 v1.9.1

Future situation (with CCP adopted)

Legacy systems (v1.7.1) will coexist with new systems (v1.8.1) and CCP systems (v1.9.1)

Consequences:

- In CCP controlled areas, best spectrum efficiency and good performance for CCP controlled devices (sharing is guaranteed)
- In non-CCP controlled areas, adaptivity acc. to v1.8.1 is ensuring access to the media
- devices not supporting CCP need to be adaptive acc. to v1.8.1

Basic idea to improve EN 300 328 v1.9.1

Conclusion 1/2

- The idea of a central control point (CCP) is to coordinate between multiple devices and/or multiple networks using single RAT or multiple RATs

- Radio devices working with a CCP will optimize spectrum efficiency and maximize coexistence

- The CCP concept improves wireless communication in every application field like
  - Hotels (WiFi access point planning will be needless)
  - Airports or other public places (improvement of performance)
  - Home (ease of use of multiple wireless devices – even with different RATs)
  - Industry (manual management will be needless, guaranteed quality of service)

Basic idea to improve EN 300 328 v1.9.1

Conclusion 2/2

- The CCP avoids (harmful) interference and improves the efficient use of spectrum if compared to randomly based media access mechanisms.

- Wireless devices which cannot operate with a CCP (because they don´t offer this capability or because there is no CCP available) must use an automatic, adaptive media access mechanism acc. to EN 300328 v1.8.1