

GRUPPO TELECOM ITALIA

Seminario FUB, 18 June 2009

ROMA – Telecom Italia LAB

SDR (Software Defined Radio) & Cognitive Radios Overview

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Outline

- ▶ Overview on Telecom Italia activities on SDR/CR
- ▶ SDR concept and related technological challenges
- ▶ Cognitive Radios & Cognitive Networks concept
- ▶ Research activities: E3 project
- ▶ Standardisation: ITU, ETSI and IEEE 802.22
- ▶ Mid and long terms solutions:
 - ▶ Reconfigurable base stations
 - ▶ Dynamic spectrum management
 - ▶ Cognitive Pilot Channel
- ▶ Conclusions

Outline

- ▶ Overview on Telecom Italia activities on SDR/CR

SDR/CR: Main TI Activities

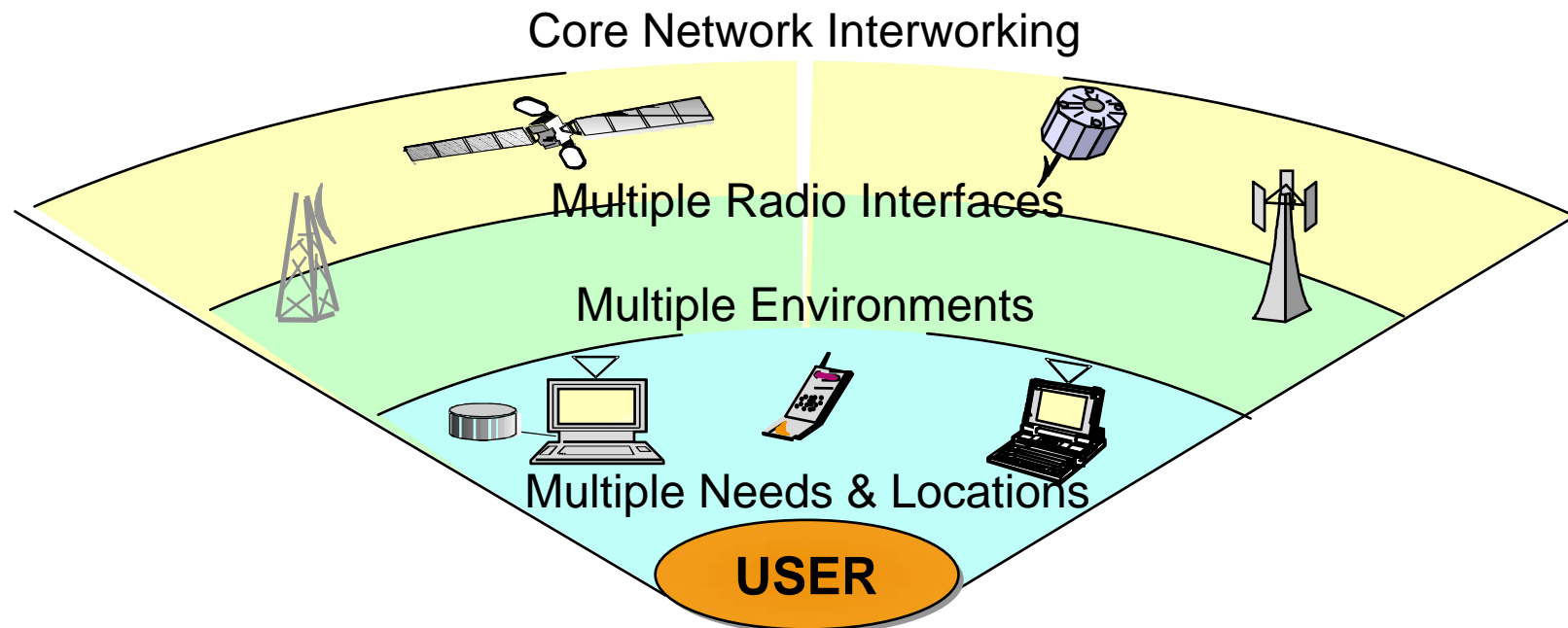
- ▶ **1997:** SDR activities started within **SORT & SLATS EU project**
- ▶ **1998:** Organization, jointly with EC, of the **1st EU symposium on SDR & Reconfigurable Radios & Systems**
- ▶ **2000:** IEEE Comms. Magazine paper on **SDR Concept (E.Buracchini)**
- ▶ **Since 2002:** Internal activities on **SDR/CR**
- ▶ **2004-5:** Participation to **IST project E2ER I**
- ▶ **2006-7:** Participation to **IST project E2ERII (wp6 Leadership)**
- ▶ **2008-9:** Participation to **IST project E3 (wp5 Leadership)**

Outline

- ▶ SDR concept and related technological challenges

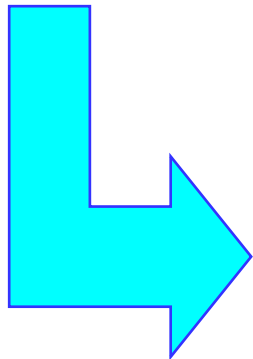
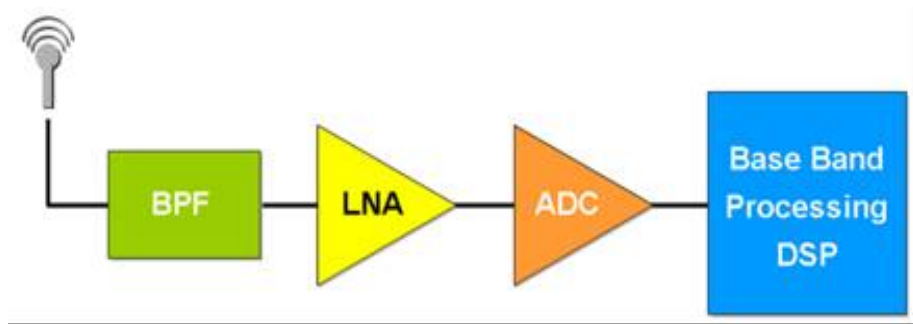
Software Defined Radio

**Emerging technology for flexible radio systems,
“multi-service”, “multi-standard”, “multi-band”,
reconfigurable and reprogrammable by software**

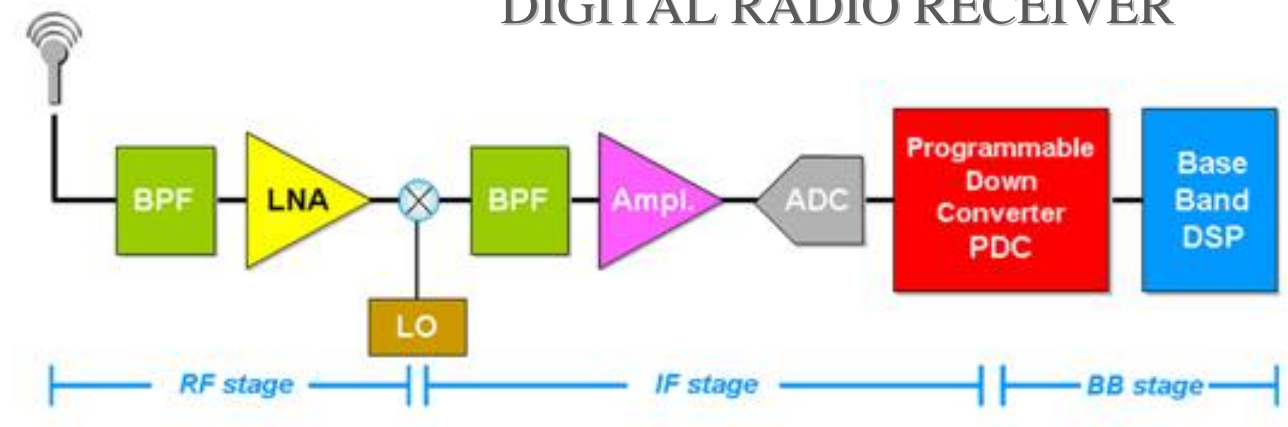


Software radio transceiver

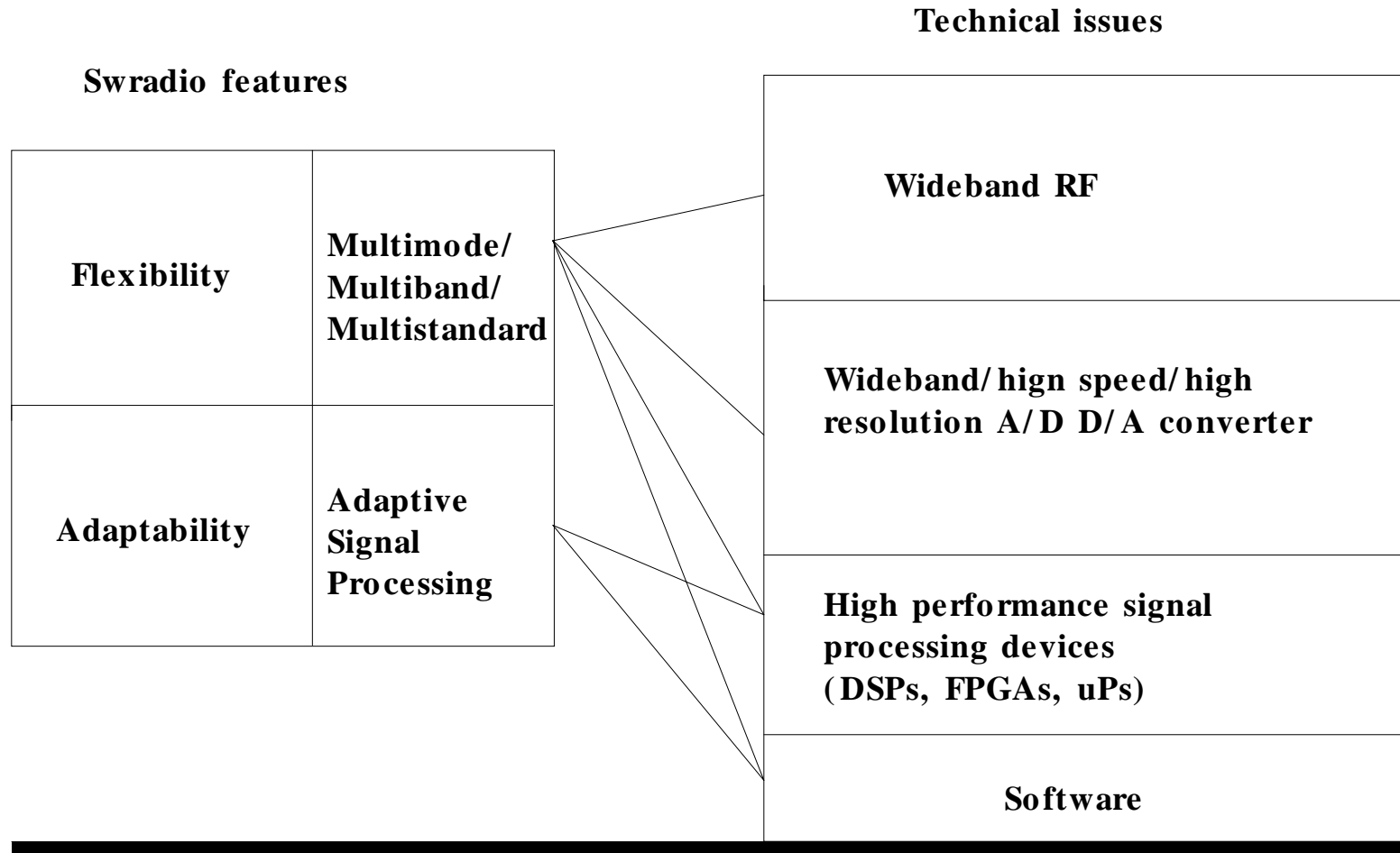
IDEAL SOFTWARE
RADIO RECEIVER:



DIGITAL RADIO RECEIVER



Technical issues for a SW radio transceiver



Outline

- ▶ **Cognitive Radios & Cognitive Networks concept**

Cognitive Radios

- **Cognitive Radio definitions:**

- ✓ First defined by Mitola as “the point in which wireless personal digital assistants (PDAs) and the related networks are sufficiently computationally intelligent about radio resources and related computer-to-computer communications to: (a) detect user communications needs as a function of use context, and (b) to provide radio resources and wireless services most appropriate to those needs.”

- ✓ The FCC suggests: “A Cognitive Radio (CR) is a radio that can change its transmitter parameters based on interaction with the environment in which it operates. The majority of cognitive radios will probably be Software Defined Radios (SDRs), but neither having software nor being field programmable are requirements of a cognitive radio.”

Cognitive networks & nodes

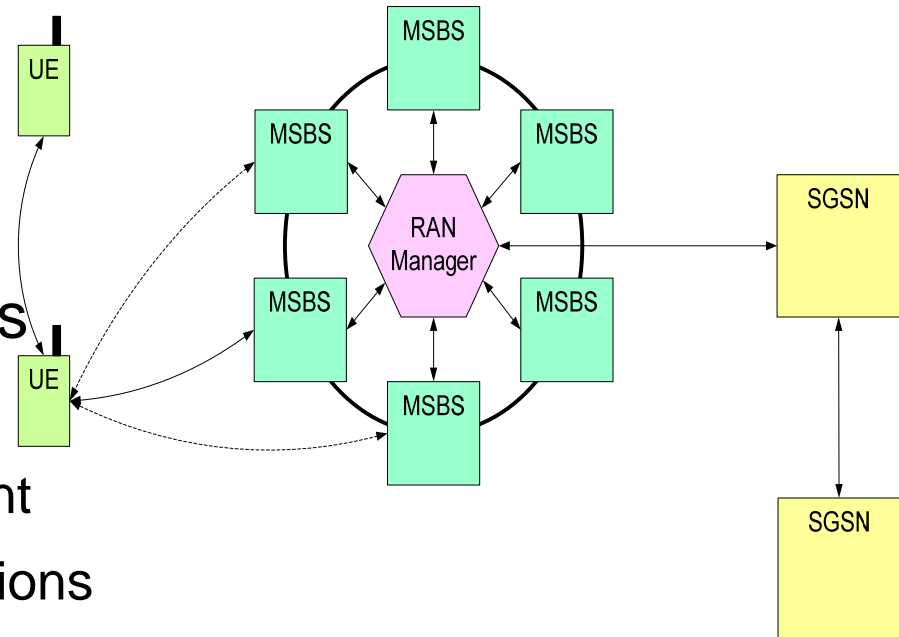
▶ Cognitive Process

- Cognitive Framework
- Applications for cognitive nodes

- ✓ Advanced Antenna Systems
- ✓ Multi-RAT Resource Management
- ✓ Management of multiple connections
- ✓ Cognition enablers, e.g. CPC (Cognitive Pilot Channel)

▶ **DYNAMICAL** resource adaptations on the basis of:

- ▶ **Radio conditions**
- ▶ **Traffic conditions**
- ▶ **User context**



Outline

- ▶ Research activities: E3 project
- ▶ Standardisation: ITU, ETSI and IEEE 802.22

E3 EU FP7 IP

▶ E3 (End-to-End Efficiency) project is an European Integrated Project (IP) europeo in the framework of FP7 and it is active since January 2008 and it has 2 years duration.

▶ Partners:

- ▶ 6 Vendors (Alcatel-Lucent, Ericsson, Nokia, Toshiba, NEC, Thales Communications),
- ▶ 4 Operators (Telecom Italia, Telefonica, Deutsche Telekom e France Telecom),
- ▶ 4 regulators (UK, FR, GE, ND)
- ▶ 8 university/R&D centers

▶ The End-to-End Efficiency (E3) project is aiming at integrating cognitive wireless systems in the Beyond 3G (B3G) world, evolving current heterogeneous wireless system infrastructures into an integrated, scalable and efficiently managed B3G cognitive system framework. The key objective of the E3 project is to design, develop, prototype and showcase solutions to guarantee interoperability, flexibility and scalability between existing legacy and future wireless

▶ Several of the aforesaid technologies and methodologies, such as e.g. "Cognitive Networks", cognition radio enablers as CPC, are studied inside E3.

E3 EU FP7 IP: Telecom Italia activities

- ▶ Inside E3 is mainly active into 2 Work Packages:
 - ▶ Wp5: leadership of “Support to heterogeneous standards” with the main R&D effort on definition of appropriate solutions for CPC (Cognitive Pilot Channel)
 - ▶ Wp3: main R&D effort on methodologies/algorithms for reconfigurable base stations and studies on reliability of advanced Radio Resources Management methodologies

ITU R Wp5A & ETSI RRS

- ▶ Inside ITU-R, into group WP 5A, it is under preparation a working document describing all main aspects of Cognitive Radios Systems, starting from their definition;
- ▶ Inside ETSI, it has been recently open a committee (TC RRS) whose mandate is to perform a feasibility study on some items related to SDR, CR e CRS (Cognitive Radio Systems), aiming to evaluate the possibility to create an ETSI standard.
 - ▶ TC RRS (Technical Committee Reconfigurable Radio System) is currently studying items related to systems aspects (architecture & requirements), to reconfigurable radio equipment (both UE both network side), to Cognitive Pilot Channel and to public safety.

ITU R Wp5A & ETSI RRS: Telecom Italia activities

- ▶ Inside ITU-R WP 5A, Telecom Italia, in E3 project framework, has actively contributed to definition and is actively contributing on main peculiarities of Cognitive Radios Systems
- ▶ Inside ETSI TC RRS, in E3 project framework, is actively contributed to define appropriate solutions for CPC and to definition of some requirements for reconfigurable base stations

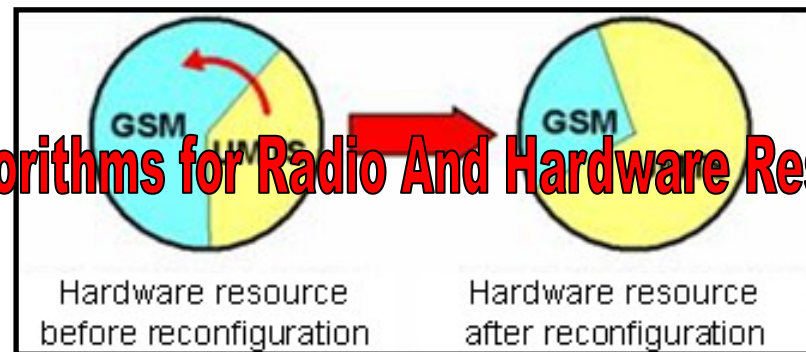
Outline

- ▶ **Mid and long terms solutions:**
 - ▶ Reconfigurable base stations
 - ▶ Dynamic spectrum management
 - ▶ Cognitive Pilot Channel

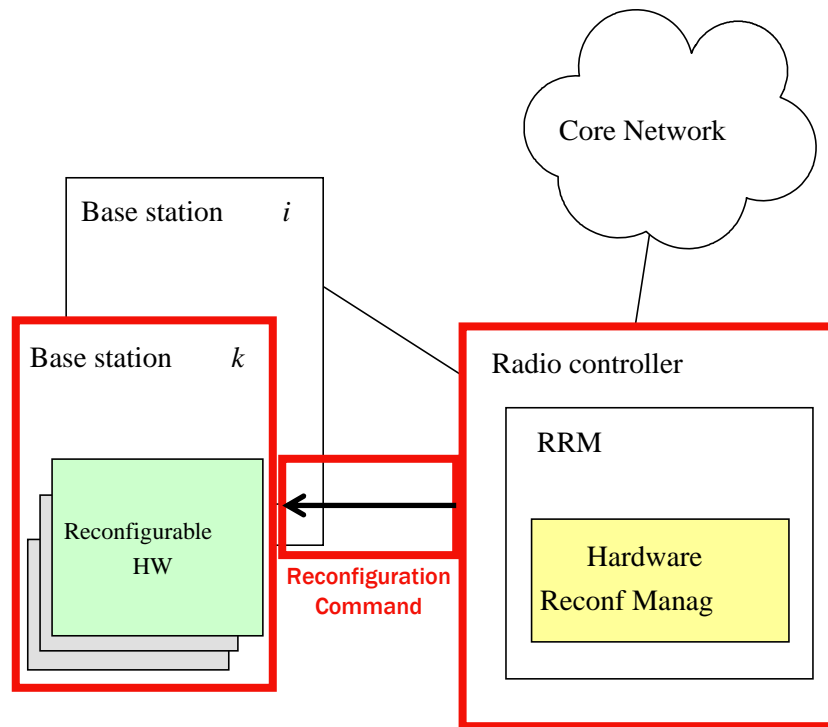
Reconfigurable BTS: rationale

- ▶ The **availability** of **reconfigurable nodes** in the networks will give the network operators further means for **managing** in a **more efficient way** the **radio** and **hardware resource** pools in order to exploit **higher capacity**
- ▶ GSM and UMTS systems deployed in a geographical area
 - ▶ Network built with **reconfigurable nodes**
 - ▶ **Hardware resources** of each node are **shared between GSM** and **UMTS functionalities**
- ▶ **Different traffic loads** on the **two RATs** could lead to **increase** the **percentage** of **hardware resources** devoted to the over-loaded system while **decreasing** the **resources** given to the **other** (supposed under-loaded)

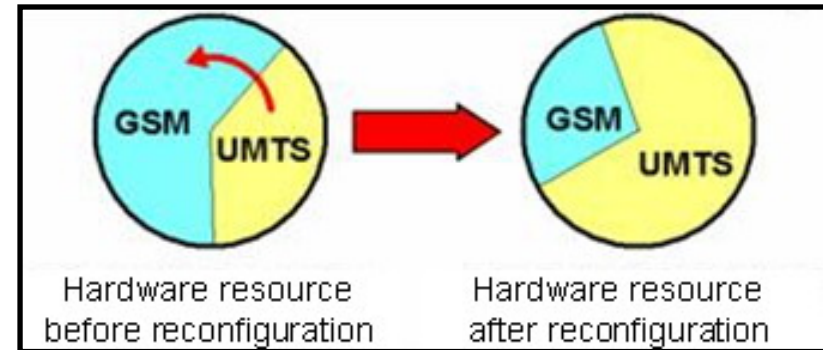
New family of algorithms for Radio And Hardware Resource optimization



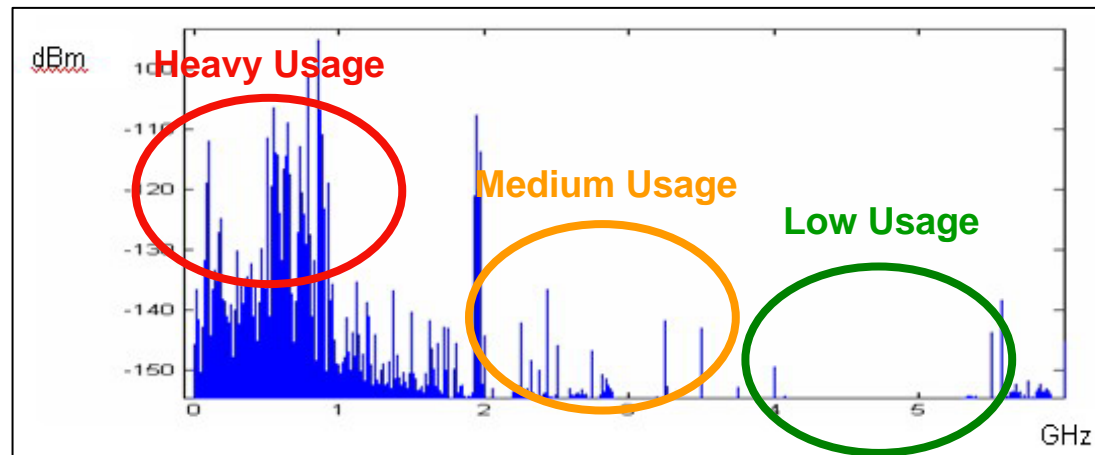
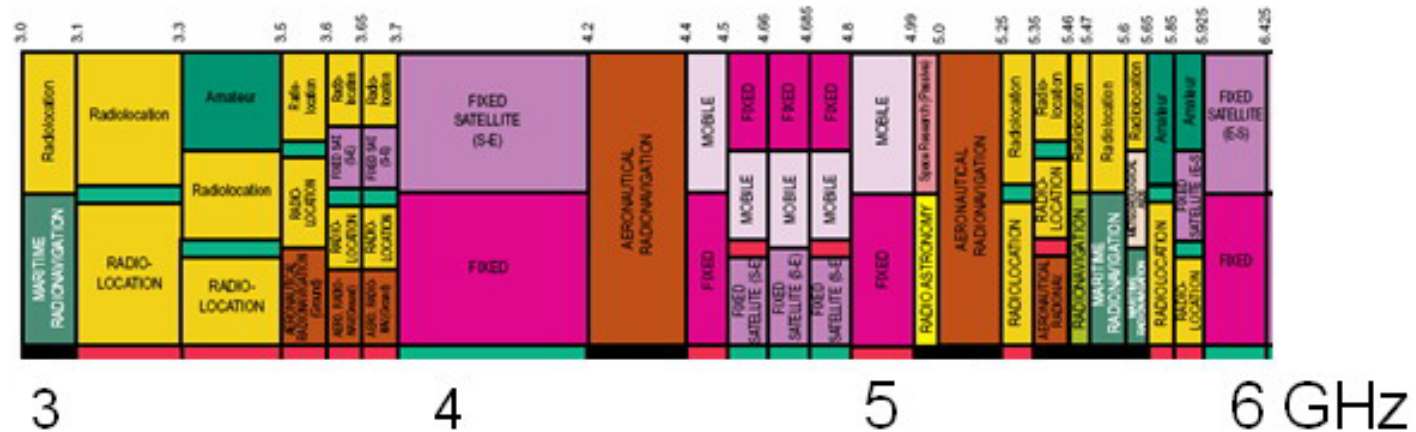
Management of multi-RAT reconfigurable BTS



Mechanisms for self-adaptive RRM algorithms that can dynamically adapt the radio resource to changing traffic conditions



Dynamic Spectrum Management (DSM)

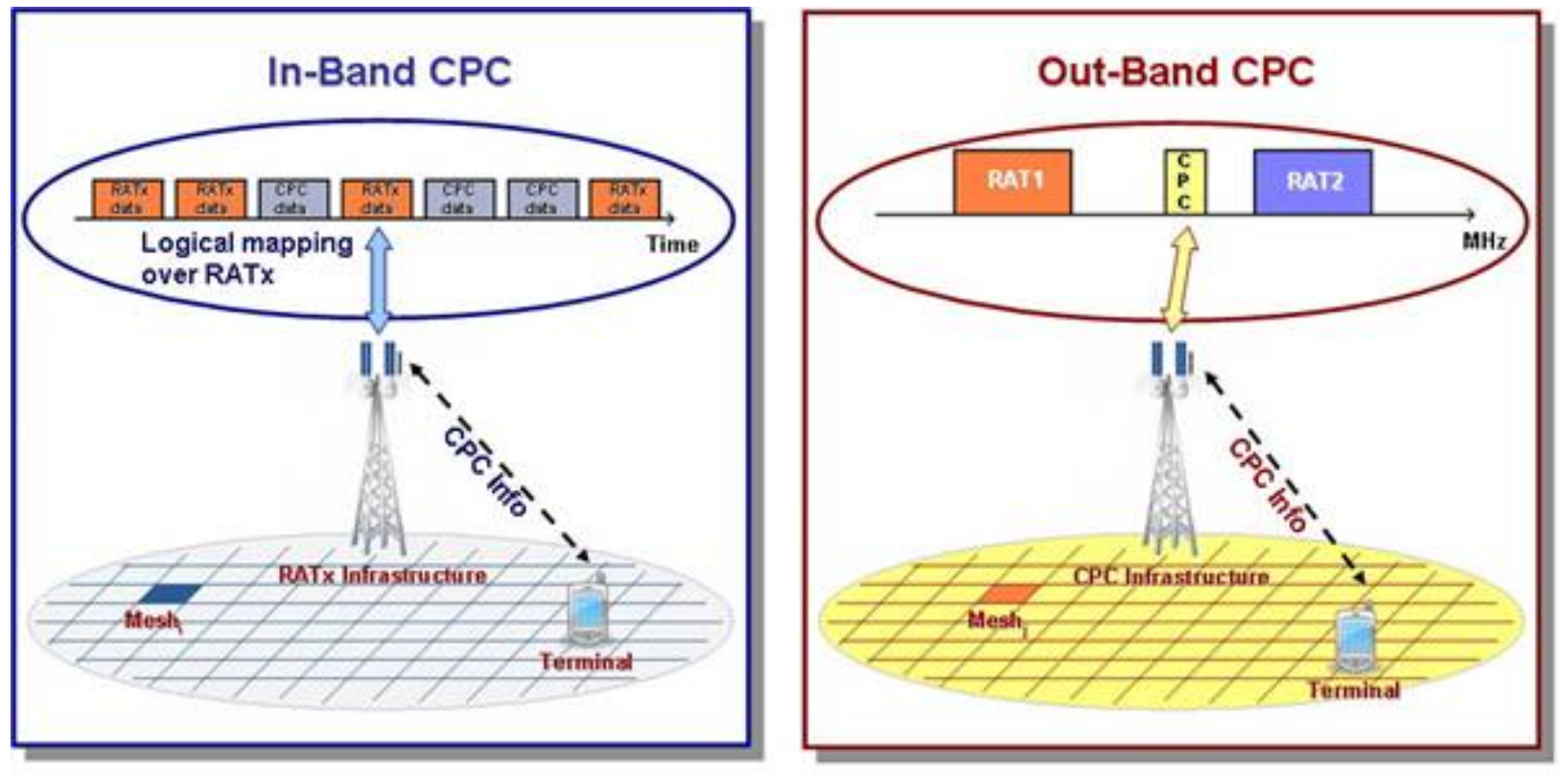


- **Sensing?** (terminal centric solution)
- **CPC?** (network centric solution)

Cognitive Pilot Channel (CPC) use cases

- ▶ **UE (User Equipment) Switch-on (mainly in case of dynamic spectrum management)**
- ▶ **Radio Resource selection policies (complementary to CRRM)**
- ▶ **Secondary spectrum usage**
- ▶ **Information provisioning (e.g. Software Download)**

CPC Implementation solutions: Out-band and In-band



Outline

- ▶ **Conclusions: impacts and open issues**

Impacts of SDR/CR

FOR NETWORK OPERATORS:

- **Simultaneous implementation of more standards on the same BS: possible reduction of investments & coverage flexible upgrade**

FOR MANUFACTURERS:

- **Reduced set of HW platforms development for each radio system and for each market**
- **cost reduction, reduced inventory, scale economy**
- **possibility to correct and improve SW in successive phases**

FOR CUSTOMERS:

- **Better fruition of existing/new services depending on the context**

Open issues

- **R&D efforts still necessary and ongoing (maturity of technology and reliability of related algorithms/methodologies, impact on network management and planning processes,)**
- **Dawning of standardisation & regulation**