Managing Future Radiomobile and Wireless Networks through Reconfigurable Radio Systems

The First International Conference on Advances in Cognitive Radio
COCORA 2011
April 17-22, 2011 - Budapest, Hungary

TELECOM ITALIA
HR SERVICES

Maria Stella Iacobucci

HR SERVICES

mariastella.iacobucci@hrs.telecomitalia.it

Outline

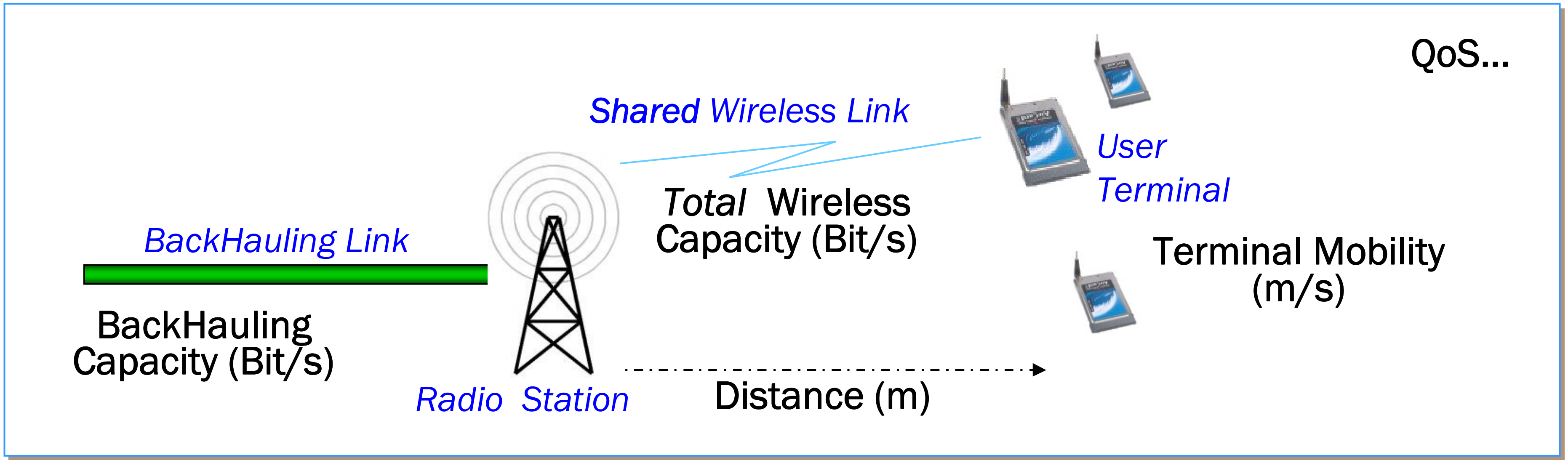
- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and introduction
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

Outline

- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and capabilities
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

WiFi… 2G/3G… LTE… back to basic !

What is fundamental….



…and….

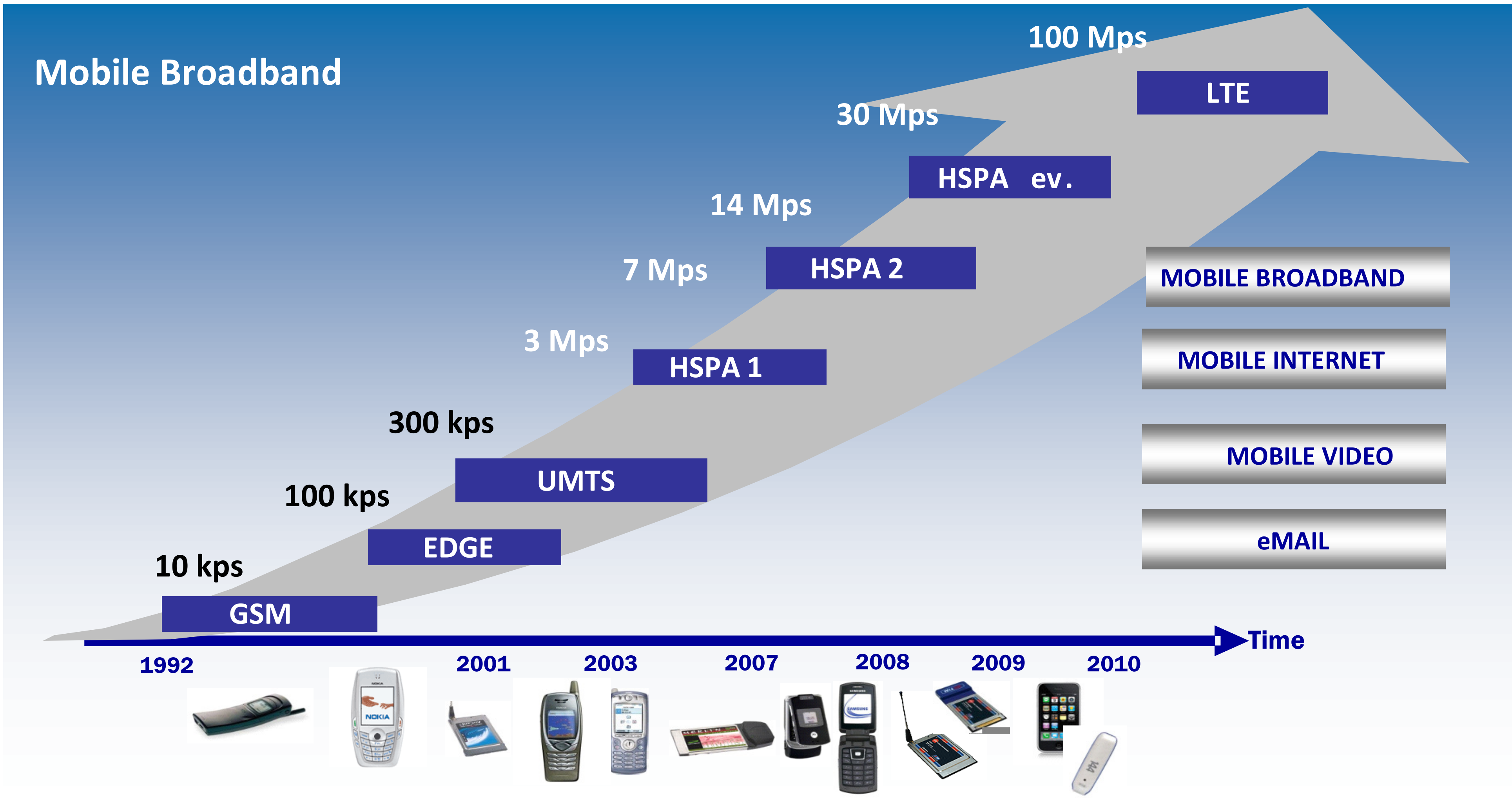
- ✓ Indoor / Outdoor coverage
- ✓ "Radio Carrier" Frequency (GHz)
- ✓ Allocated Spectrum width (MHz)
- ✓ Radio Modulation Technology
- ✓ Power constraints (Watt)
- ✓ Radio Interference
- ✓ Licenced / Unlicenced Radio Spectrum
- ✓ Reliability
- ✓ Security
- ✓ Standard
- ✓ Economic Sustainability …

Outline

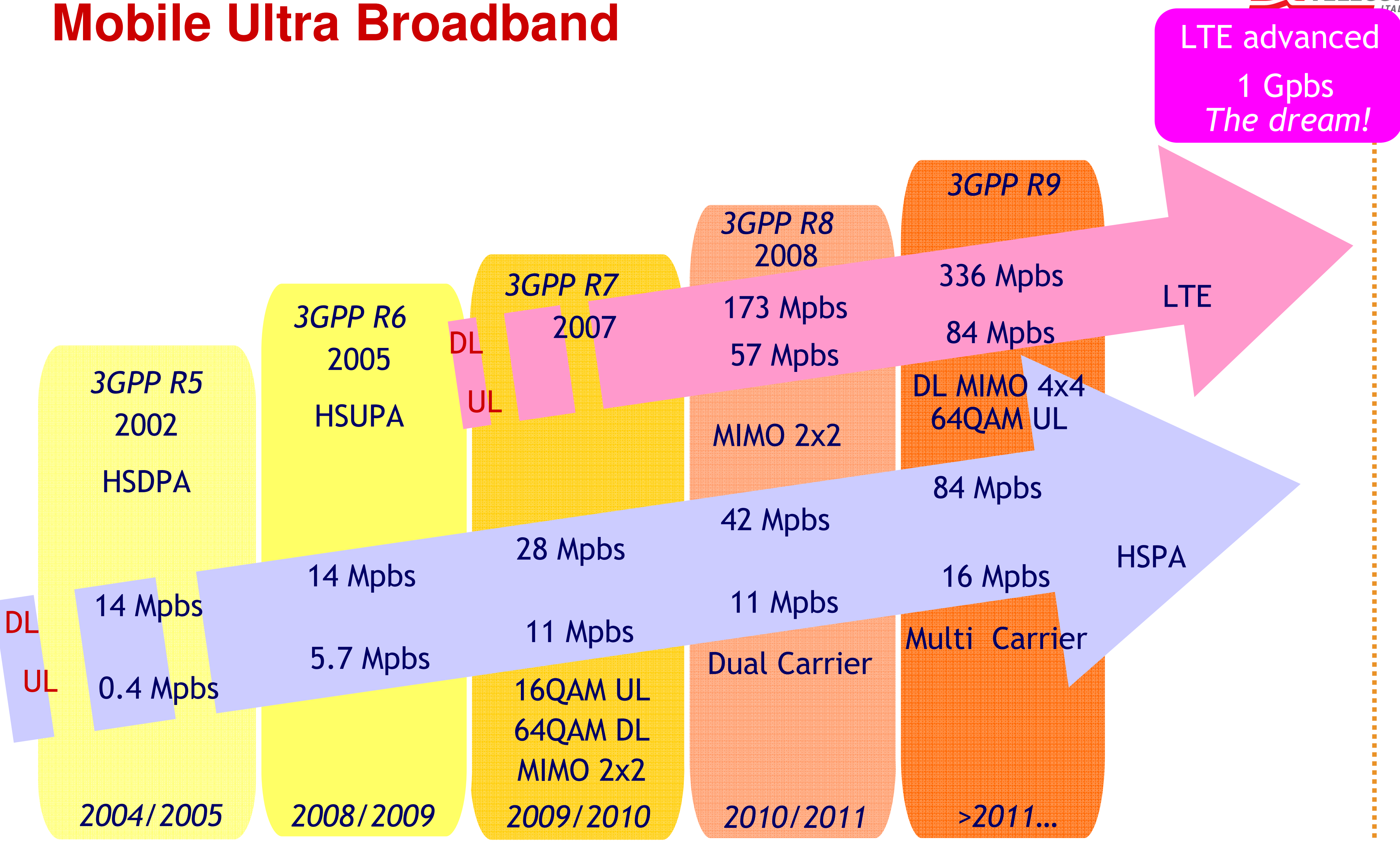
TELECOM ITALIA
HR SERVICES

- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and capabilities
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

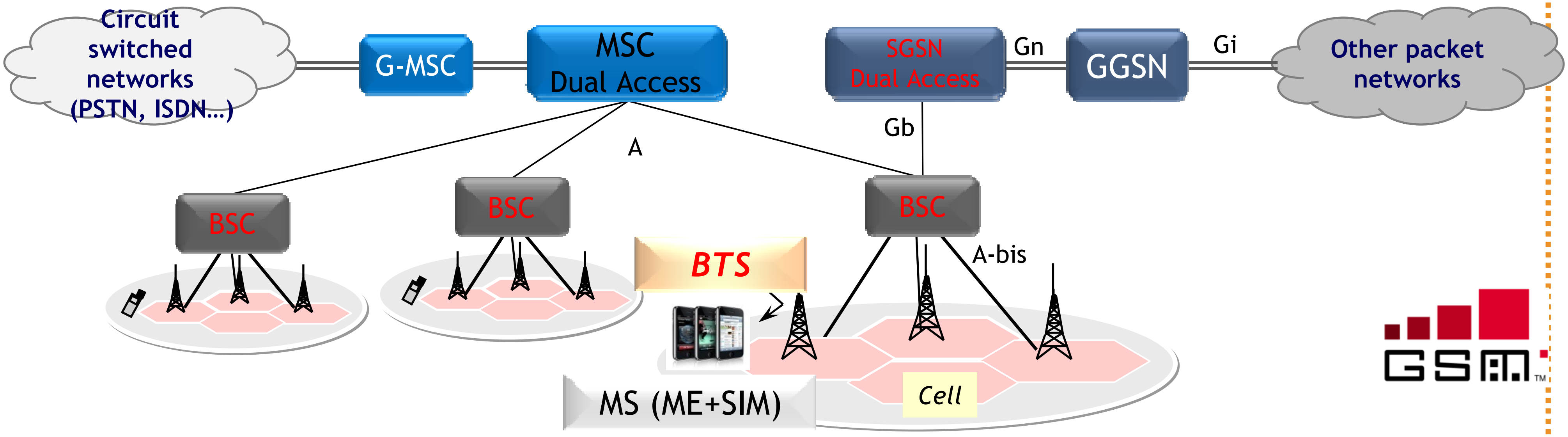
Mobile Access: from BB (BroadBand) to UBB (Ultra BroadBand)



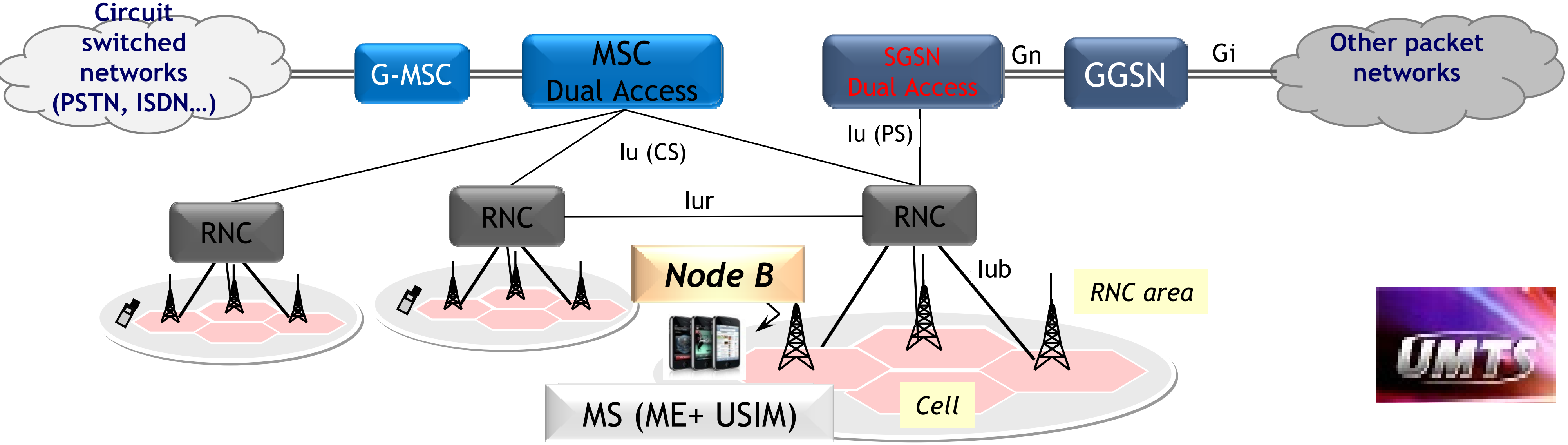
Mobile Ultra Broadband



GSM/GPRS/EDGE network architecture

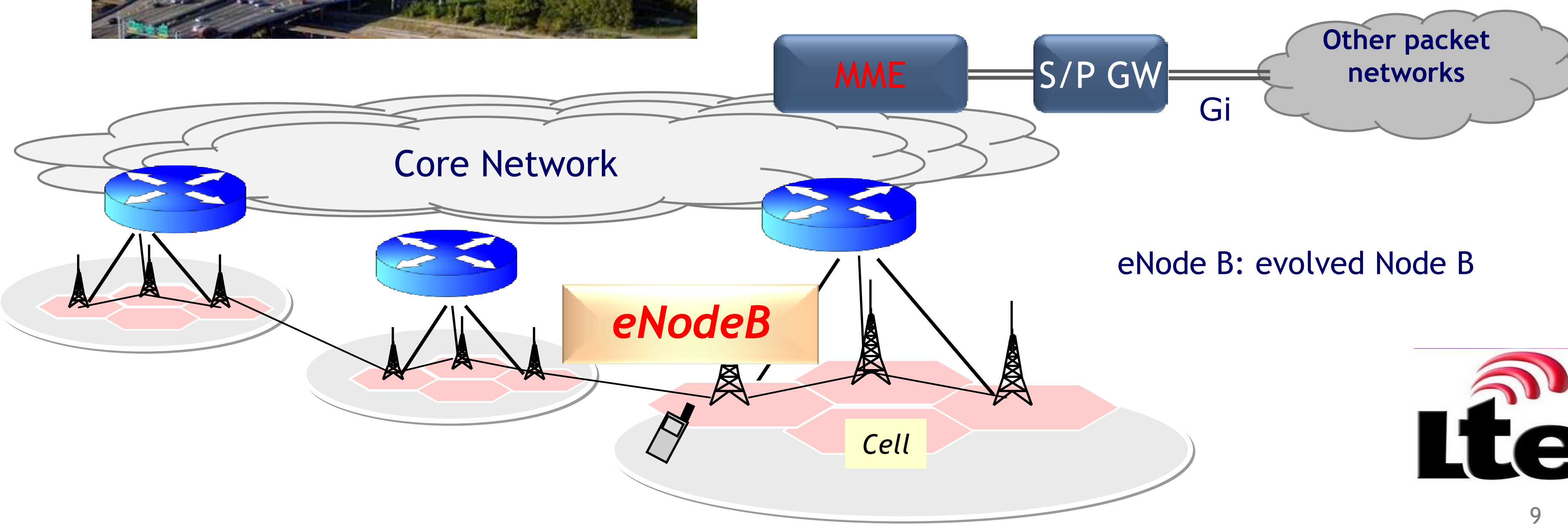


UMTS/HSPA network architecture



LTE: Long Term Evolution

Full Ip Architecture

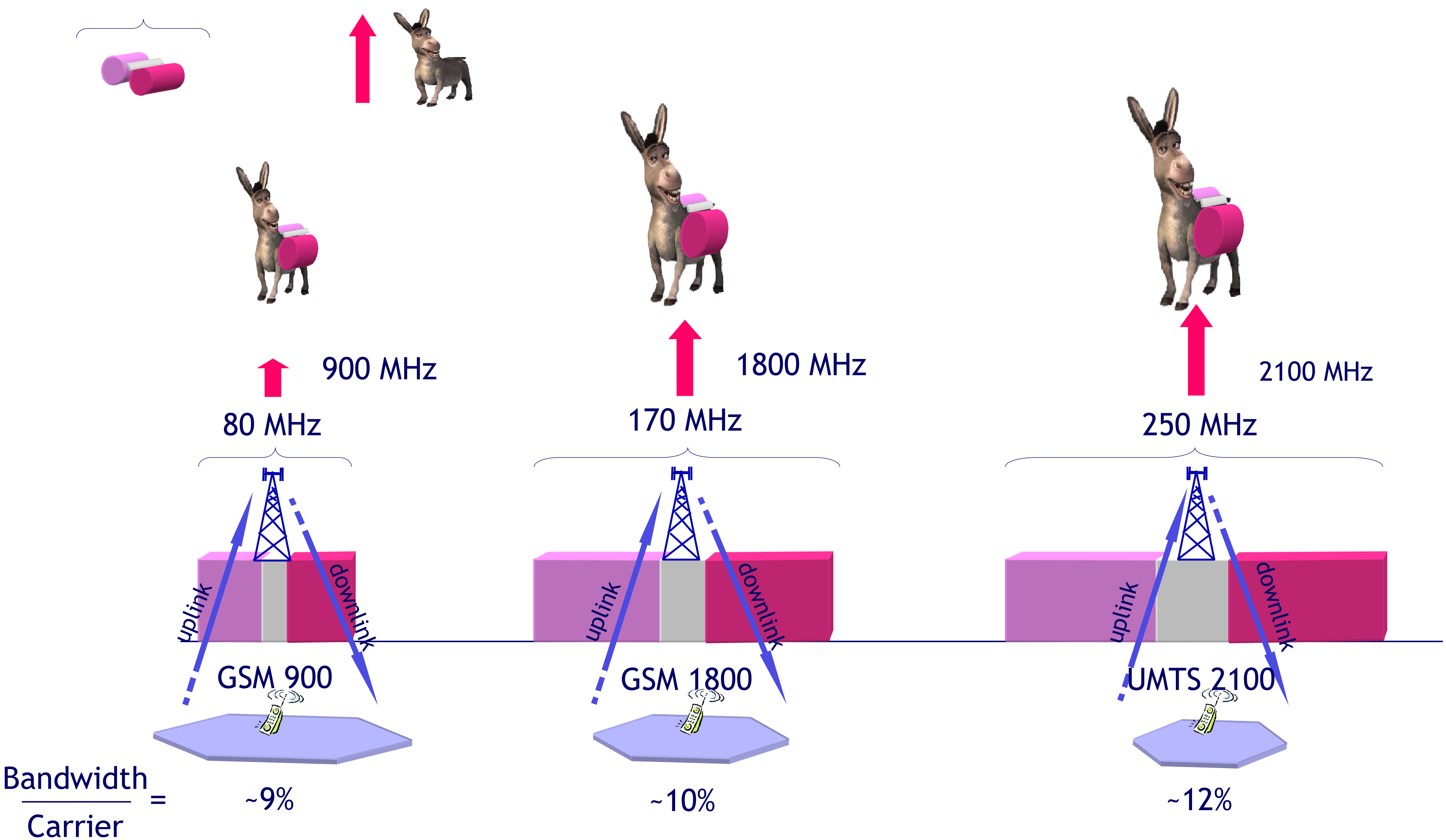


9

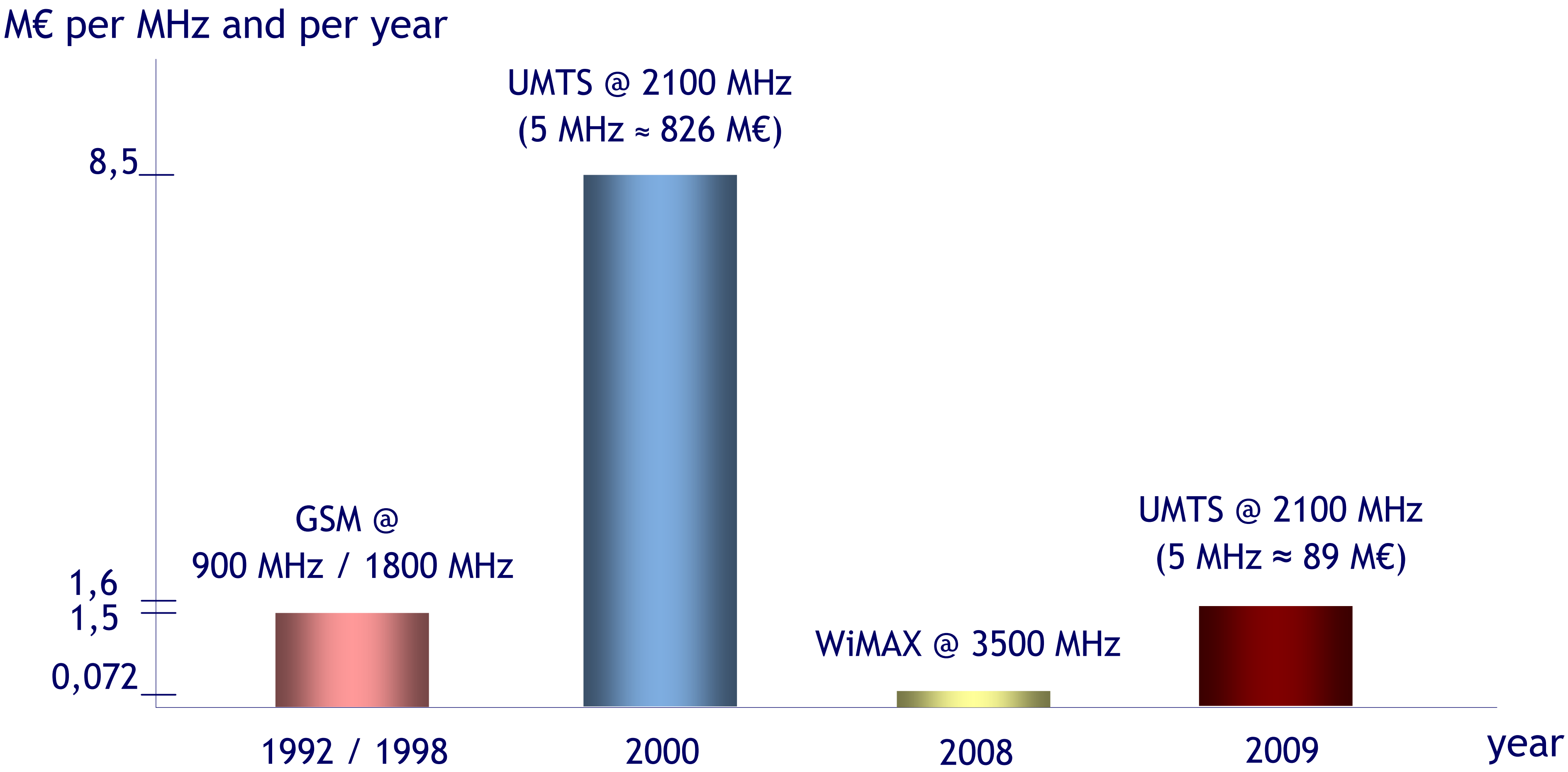
Radiomobile spectrum

Band	Uplink (MHz)	Downlink (MHz)	Carrier Bandwidth (MHz)	Comments
700 MHz	746-763	776-793	1.25 5 10 15 20	Digital Dividend. U.S. commercial spectrum auctioned Q108. "D" block to be re-auctioned. Potential future alignment with Europe
AWS	1710-1755	2110-2155	1.25 5 10 15 20	U.S. Auctions completed September 2006
IMT Extension (Paired)	2500-2570	2620-2690	1.25 5 10 15 20	Initially Western Europe. Offers a unique opportunity for the deployment of LTE in channels of up to 20 MHz.
IMT Extension (Unpaired)	2570-2620		1.25 5 10 15 20	Potential for LTE –TDD in Europe and Asia Pac.
GSM 900	880-915	925-960	1.25 5 10 15 20	Reallocate this spectrum to advanced networks, such as LTE, from 2009 onwards
UMTS Core	1920-1980	2110-2170	1.25 5 10 15 20	Europe and Asia Pac. Potential for unused WCDMA carriers
GSM 1800	1710-1785	1805-1880	1.25 5 10 15 20	Europe and Asia Pac. Refarm underutilized band along with GSM 900
PCS 1900	1850-1910	1930-1990	1.25 5 10 15 20	U.S. Refarm after new 700 MHz and AWS spectrum is consumed.
Cellular 850	824-849	869-894	1.25 5 10 15 20	U.S. Refarm after new 700 MHz and AWS spectrum is consumed.
Digital Dividend	470-854		1.25 5 10 15 20	Identified at WRC-07.

Bandwidth and Carrier



How much are the costs (Italy)?



…and the radio performances?

System	Theoretic peak bit rate (Mbit/s)	Bandwidth (MHz)	Efficiency (bit/s/Hz)
EDGE	0,236	0,2	1,2
UMTS	0,384 *	5	0,5
HSDPA	1,8 ÷ 14,4	5	0,35 ÷ 2,9
HSPA+ (64QAM)	21	5	4,2
HSPA+ (MIMO)	28	5	5,6
LTE	≈ 150 ÷ 300	20	7,5 ÷ 15

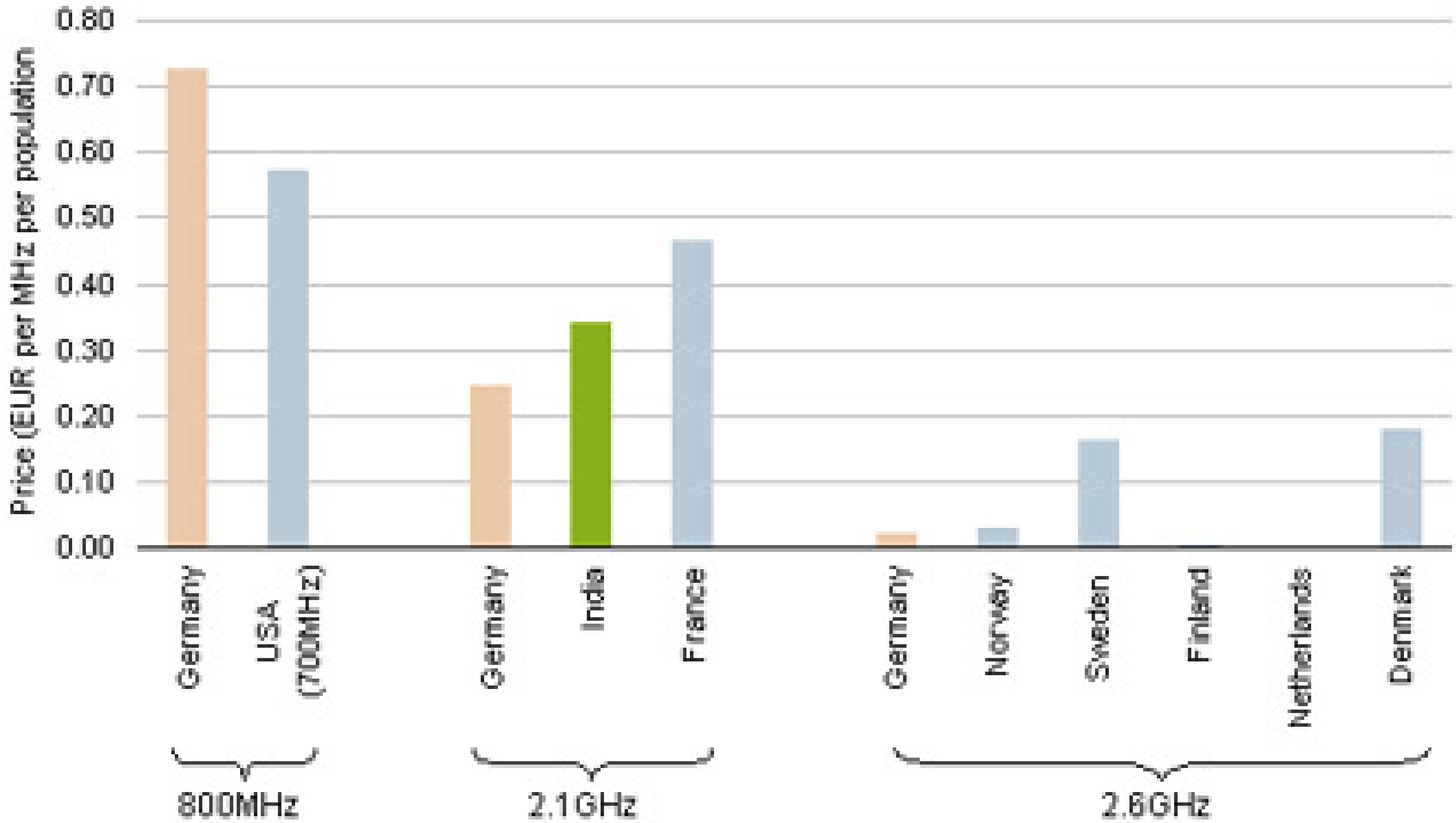
*seven data contemporary connections at 384 kbit/s each

Example: LTE frequencies and prices

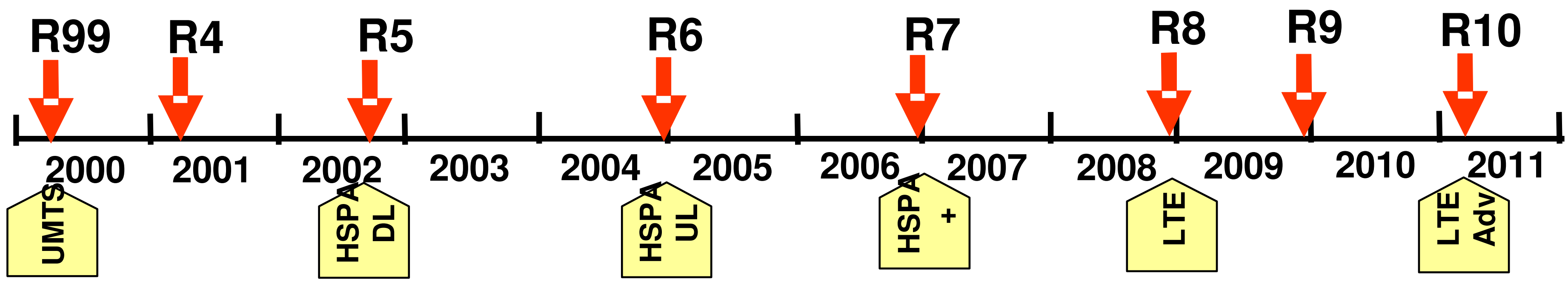
German spectrum auction frequency allocation, May 2010

BAND	T-Mobile Germany	Vodafone Germany	O2 Germany	E-Plus Germany	TOTAL (MHz)	TOTAL (€m)
800MHz	2 paired blocks 2x5	2 paired blocks 2x5	2 paired blocks 2x5	-	60	3,576.4
1.8GHz	3 paired blocks			2 paired		
2GHz	-					
2.6GHz	4 pair blocks 1 unpai block 1					
TOTAL (MHz)	95					
TOTAL (€m)	**1,29**					

Sources: BNetz, Pyran



Radiomobile networks: 3GPP releases



- Adaptive Modulation &Coding
- Hybrid ARQ&Incremental Redundancy

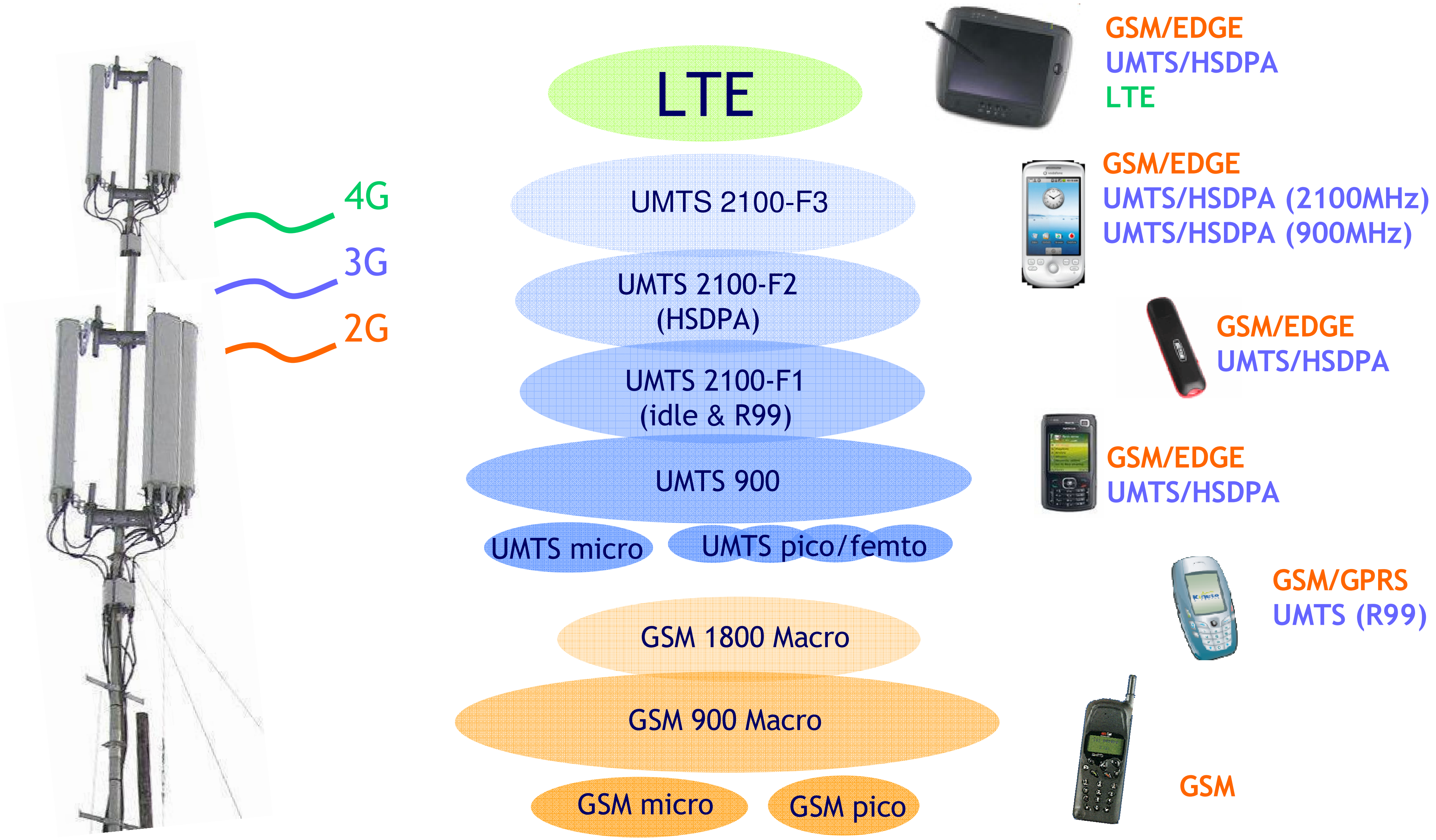
- Hybrid ARQ

- Higher Order Modulation (HSUPA)
- Adaptive Modulation &Coding
- Hybrid ARQ&Incremental Redundancy
- 2x2MIMO
- Dual carrier

- OFDM
- SC-FDMA
- 4x4MIMO
- Multicarrier channel-dependent resource scheduling
- Fractional frequency reuse

  - Spectrum aggregation ; spectrum flexibility
- Advanced MIMO techniques: up to 8 layer transmission in downlink
  - Single user MIMO up to 4 layer transmission in uplink
- Coordinated multipoint transmission and reception

Radiomobile networks – the multi-standard network



Radiomobile networks – Common Radio Resource Management

- Definition of traffic allocation strategies:
  - Among different radio access strategies
  - Inside the same radio technology, among different cellular layers

INPUT

- Terminal capability;
- Type of Service / Quality of Service;
- User profile;
- Cell load
- …

CRRM

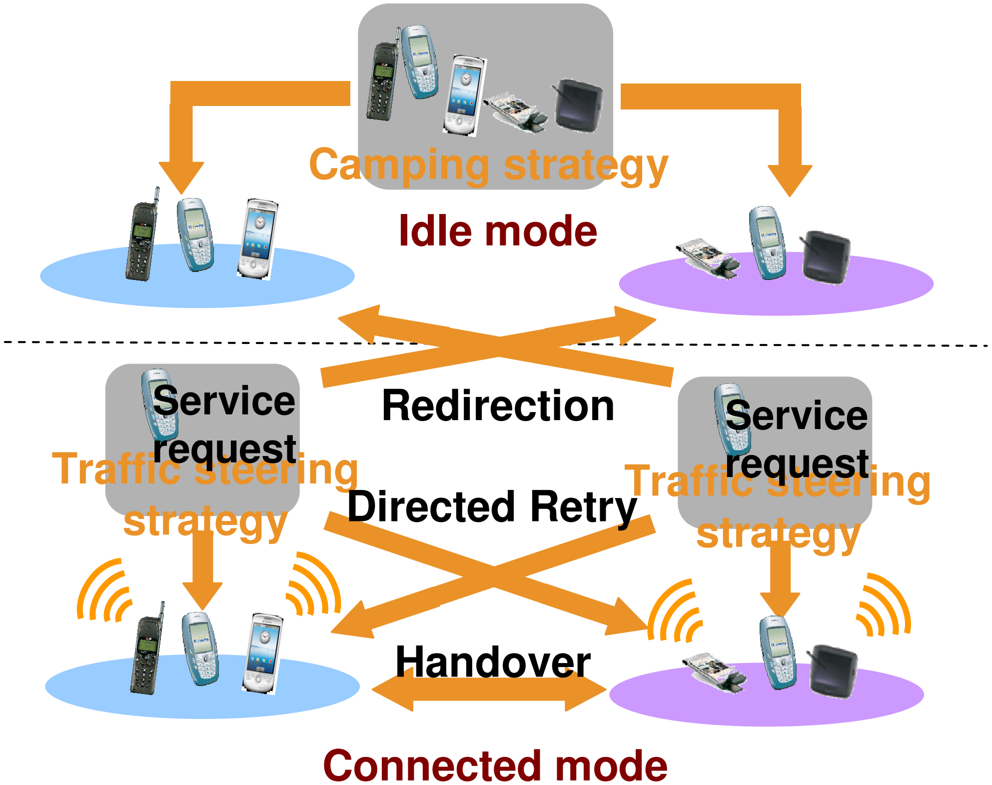
OUTPUT

- Choise of the layer that optimizes KPI (Key Performance Indicator)

- Examples: voice on GSM, HSDPA data on F2, load sharing, …

Radiomobile networks – Common Radio Resource Management

- Traffic Steering
  - Users/services segregation on different resources
- Load balancing
  - Traffic balancing among resources in order to optimize the whole capacity



State of the art and near term evolution

Radiomobile networks – Next Challenges

Efficiently control a more and more dynamic network

Self-Organization

Dynamic adaptation of parameters:

- Self-Organizing Network (SON)
- Real Time Planning System

Common RRM

Multi-RAT Access Network
Static configuration of parameters

Cognitive Network

Adaptive network

(including radio frequency: Dynamic Spectrum Management)

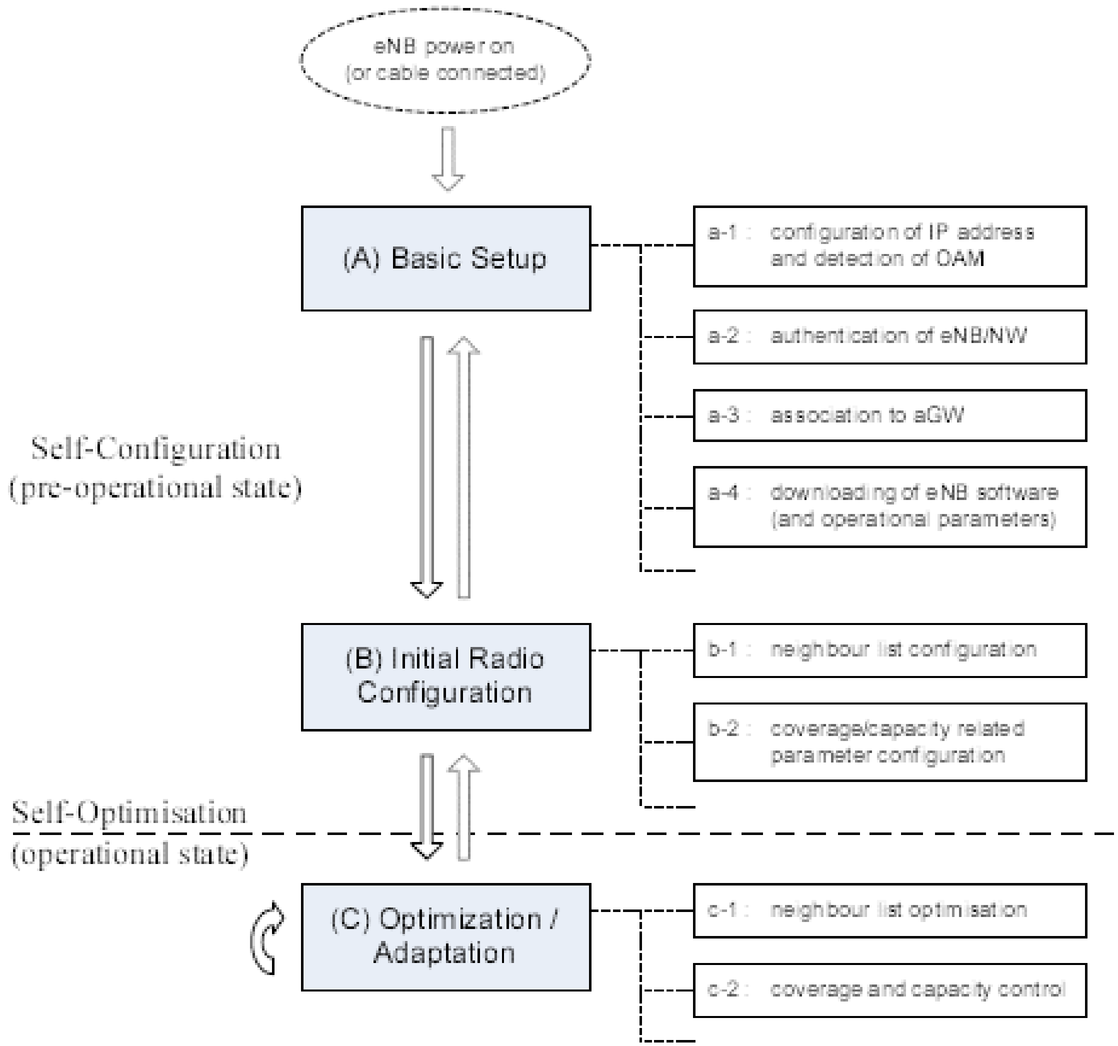
Riconfigurability

Flexible handling of ratio terminales in available bandwidths.

Software Defined Radio (SDR)

Self Organizing Networks

- From Wikipedia:
- The vision of self-organizing networks (SON), which is in line with the views of 3GPP (3rd Generation Partnership Project) and theNGMN (Next Generation Mobile Networks) group, is that future radio access networks needs to be easier to plan, configure, manage, optimize and heal compared to how it used to be
- Newly added base stations should be self-configured in line with a 'plug-and-play' paradigm, while all operational base stations will regularly self-optimize parameters and algorithmic behavior in response to observed network performance and radio conditions
- Self-healing mechanisms can be triggered to temporarily compensate for a detected equipment outage, while awaiting a more permanent solution

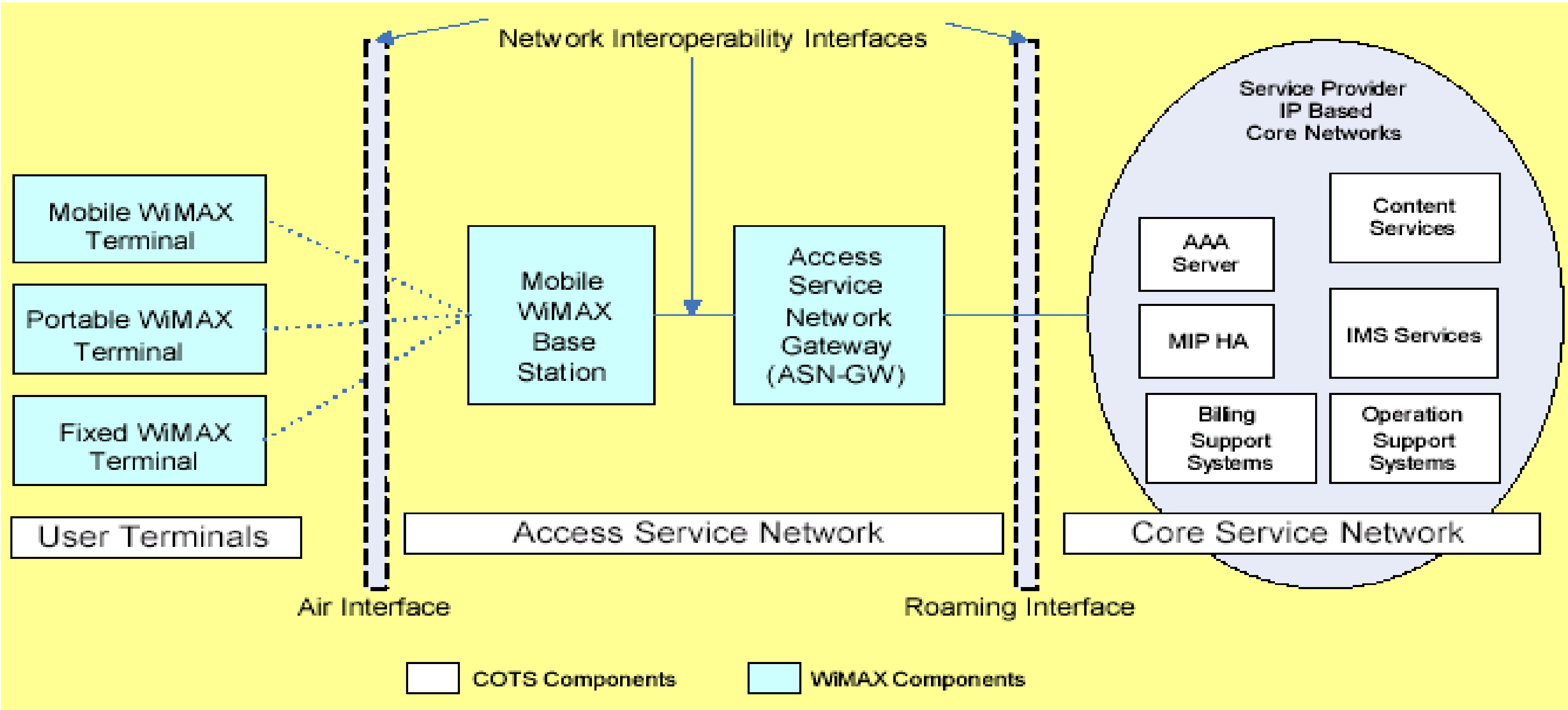


Framework of SON in 3GPP

Outline

- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and capabilities
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

WiMAX & 802.16

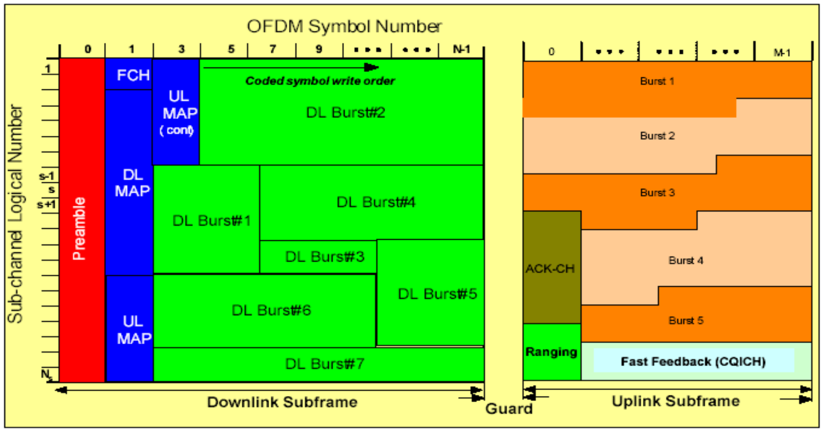


Frequency	2.5 GHz	3.5 GHz	5.8 GHz
Allocation	Licensed	Licensed	Unlicensed/Light licensing
Countries	US Mexico Brazil Southeast Asia Korea (2.3 GHz)	Most countries	Most countries
Target	Operators	Operators	"Grass roots" ISPs

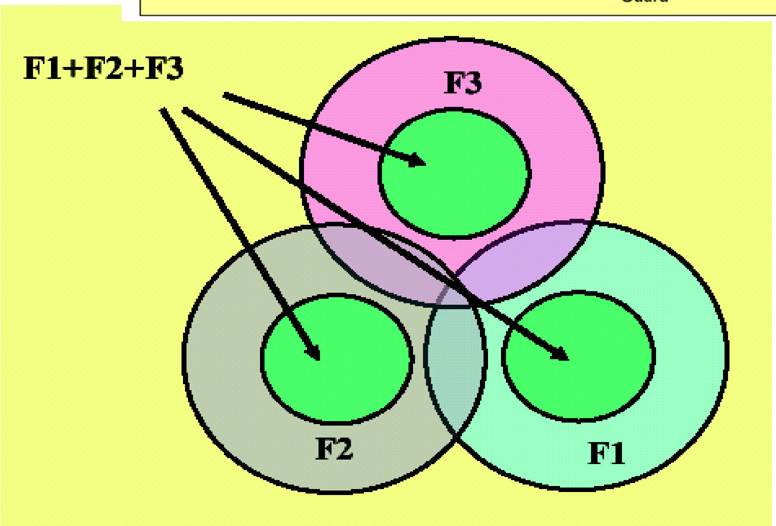
Source: WiMAX Forum.

WiMAX

- WiMax (IEEE 802.16)
  - Adaptive Modulation & Coding
  - Frequency selective scheduling



  - Fractional frequency reuse

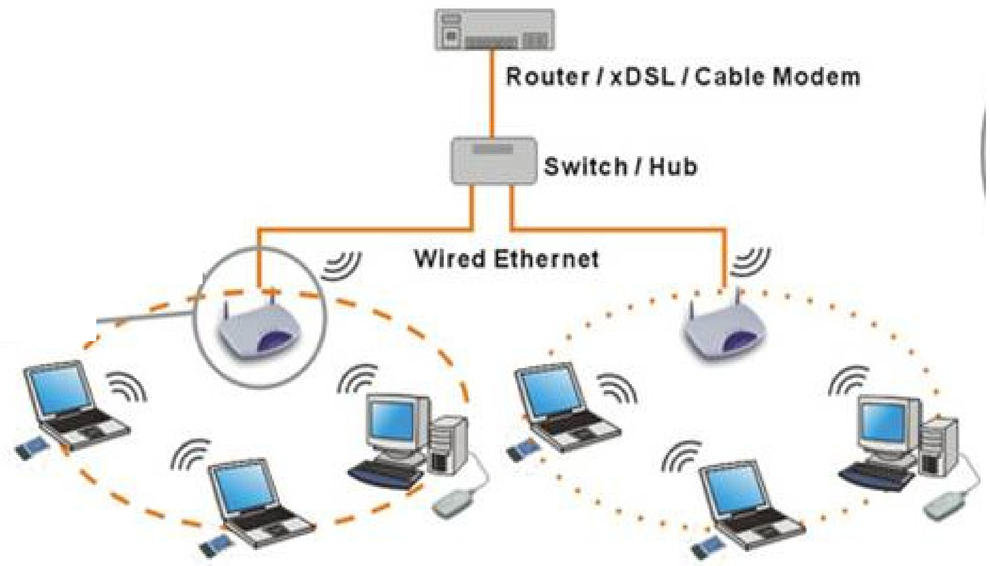


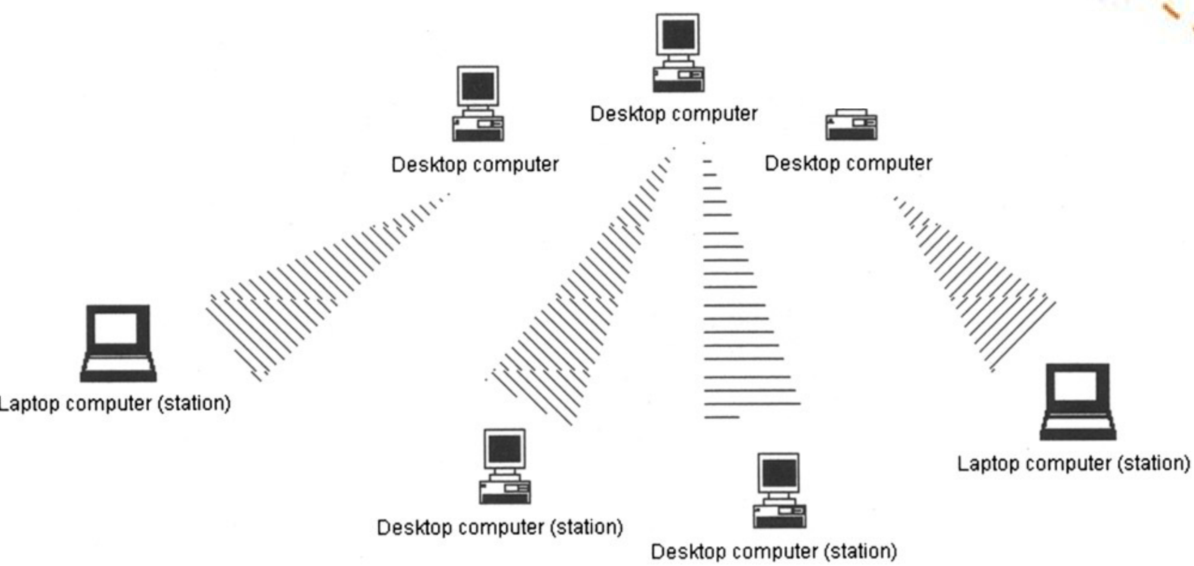
Wireless LANs

TELECOM ITALIA
HR SERVICES

Wired LAN

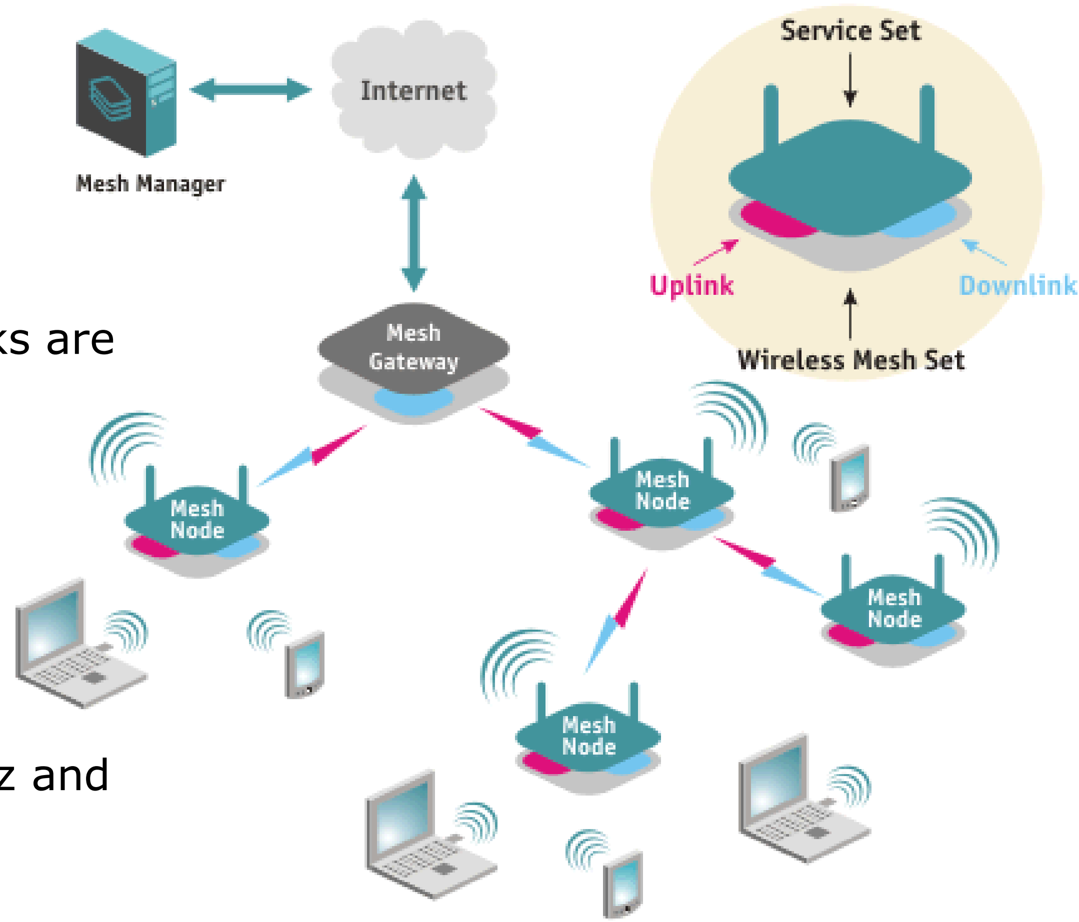
Infrastructure network architecture





Ad hoc network architecture

Mesh networks



- Single radio: radio coverage and AP links are both at 2.4 GHz

- Dual radio: radio coverage is at 2.4 GHz and AP links are at 5 GHz

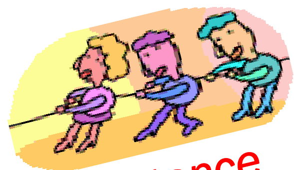
Unlicenced 2.4 and 5 GHz bandwidth

2.4GHz → ***Industrial Scientific and Medical (ISM) Band***

Only **3x20 Mhz** non overlapping channels available (in practical implementations)

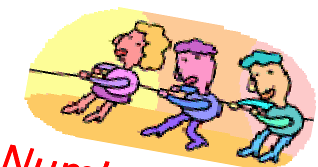
Terminal Mobility

User Bit Rate



Distance

Radio Noise



Number of Users in the area

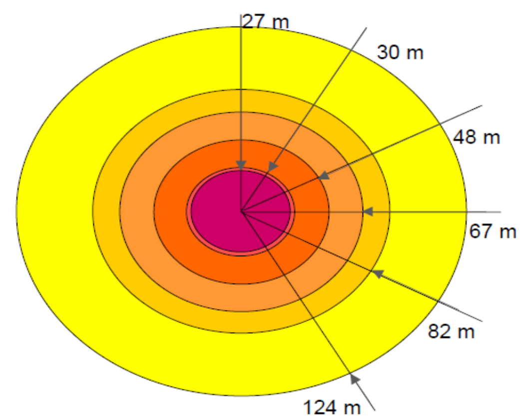
Indoor Propagation

Non Line-of-sight

Max rate at the physical level

(the corresponding data throughput is < 50%)

54 Mbit/s	- 68 dBm	
36 Mbit/s	- 75 dBm	
11 Mbit/s	- 80 dBm	
5.5 Mbit/s	- 82 dBm	
2 Mbit/s	- 85 dBm	
1 Mbit/s	- 88 dBm	



Example from a commercial data sheet

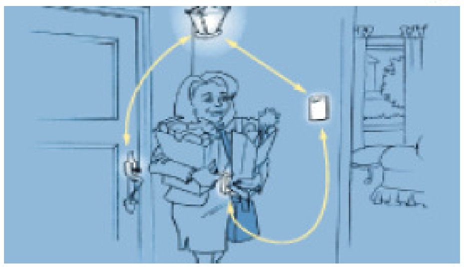
Personal Area Networks

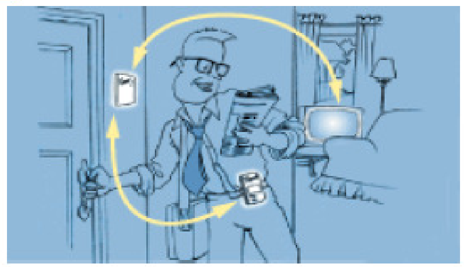
RFID

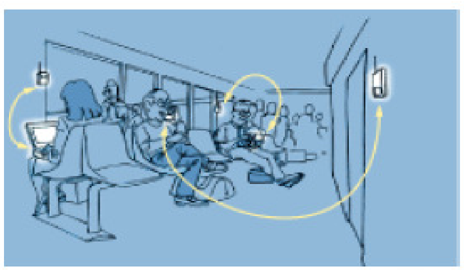
NFC

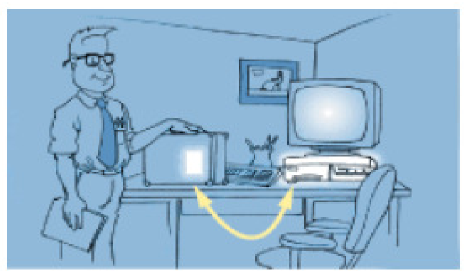
802.15 radio standards

AT HOME



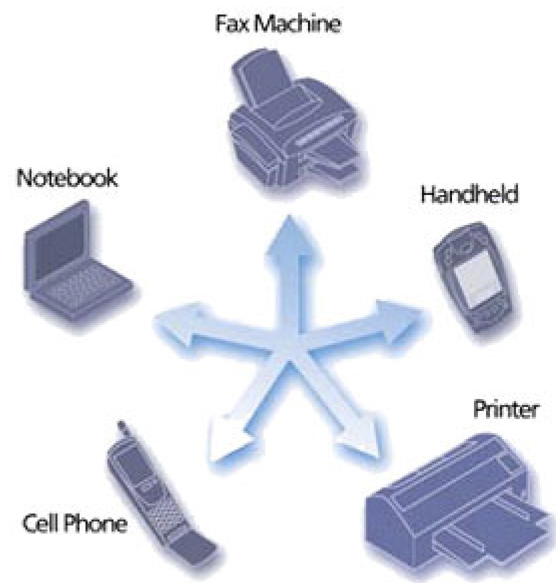






OUTDOOR

IN OFFICE



802.15.4 & Zigbee

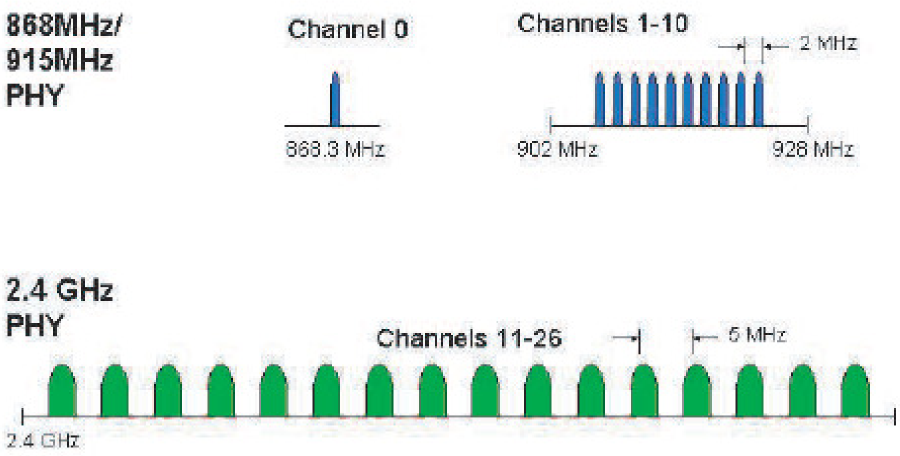
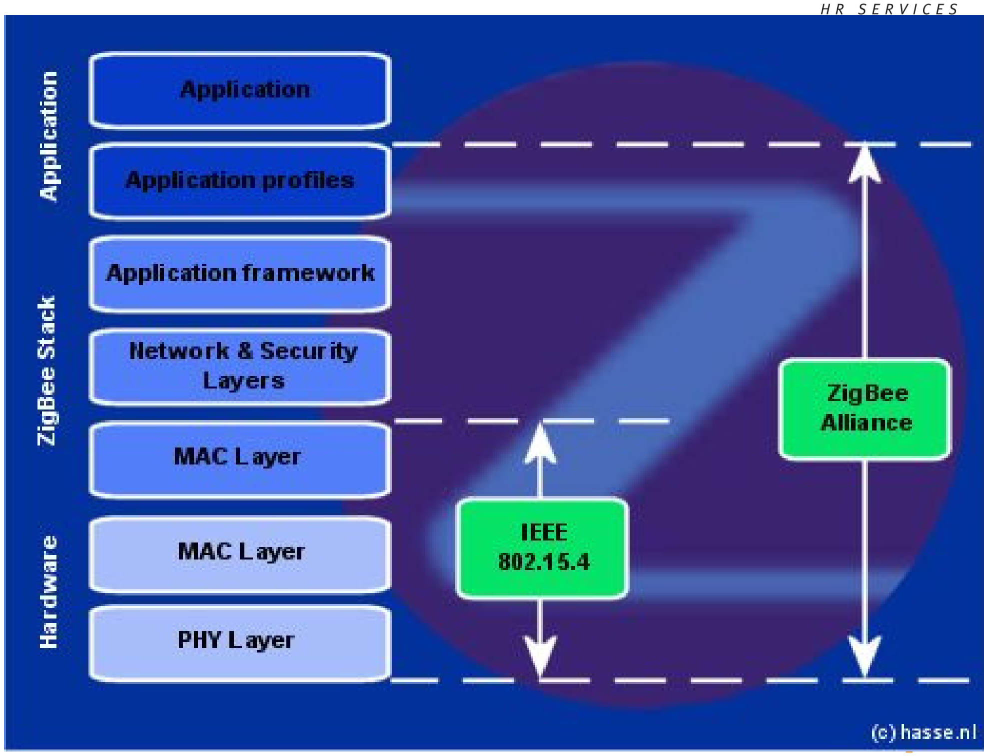
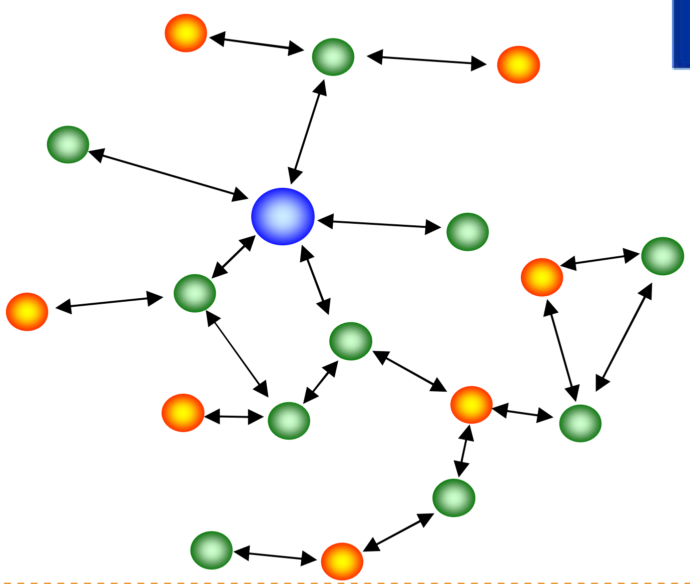


Figure 3.2: Operating frequency bands.



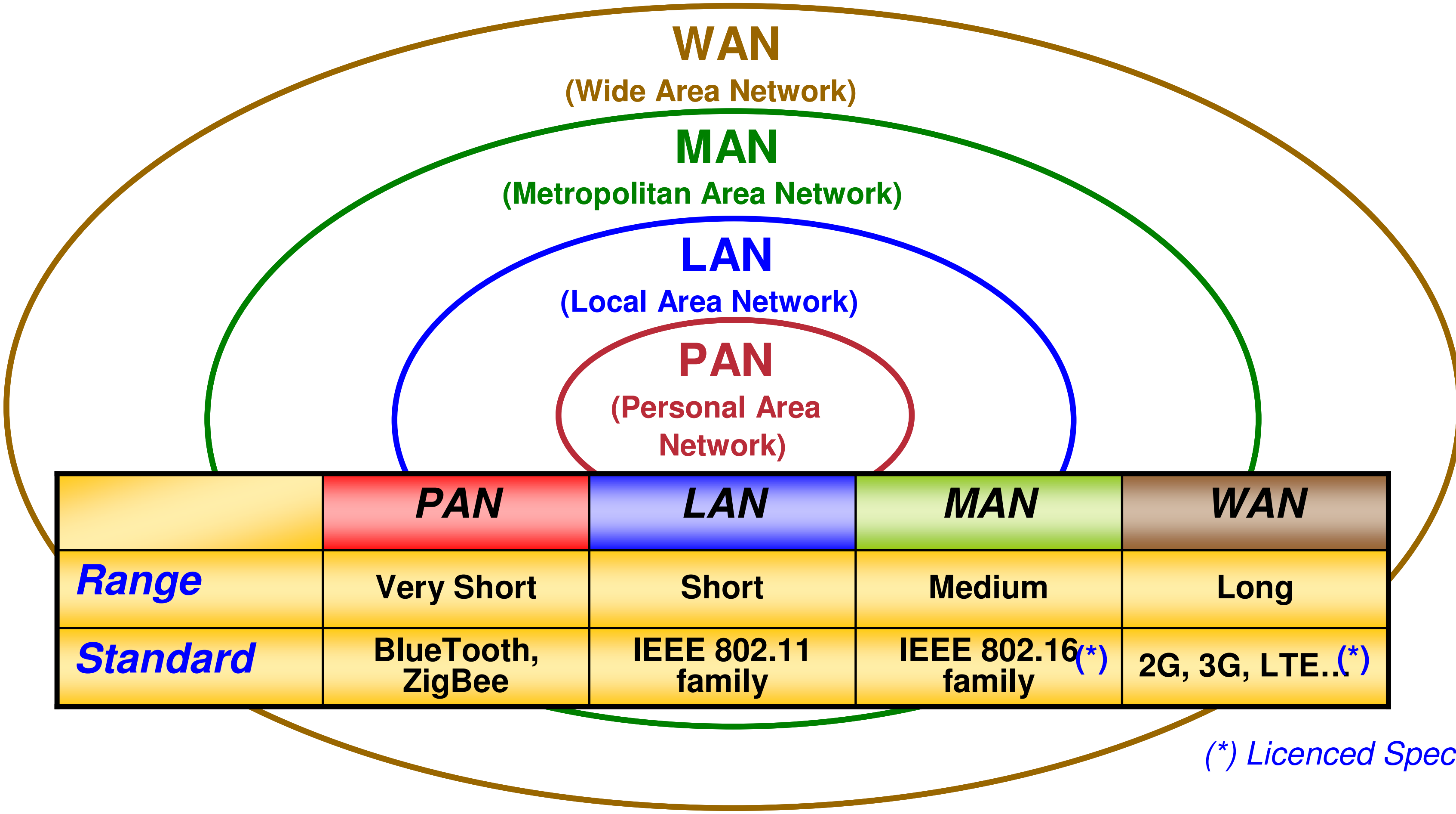


- SENSOR NETWORKS
- Home Networking
- Automotive Networks
- Remote Metering
- ….

Wifi & Zigbee

- Wifi (IEEE 802.11)
  - Global operation in the 2.4GHz and 5GHz frequency
  - Automatic frequency selection
  - Adaptive Modulation & Coding
- Zigbee (IEEE 802.15.4)
  - Global operation in the 2.4GHz frequency band according to IEEE 802.15.4
  - Regional operation in the 915Mhz (Americas) and 868Mhz (Europe).
  - Frequency agile solution operating over 16 channels in the 2.4GHz frequency
  - Discovery mechanism with full application confirmation
  - Pairing mechanism with full application confirmation

...Distance...

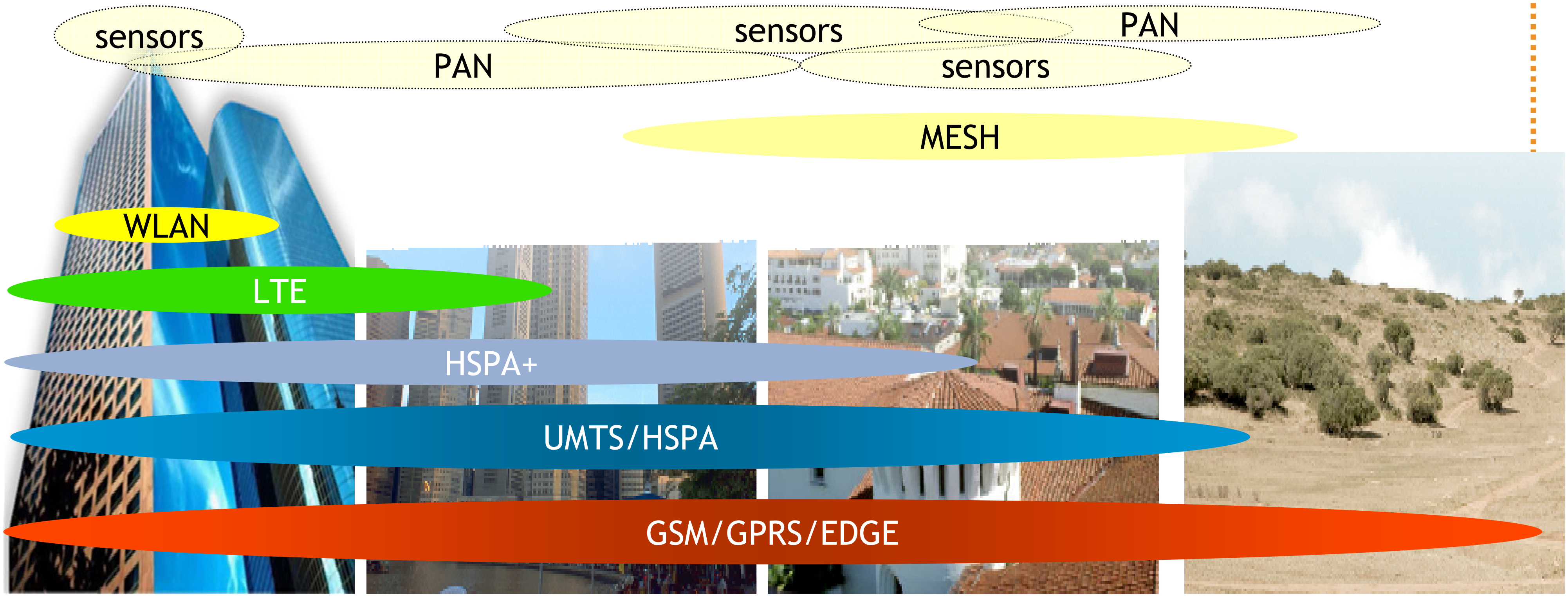


	PAN	*LAN*	*MAN*	*WAN*
Range	Very Short	Short	Medium	Long
Standard	BlueTooth, ZigBee	IEEE 802.11 family	IEEE 802.16(*) family	2G, 3G, LTE..(*)

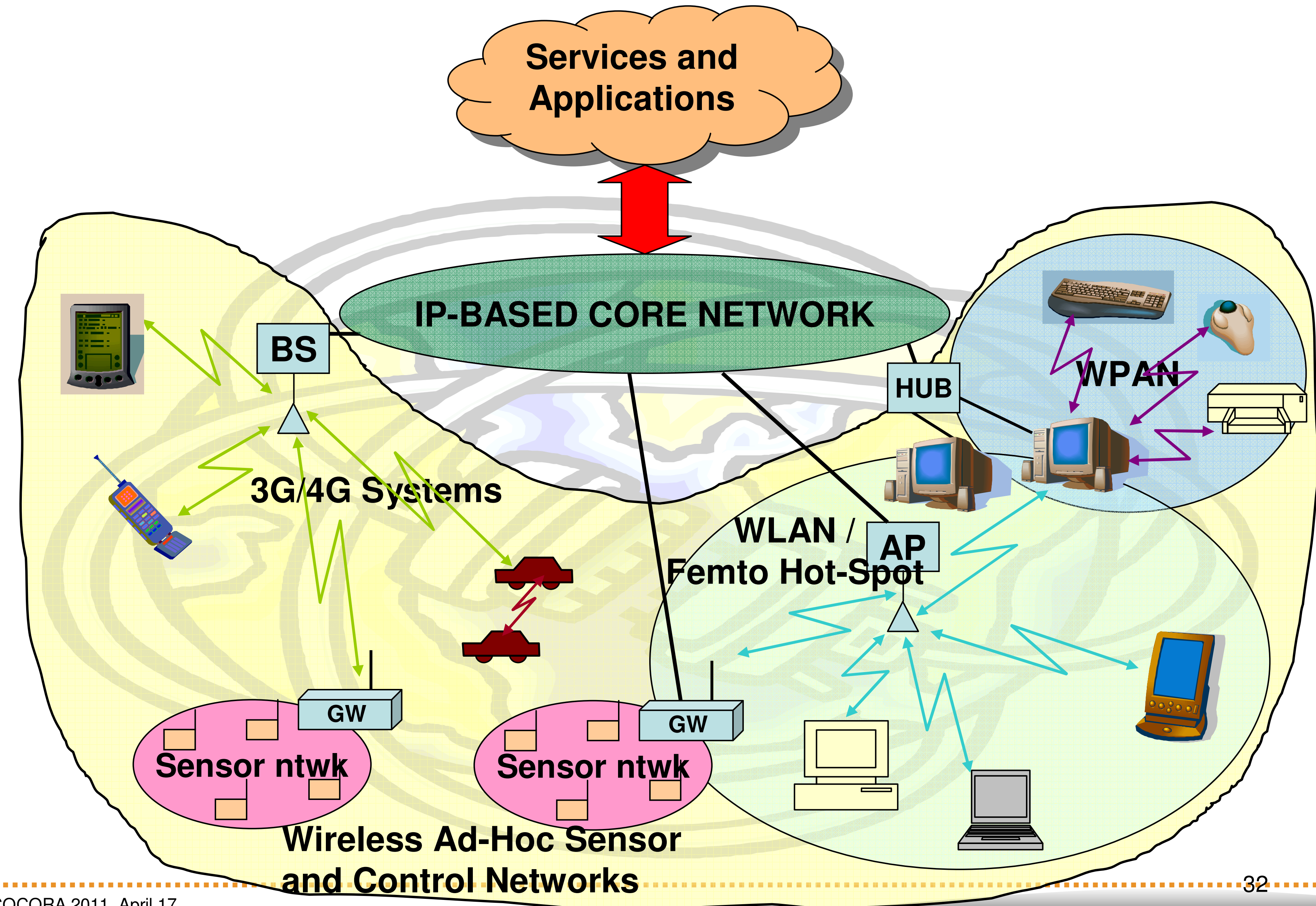
(*) Licenced Spectrum

Metti BAN dentro

Seamless Network



Scenario: multimode, multiband future

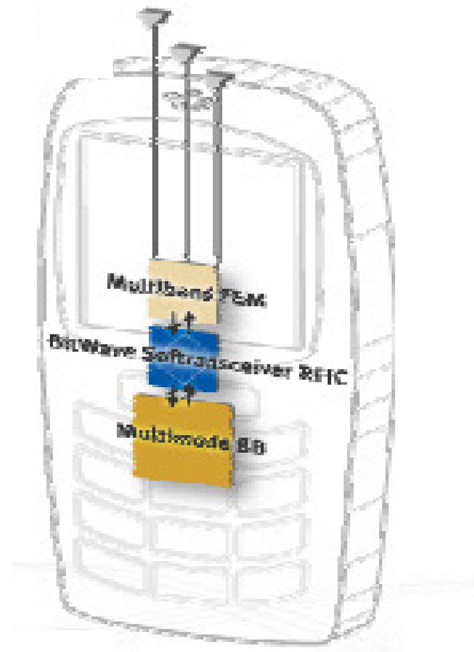


Outline

TELECOM ITALIA
HR SERVICES

- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and capabilities
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

Towards multimode, multiband Software Radio

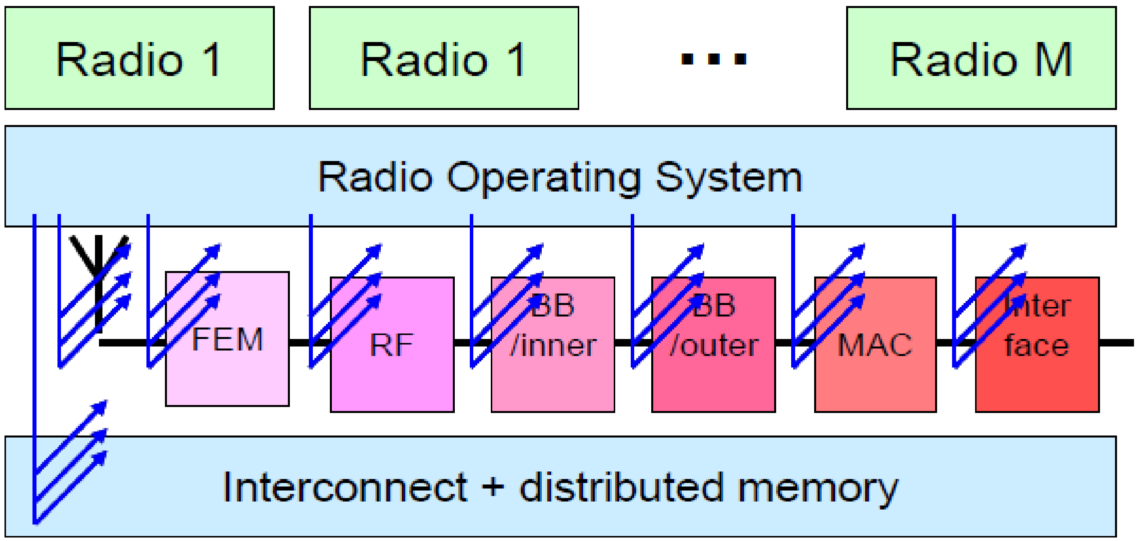


- Each radio interface is implemented through Integrated Circuits conceived for a set of specific functions
- Wireless device characteristics are fixed

Software Radio approach:

- the wireless terminal is reconfigurable via software
- It can be easily updated to new or later versions of the air interface and allows multiple interfaces to be supported

Software radio wireless terminal



The physical platform is made of :

1) antennas;
2) front-end modules (filters, power ampl, etc.);
3) RF transceiver;
4) baseband processors for (de)modulation;
5) baseband processors for (de)coding;
6) control processors for protocol stacks;
7) application interface units

- Such a **radio computer** is capable to run multiple radios simultaneously and can change this set of radios by loading new radio application software even at run-time

digital radio   multiband   multimode

Economic and effective upgrade of terminals and network infrasfructures through download of software modules

Outline

TELECOM ITALIA
HR SERVICES

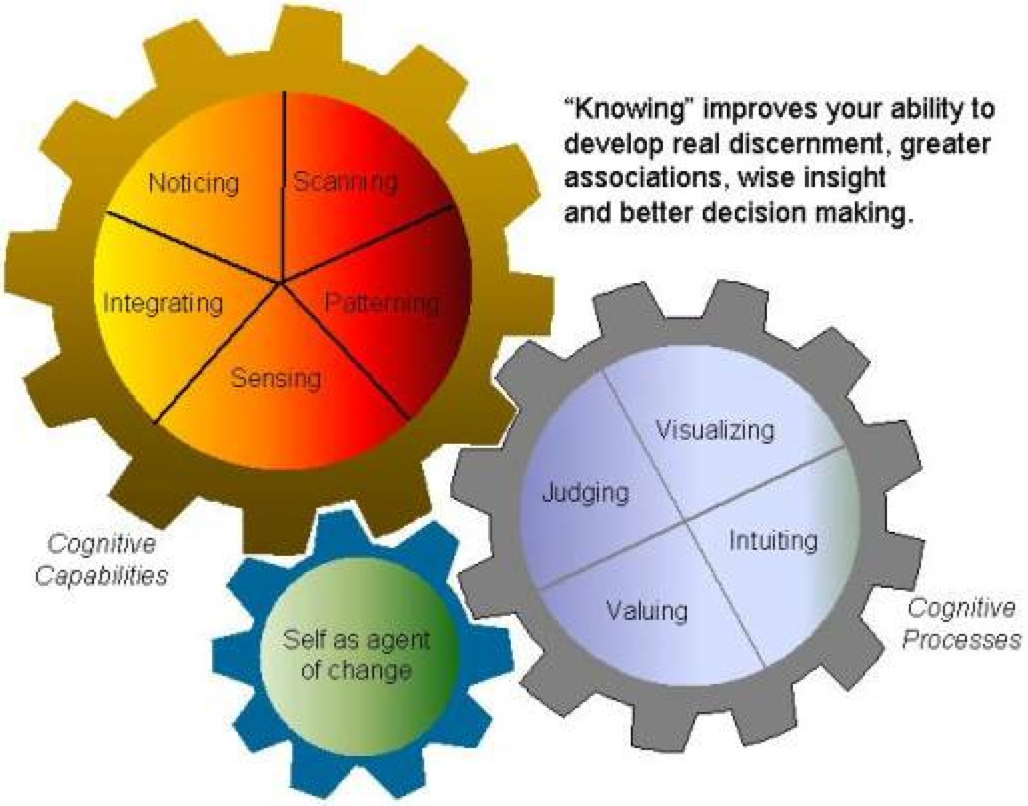
- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and capabilities
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

The cognitive concept

From Wikipedia, the free encyclopedia:

Cognition is the scientific term for "the process of thought"

*The term **cognition** (from latin cognoscere, "to know", "to conceptualize" or "to recognize") refers to a faculty for the processing of information, applying knowledge, and changing preferences*

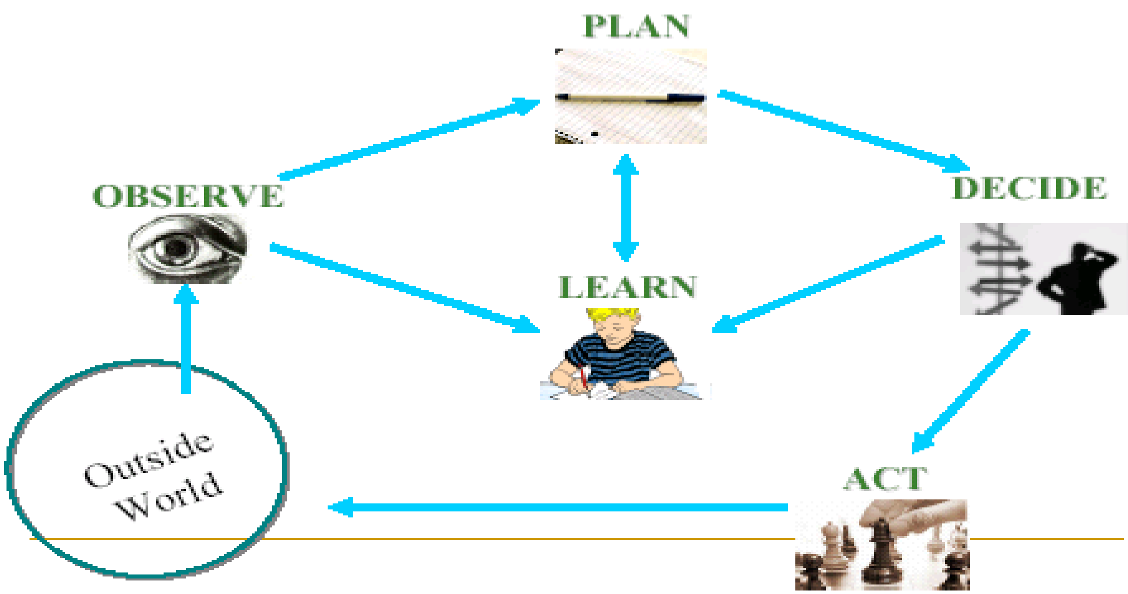


Cognitive radio

Joseph Mitola in 1999 introduced the following definition for CR:

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 detect user communications needs as a function of use context, and to provide radio resources and wireless services most appropriate to those needs

Full Cognitive Radio: in which every possible parameter observable by a wireless node or network is taken into account



Spectrum Sensing Cognitive Radio: in which only the radio frequency spectrum is considered

Capabilities of Cognitive Radio Networks

- Cognitive capabilities
  - *Spectrum Sensing:* possibility to individuate spectrum holes
  - *Spectrum Sharing:* possibility of sharing spectrum under the terms of an agreement between a licensee and a third party. Parties may eventually be able to negotiate for spectrum use on an ad hoc or real-time basis, without the need for prior agreements between all parties
  - *Location Identification:* ability to determine the MT location and the location of other transmitters, and then select the appropriate operating parameters such as the power and frequency allowed at its location
  - *Network/System Discovery:* for a cognitive radio terminal to determine the best way to communicate, it shall first discover available networks around it
  - *Service Discovery:* service discovery usually accompanies with network/system discovery

Capabilities of Cognitive Radio Networks

- **Reconfigurable Capabilities**
- *Frequency Agility:* it is the ability of a radio to change its operating frequency
- *Dynamic Frequency Selection:* it is a mechanism that dynamically detects signals from other radio frequency systems and avoids co-channel operation with those systems
- *Adaptive Modulation/Coding:* possibility of modifing transmission characteristics and waveforms to provide opportunities for improved spectrum access and more intensive use of spectrum
- *Transmit Power Control:* transmit power control is a feature that enables a device to dynamically switch between several transmission power levels in the data transmission process
- *Dynamic System/Network Access: f*or a cognitive radio terminal to access multiple communication systems/networks which run different protocols, the ability to reconfigure itself to be compatible with these systems is necessary

Capabilities of Cognitive Radio Networks

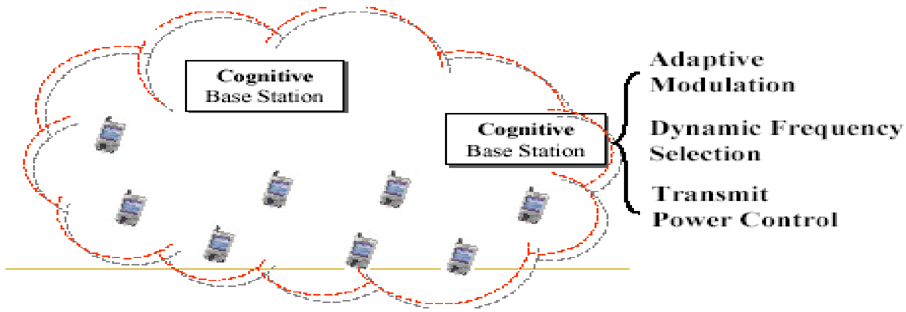
- **Self-Organized capabilities**
- *Spectrum/Radio Resource Management:* manage and organize spectrum holes information among cognitive radios
- *Mobility and Connection Management:* due to the heterogeneity of CRNs, routing and topology information is more and more complex. Good mobility and connection management can help neighborhood discovery, detect available Internet access and support vertical handoffs, which help cognitive radios to select route and networks
- *Trust/Security Management:* trust is thus a prerequisite for securing operations in CRNs.

Outline

- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and capabilities
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

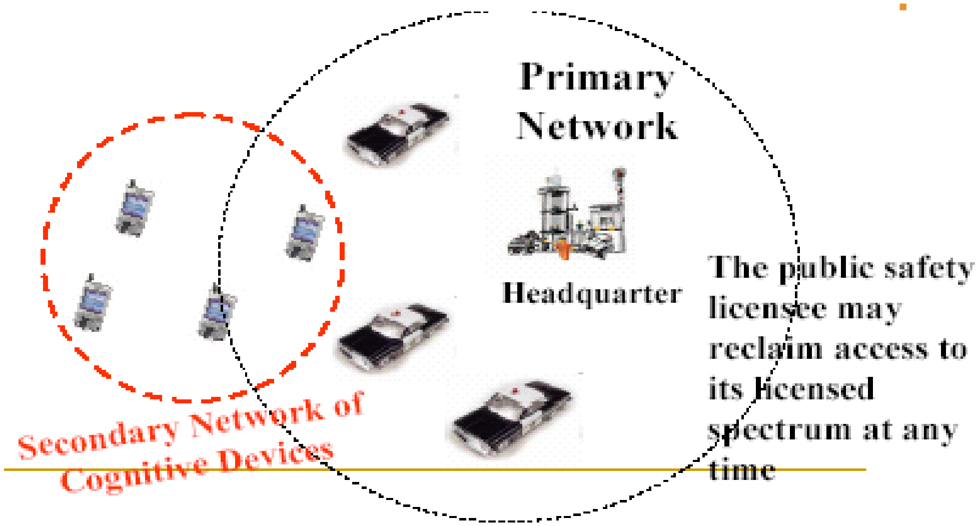
Regulatory issues in US

- FCC, December 2003:
- *Advances in technology are creating the potential for radio systems to use spectrum more intensively and more efficiently than in the past*
- *Cognitive radio technologies have the potential to provide a number of benefits that would result in increased access to spectrum and also make new and improved communication services available to the public*
- FCC indicates four different application scenarios:
- Scenario 1: **Licensed Networks**
  - A licencee operator uses Cognitive Radio Technologies inside its network to increase the efficient use of radio resource

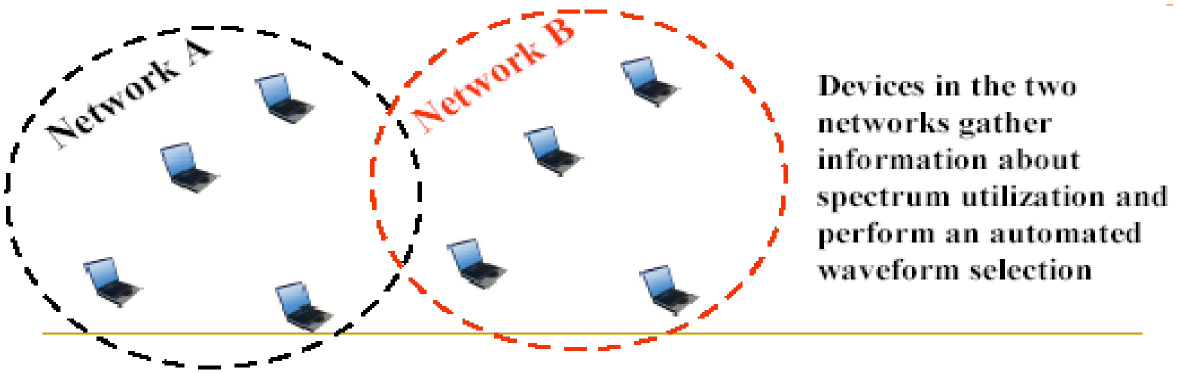


Regulatory issues in US

- Scenario 2: **Secondary Markets**
  - A licencee operator and a secondary unlicenced operator agree to a secondary spectrum usage for cognitive radio terminals

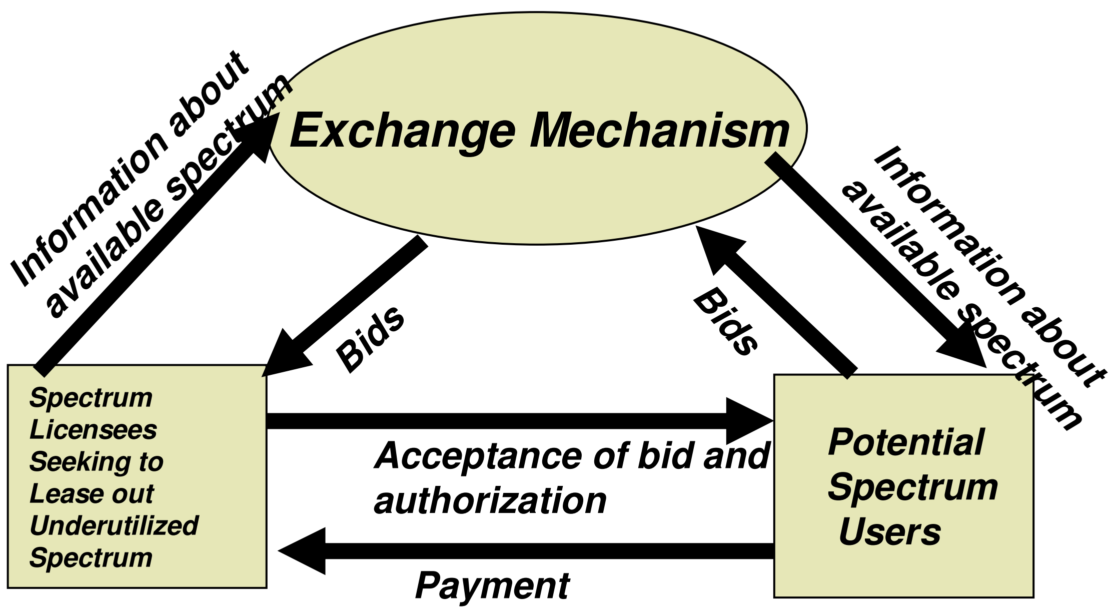


- Scenario 3: **Coordination of Licensed Operation**



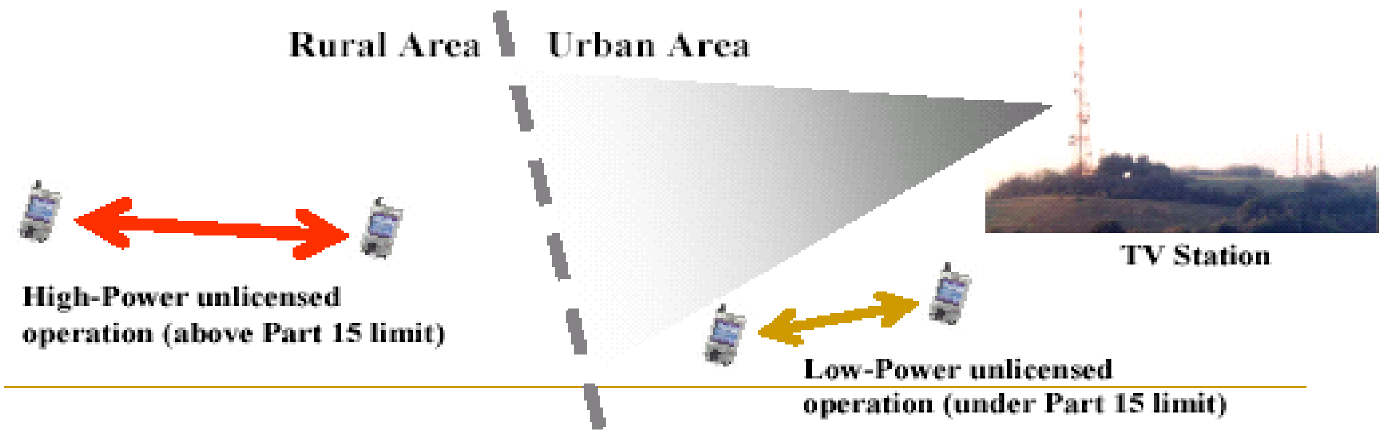
Regulatory issues in US

- **Near Real Time Secondary Markets**
- In the electric power industry there is an hour-to-hour market for power exchange
- Should we remove any barriers to such a market in the commercial spectrum area?
- Such a market might require:
  - An exchange mechanism to bring buyers and sellers together
  - A standard definition for what is being bought and sold
  - A real time spectrum management monitor to insure compliance



Regulatory issues in US

- Scenario 4: **non voluntary third party access**
  - Unlicenced cognitive radio terminals operate in times and zones where licenced spectrum is underutilized



Regulatory issues in US

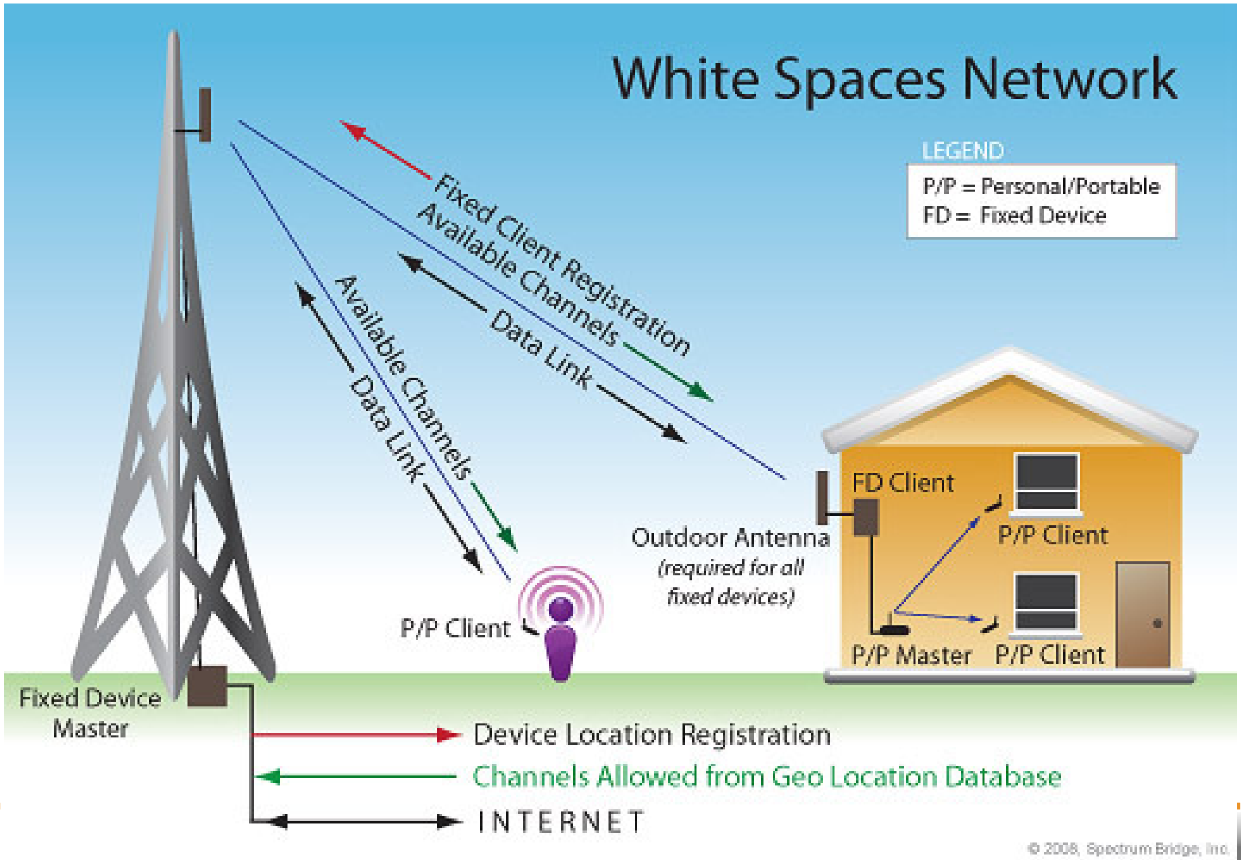
- On November 4, 2008, the FCC voted 5-0 to approve the unlicensed use of white space devices must both consult an FCC-mandated database to determine which channels are available for use at a given location, and must also monitor the spectrum locally once every minute to confirm that no legacy wireless microphones, video assist devices or other emitters are present. If a single transmission is detected, the device may not transmit anywhere within the entire 6 MHz channel in which the transmission was received
- On September 23, 2010 the FCC released a Memorandum Opinion and Order that determined the final rules for the use of white space for unlicensed wireless devices. The new rules removed mandatory sensing requirements which greatly facilitates the use of the spectrum with geolocation based channel allocation. The final rules adopt a proposal from the White Spaces Coalition for very strict emission rules that prevent the direct use of IEEE 802.11 (Wi-Fi) in a single channel effectively making the new spectrum unusable for Wi-Fi technologies

Outline

- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and capabilities
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

White spaces

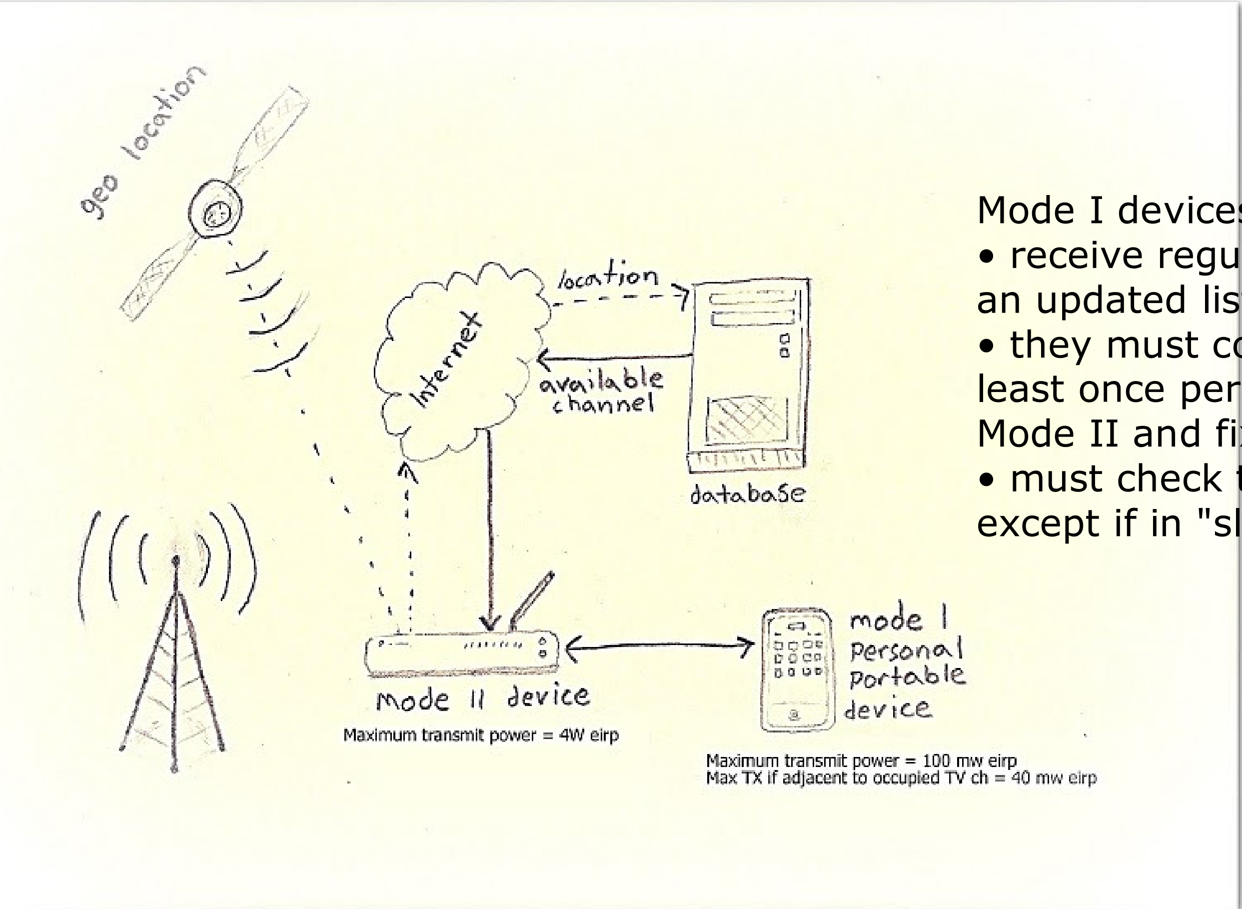
- September 2010: FCC has given a green light for the use of "white spaces" in order to deliver broadband connections as super "WiFi"
- to prevent interference to authorised users of the TV bands, TV bands devices must include a geo-location capability and the capability to access a database that identifies incumbent users entitled to interference protection
- The TV bands databases will be used by fixed and personal portable unlicensed devices to identify unused channels that are available at their geographic locations



White spaces transmissions

spectrum sensing and a geo-detecting database system to protect the TV signals from interference

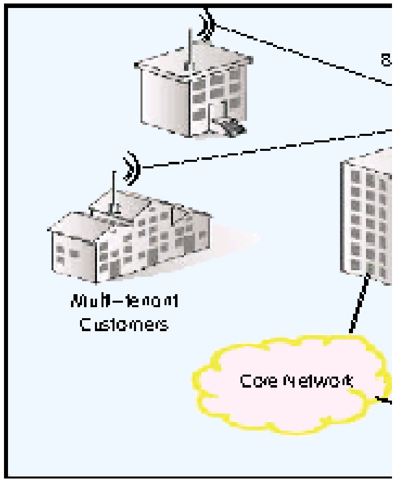
September 23, 2010: FCC FREES UP VACANT TV AIRWAVES FOR “SUPER WI-FI” TECHNOLOGIES



Mode I devices
• receive regular signals from Mode II devices providing an updated list of good-to-go channels, or
• they must contact the Mode II devices themselves at least once per minute
Mode II and fixed devices
• must check their own locations at the same rate, except if in "sleep mode”

http://www.emcrules.com/

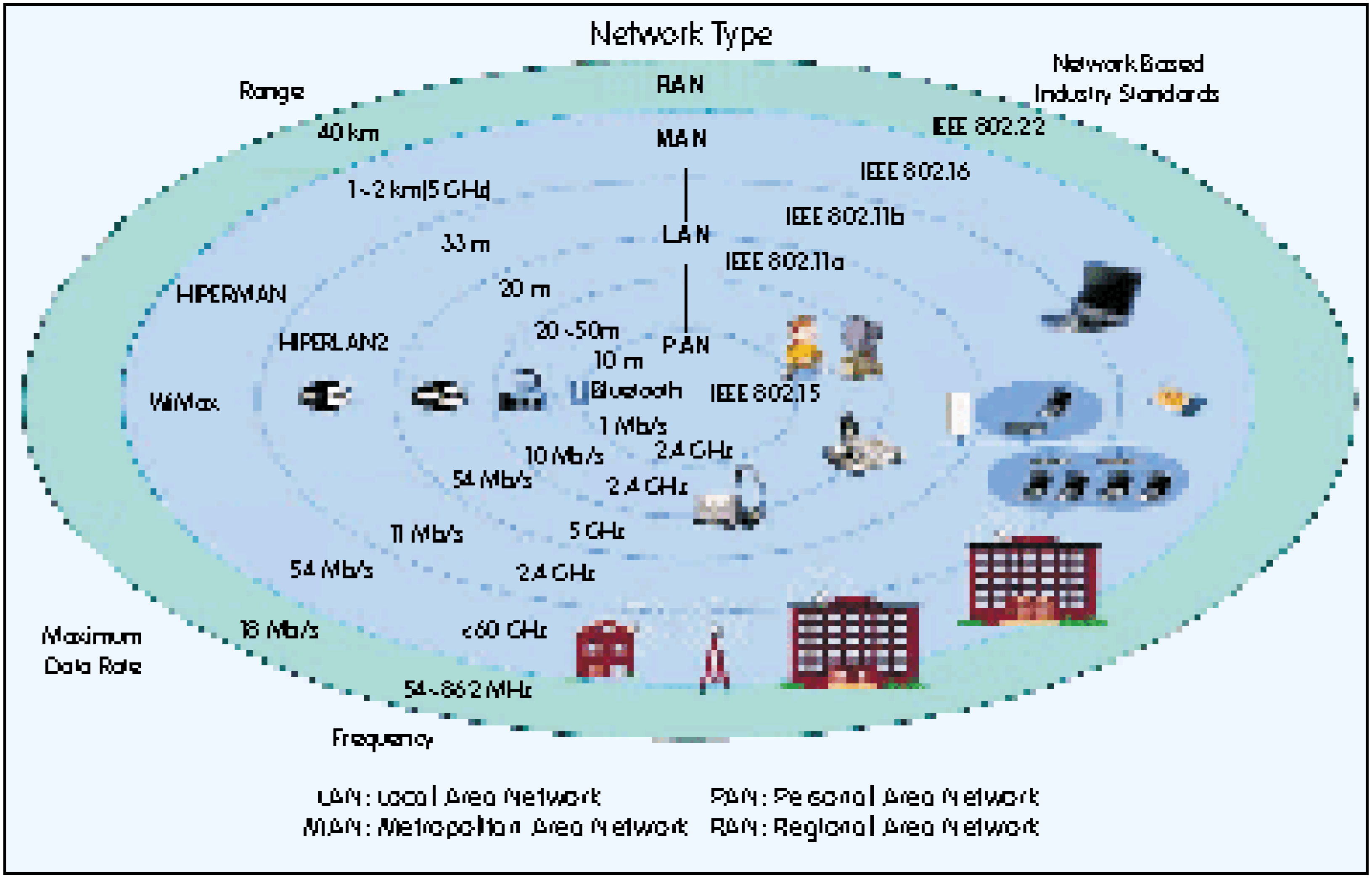
802.22: the First Wireless Standard based on Cognitive Radios



▲ Figure 1. Schematic diagram of IEEE

Fixed radios: limited to
EIRP

Portable devices: the p
100mw when not adjac
channel



▲ Figure 3. Coverage comparison between IEEE 802.22 WRAN and other wireless standards.

802.22

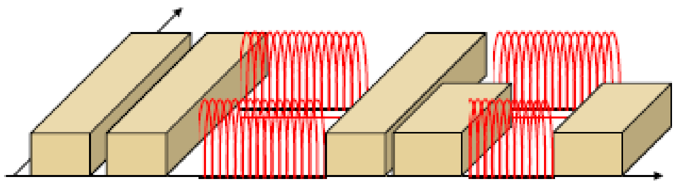
■ Target performance

Items	Requirements
Service Coverage	Typical 33 km ~ Max 100 km
Active subscribers	Minimum 12 users
Minimum Peak Throughput at Cell Edge	Forward link : 1.5 Mbps / subscriber (18 Mbps in total) Reverse link : 384 kbps / subscriber
Spectral Efficiency	Minimum : 0.5 bps/Hz Typical : 3 bps/Hz ➔ 18 Mbps for 6 MHz BW
Service Availability	50% of locations & 99.9% of time

■ General

Items	Requirements
Carrier frequency	UHF, VHF band (< 1 GHz) 54~862 MHz (PAR), 54~698 MHz (USA)
Bandwidth	6 (7, 8) MHz, Possible use of a smaller band or multiple bands
Service subscribers	Fixed location customers • Residential • Small & Medium Enterprise • SOHO (Small office/Home office)
Service type	Packet-oriented (data, voice, video)
Service model	Similar to ADSL & cable MODEM over less populated rural areas Wireless Regional Area Network (WRAN)

- OFDMA
- 6,7,8 MHz Bandwidth
- Flexible bandwidth allocation using FFT
  - Channel bonding
  - Fractional bandwidth usage
- Adaptive resource allocation according to user environments
  - Channel selectivity



Outline

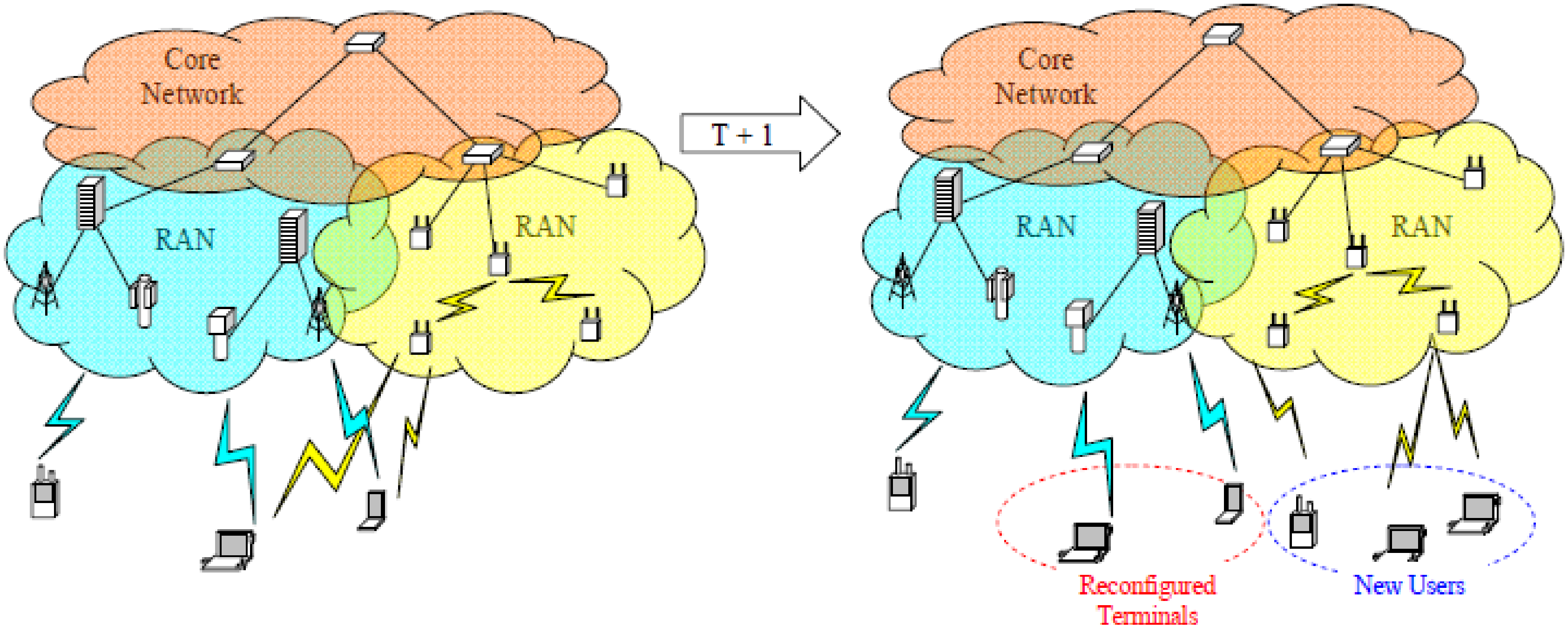
TELECOM ITALIA
HR SERVICES

- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and capabilities
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

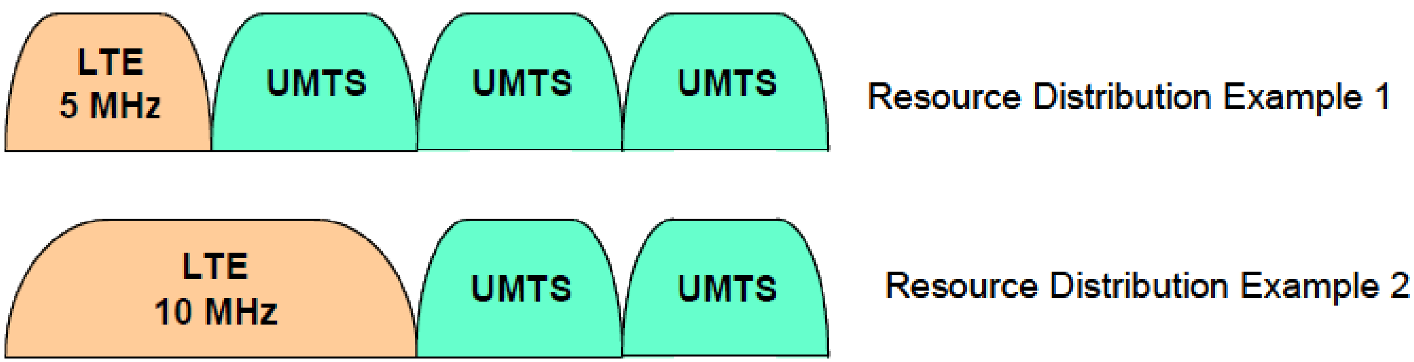
Key Challenges in Europe

- Key challenges are similar to other regions:
  - Greater fragmentation
  - Regulation not fully converged
  - Incumbents resistant to effective changes
- ETSI published deliverables on RRS (http://www.etsi.org/website/technologies/RRS.aspx) and a series of recommendation for standardization
- Asian countries are investing heavily in CR
- US has a strong wireless technology base and is motivated by FCC position

Near Term Evolution for cognitive radio networks



Terminal Reconfiguration - Joint Radio Resource Management scenario



Base Station Reconfiguration - an example

http://www.etsi.org/website/technologies/RRS.aspx

From ETSI

E

Si

JRRM-NET

•Access Selection: Select the best radio access for (or in) the mobile terminal based on requested QoS (Bandwidth, Max. delay, Realtime/non-realtime), radio conditions (e.g. abstracted signal strength/quality, available bandwidth), access network conditions (e.g. cell capacity, current cell load), user preferences, and network policies.

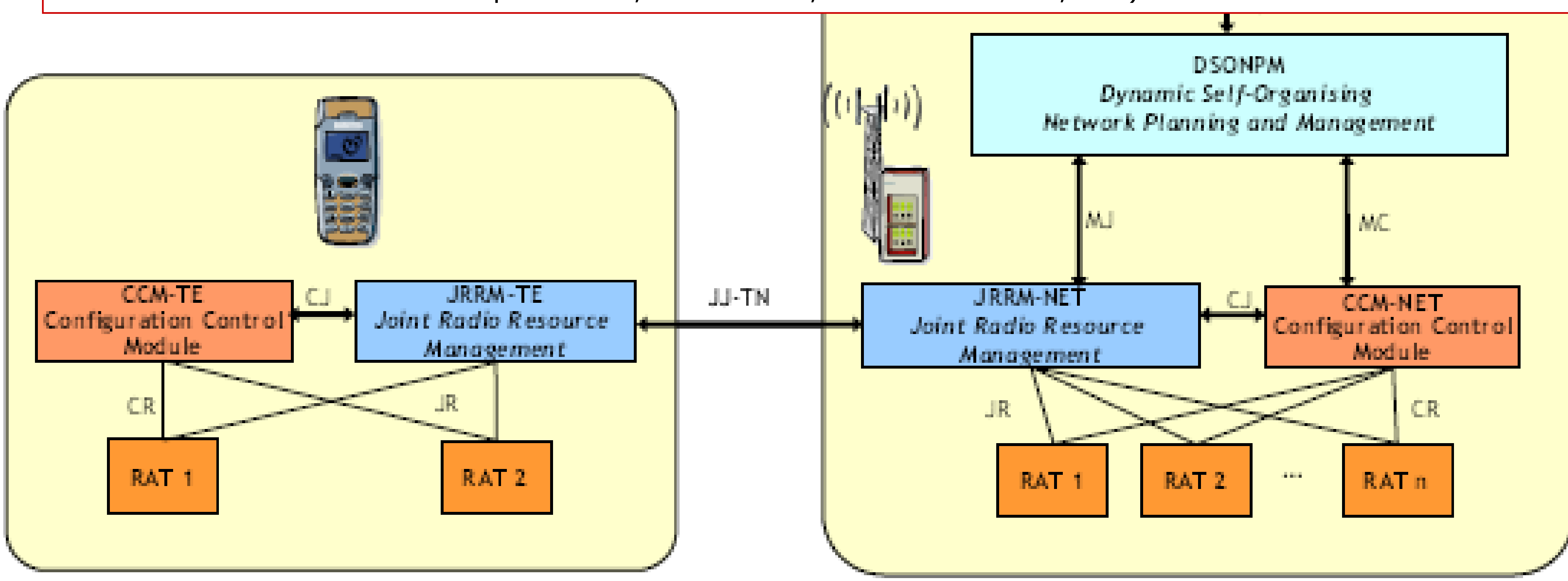
• Neighbourhood Information Provision for efficient discovery of available accesses in cooperation with the CPC. This may include information on cell location, size, capabilities, as well as other dynamic data.

• QoS/bandwidth allocation/admission control (per user session or connection based on the requested QoS of the users application(s)).

•Provision of mobility and resource management directives/constraints.

aspects to be supported)

•PHY/MAC related: Number of network element transceivers involved in decisions, RATs to be activated in the selected transceivers, Spectrum selection, Radio parameters configuration per RAT (e.g. maximum power level per carrier, Antenna tilt, channel selection, etc.)



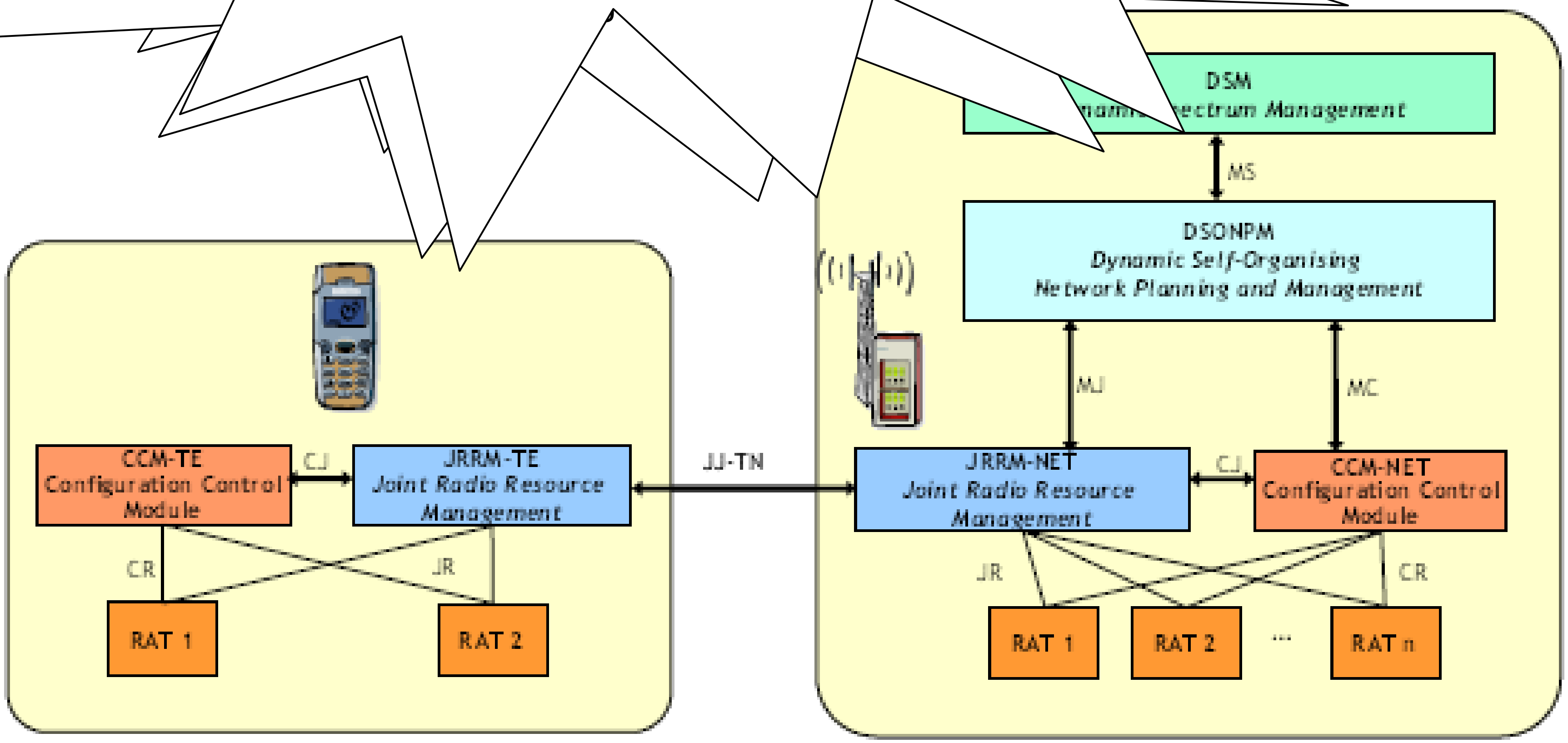
ETSI Reconfigurable Radio Systems Functional Architecture

Single Operator

JJ-TN

used to:

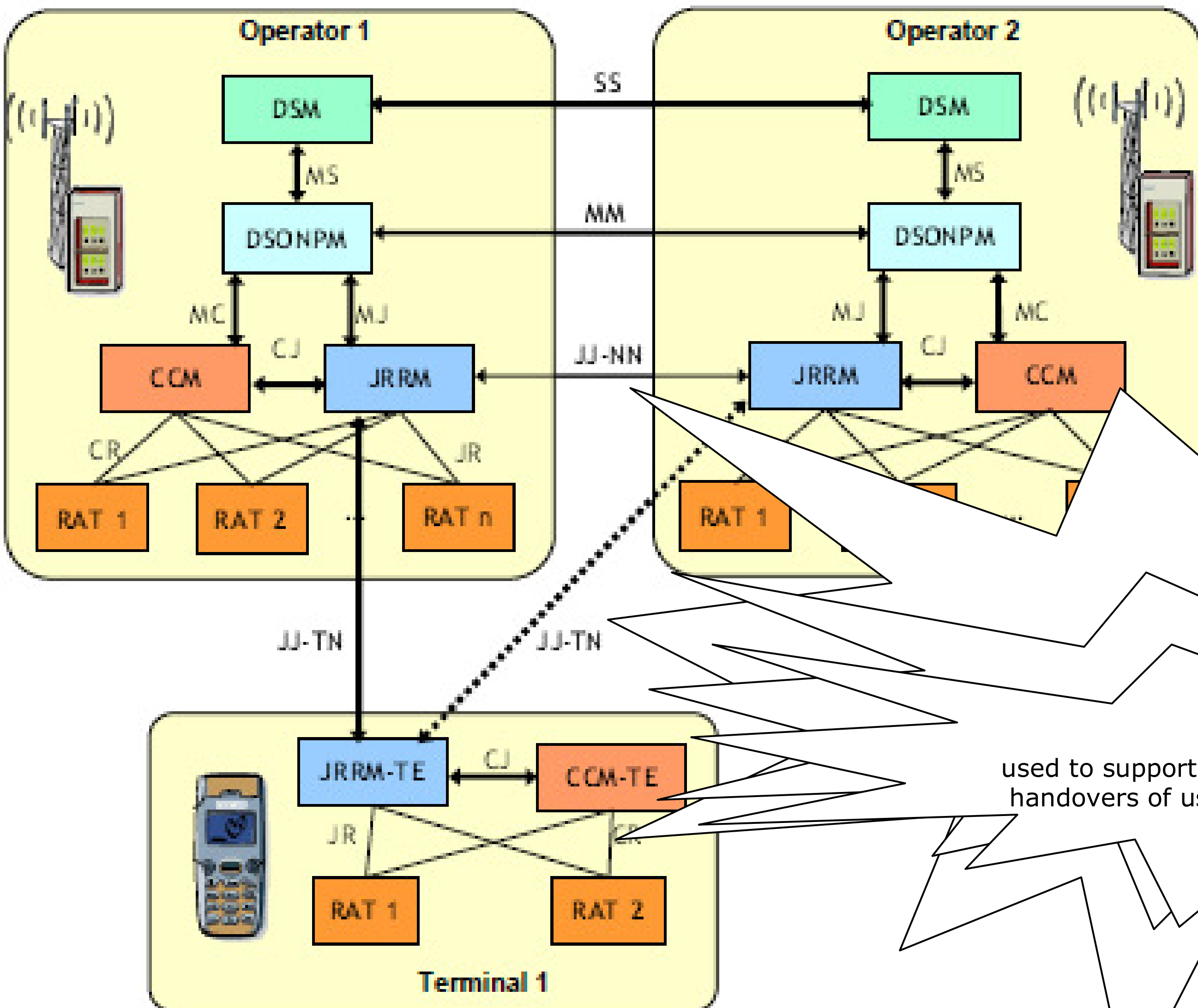
- send Neighbourhood Information from the network to the terminal;
- provide Access Selection Information (e.g. Access Selection Policies or Handover Decisions) from the network to the terminal;
- optionally exchange measurement information (Link performance of active links, measurements on candidate links, measurements on spectrum usage, etc.)



From ETSI

ETSI Reconfigurable Radio Systems Functional Architecture

Multi-Operator



SS

used to

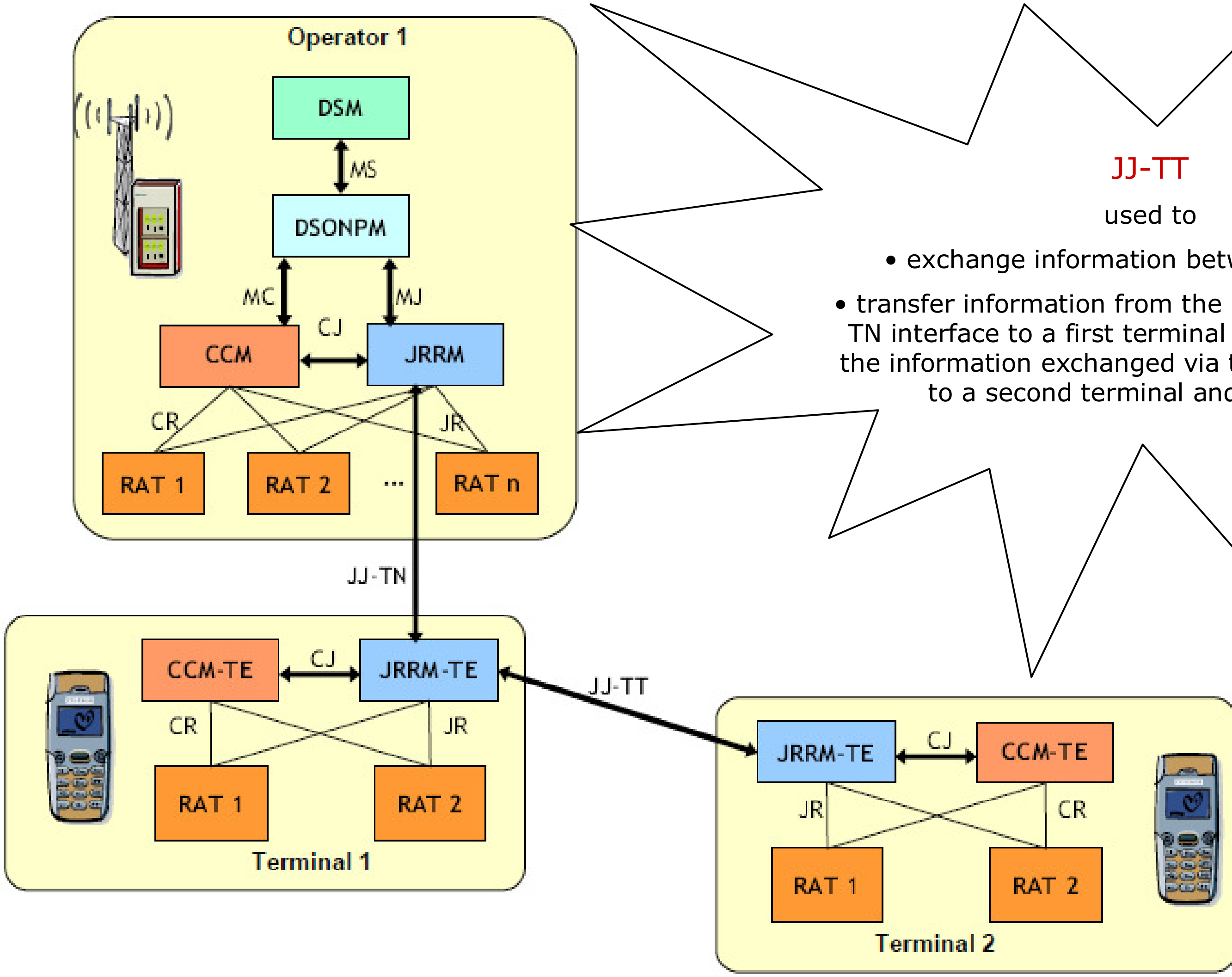
MM

JJ-NN

used to support the negotiation and execution of handovers of users between different operators

From ETSI

ETSI Reconfigurable Radio Systems Functional Architecture
Multi-hop viewpoint



JJ-TT

used to

- exchange information between terminals
- transfer information from the network via the JJ-TN interface to a first terminal which relays then the information exchanged via the JJ-TN interface to a second terminal and vice versa

Cognitive Pilot Channel (CPC): Concept and Motivation

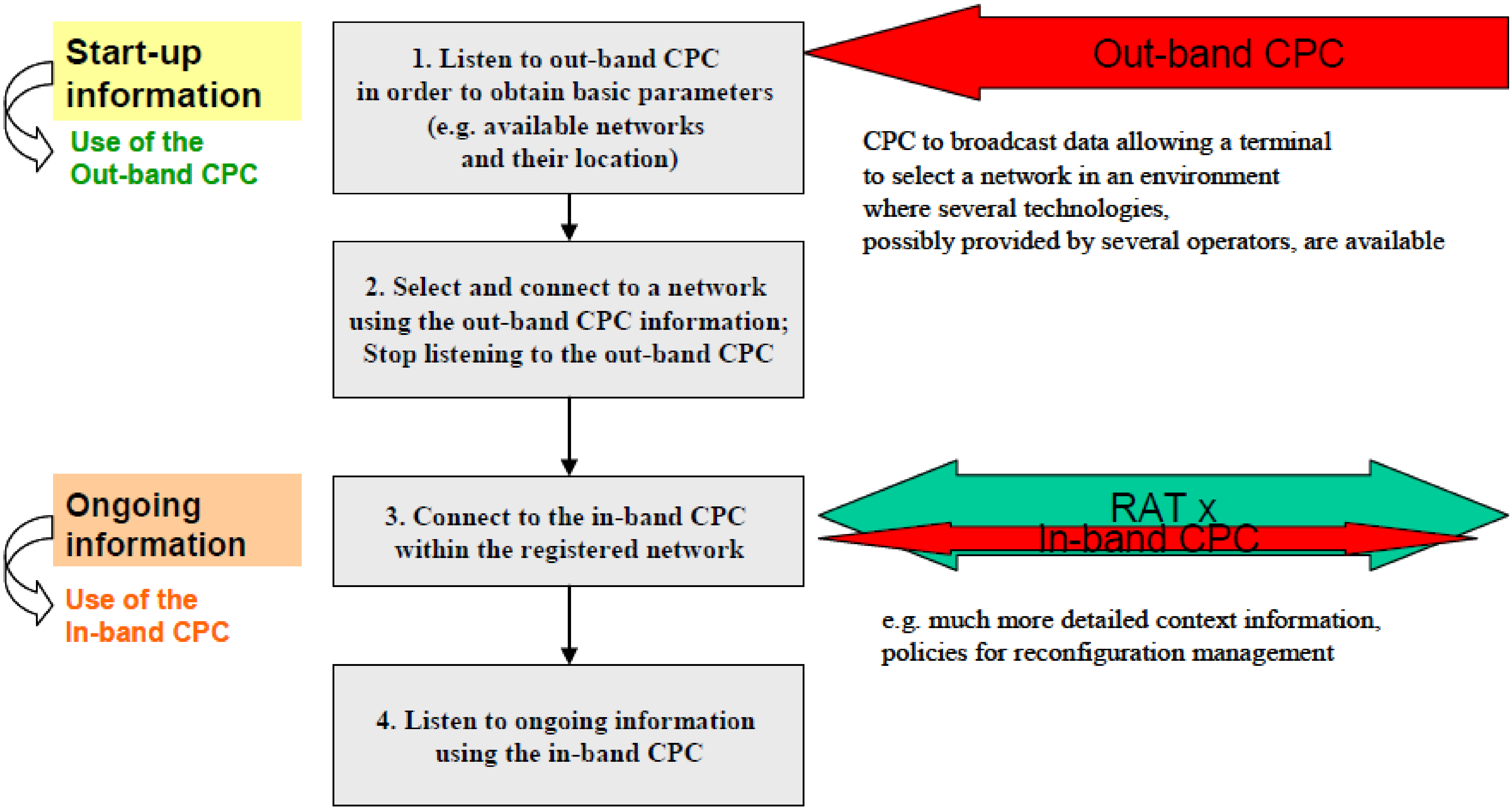
TELECOM ITALIA HR SERVICES

- The spectrum awareness arises as a basic challenge in a generic scenario, where a number of transceivers even with flexible time-varying assignment of operating frequency and/or RAT are deployed
- CPC allows the terminal to obtain knowledge of the communication means available at a given time and place
- A mobile terminal may use the CPC during one or both of the following phases:
- **"start-up"** phase:
  - turning on, the terminal detects (e.g. on one or more well-known frequencies) the CPC and optionally could determine its geographical information by making use of some positioning system
  - The information retrieved by the mobile terminal is sufficient to initiate a communication session optimized to time, situation and location
- **"ongoing"** phase:
  - When the terminal is camped on to a network, a periodic check of the information forwarded by the CPC may be useful to rapidly detect changes in the environment due to either variations of the mobile position or network reconfigurations.
  - In this phase, the same information of the "start-up" phase could be delivered by the CPC with additional data, such as services, load situation, etc.

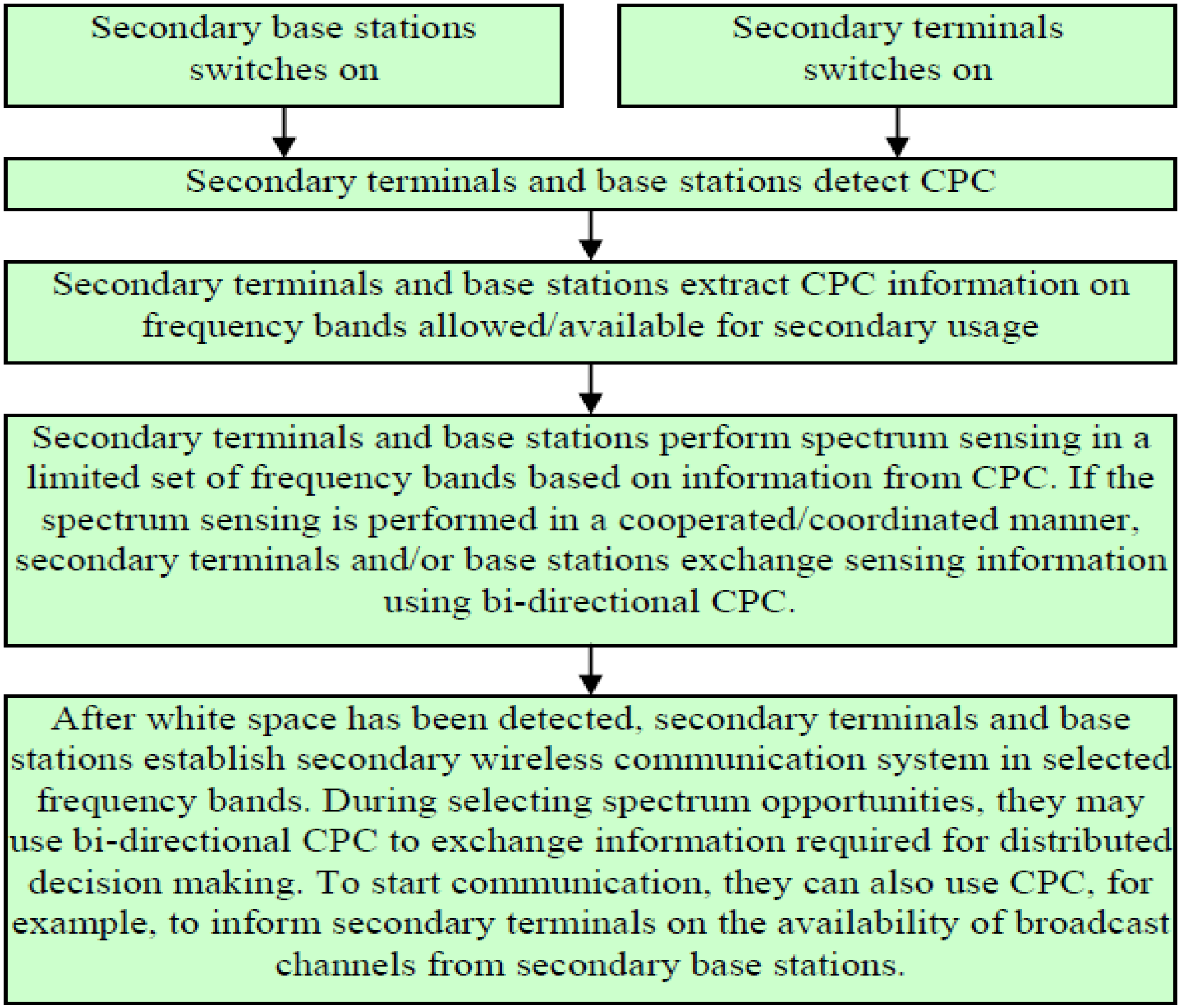
	Start-up		Ongoing	
	out-band	in-band	out-band	in-band
⇩ Downlink only	OK	NO	OK	OK
⇳ Bidirectional	OK	NO	OK	OK
NOTE: During the ongoing phase, the terminal may use the in-band CPC for bidirectional communication, while, in parallel, may receive information delivered by the out-band CPC.				

From ETSI

Scenarios/deployments and use cases



Scenarios/deployments and use cases



From ETSI

Outline

TELECOM ITALIA
HR SERVICES

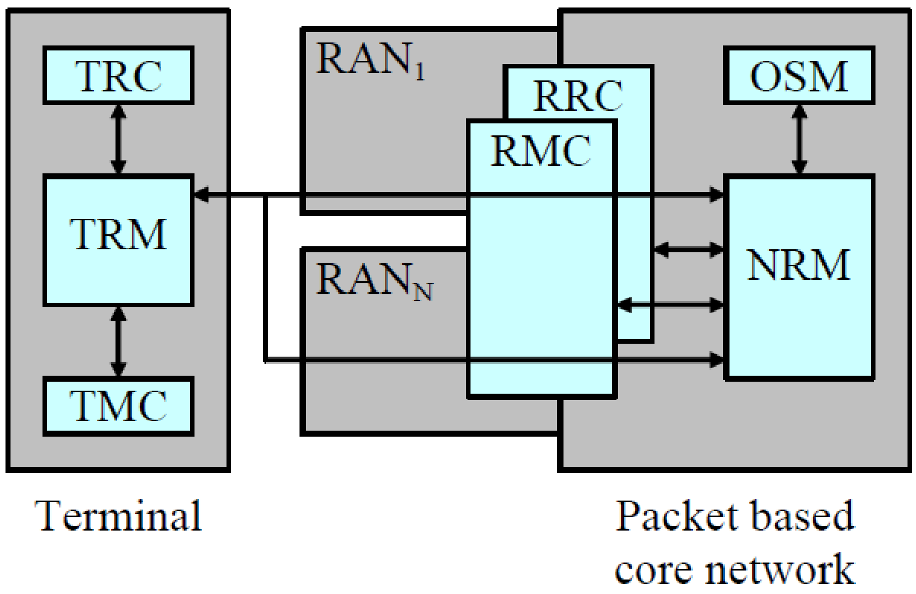
- Introduction
- Radiomobile networks
- Wireless networks
- Software Radio mobile terminal
- Cognitive Radio: concept and capabilities
- Regulatory issues in US
- White spaces and IEEE 802.22
- ETSI Funcional Architecture for Cognitive Radio networks
- IEEE 1900.4

IEEE 1900.4

- From April 2009, 1900.4 Working Group works on two projects:
- 1900.4a: Standard for Architectural Building Blocks Enabling Network-Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks - Amendment: Architecture and Interfaces for Dynamic Spectrum Access Networks in White Space Frequency Bands
- 1900.4.1: Standard for Interfaces and Protocols Enabling Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Networks

http://grouper.ieee.org/groups/scc41/4/index.htm

IEEE 1900.4
system architecure



Terminal side entities

– Terminal Measurement Collector (TMC) is the entity that collects terminal context information and provides it to the TRM

– Terminal Reconfiguration Manager (TRM) is the entity that manages the terminal for network-terminal distributed optimization of radio resource usage and improvement of QoS within the framework defined by the NRM and in a manner consistent with user preferences and available context information

– Terminal Reconfiguration Controller (TRC) is the entity that controls reconfiguration of terminal based on requests from the TRM

Network side entities

– Operator Spectrum Manager (OSM) is the entity that enables operator to control dynamic spectrum assignment decisions of the NRM

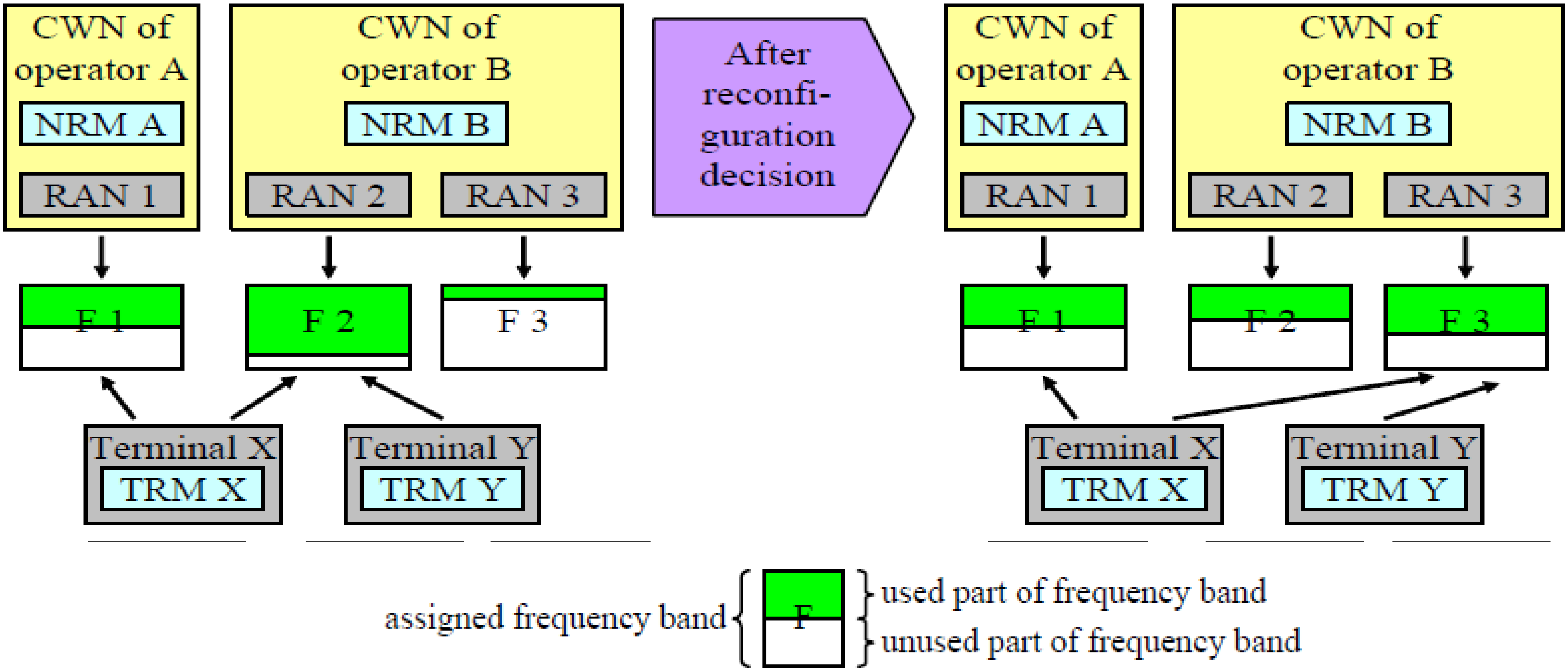
– RAN Measurement Collector (RMC) is the entity that collects RAN context information and provides it to the NRM

– Network Reconfiguration Manager (NRM) is the entity that manages the CWN and terminals for network terminal distributed optimization of radio resource usage and improvement of QoS

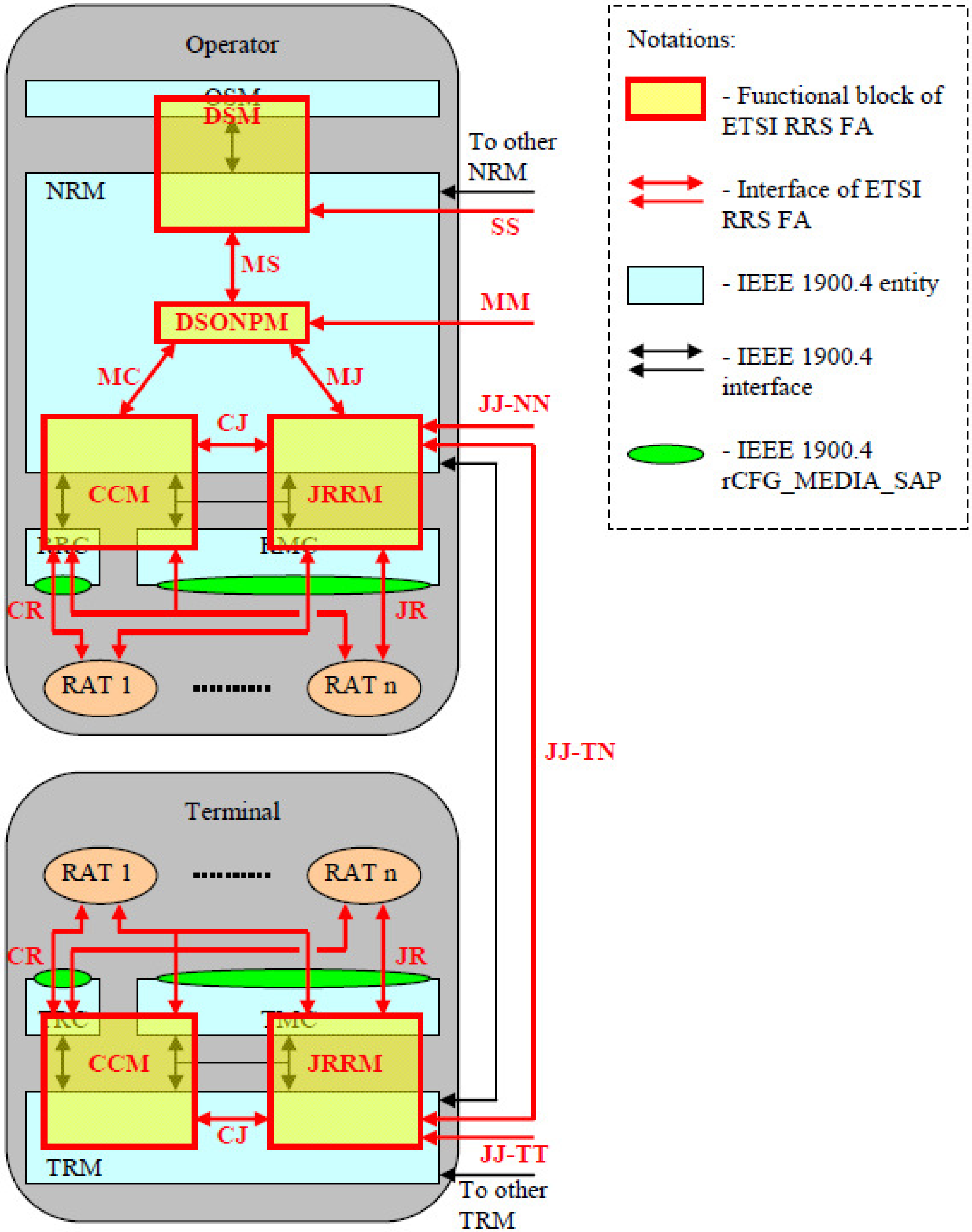
– RAN Reconfiguration Controller (RRC) is the entity that controls reconfiguration of RANs based on requests from the NRM

IEEE 1900.4
network architecture and use cases

- Distributed radio resource usage optimization



Relationship between IEEE 1900.4 system and ETSI RRS FA

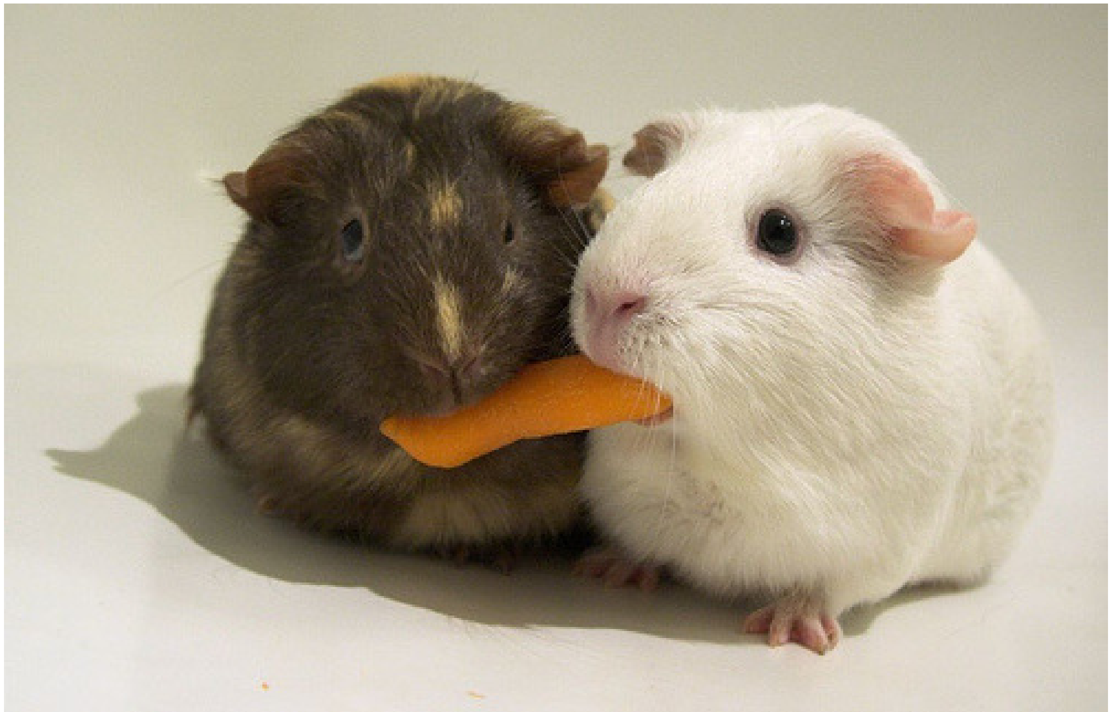


Final considerations

- Reconfigurable Radio Systems Functional Atchitectures have been propostеd from ETSI and IEEE, to optimize radio spectrum usage and network resources

BUT

will the operators promote or slow down
a so high flexibility?



Thank You!