Quality Of Service and MObility driven cognitive radio Systems

Technical Innovations from the EU FP7 project QoSMOS

28th June 2012

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'The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7) under Grant Agreement number 248454 (QoSMOS)'.

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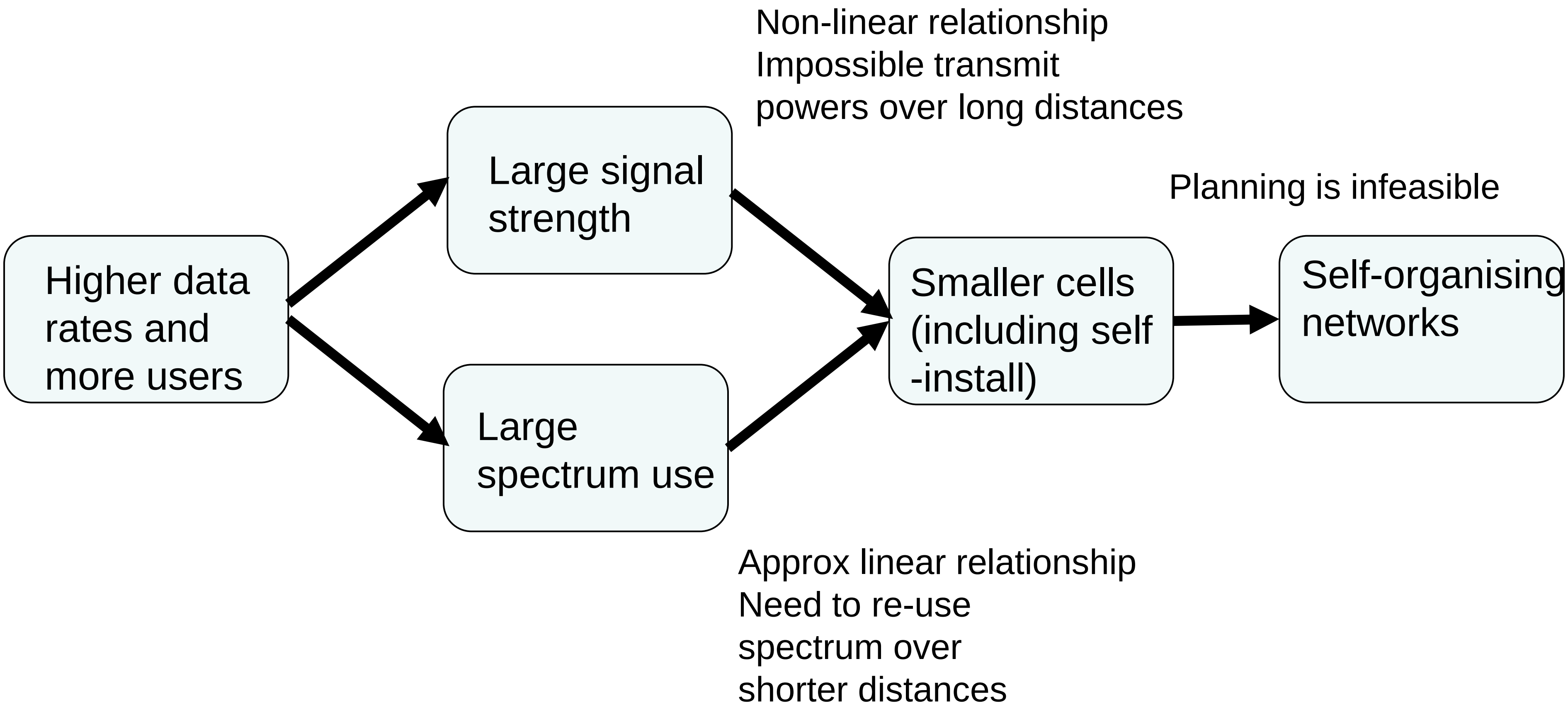
Two trends are occurring:
1. Cells are becoming smaller...



2. Regulation is changing to allow spectrum sharing

- to enable more efficient use of the spectrum

Licensed → EG GSM, 3G → High Power
Radio Planning
Spectrum shortage

Unlicensed → EG WiFi
Bluetooth → Low power
Unplanned
Interference

Shared → EG TV White Space → Medium Power
Dynamic planning

→ Flexible radios
Intelligent use of spectrum resources

My 5 year vision is very flexible and reconfigurable user terminals.
And managed use of spectrum.

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QoSMOS at a glance

- Quality of Service and MObility driven cognitive radio Systems
- To develop critical technologies, value chain and regulatory environment for spectrum sharing
- Is an FP7 Integrating Project
  - Call 4 objective ICT-2009.1.1; The Network of the Future, part (b): Spectrum-efficient radio access to Future Networks
  - Duration is 36 months from January 2010 – December 2012
- Budget
  - Approx 1200 PMs
  - Total = 14.5M€, EC contribution = 9.4M€

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Partners

Participant organisation name	Country
British Telecommunications PLC	United Kingdom
Telenor ASA	Norway
Commissariat à l'Energie Atomique	France
Oulun Yliopisto	Finland
Technische Universität Dresden	Germany
Instituto de Telecomunicões	Portugal
NEC Technologies (UK) Ltd	United Kingdom
Agilent Technologies Belgium NV	Belgium
Thales Communications SA	France
University of Surrey	United Kingdom
NEC Corporation	Japan
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.	Germany
TST Sistemas SA	Spain
Alcatel-Lucent Deutschland AG	Germany
Budapesti Műszaki és Gazdaságtudományi Egyetem	Hungary

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Objectives

- The main objective is to provide a platform for efficient radio access to future networks
- Under this are two S & T objectives
  - Cognitive Wireless Access Provision
    - Platform aspects
    - Intelligence aspects
  - Network Support Provision
- And two non-S & T objectives
  - Use-case development [guidelines on marketing]
  - Preparation of regulatory policies [response of regulators]

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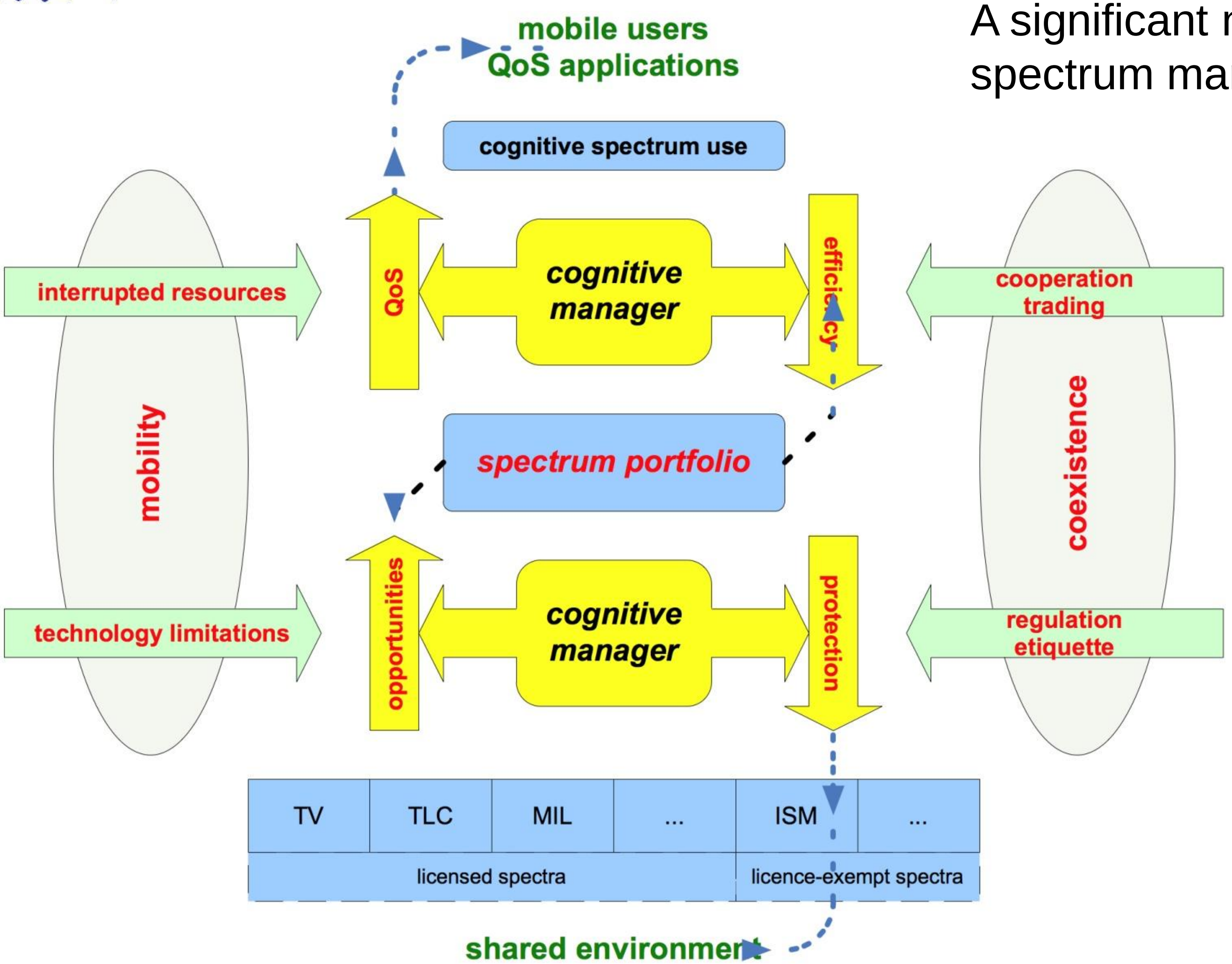
Concept



A significant novelty is a two-step spectrum management process

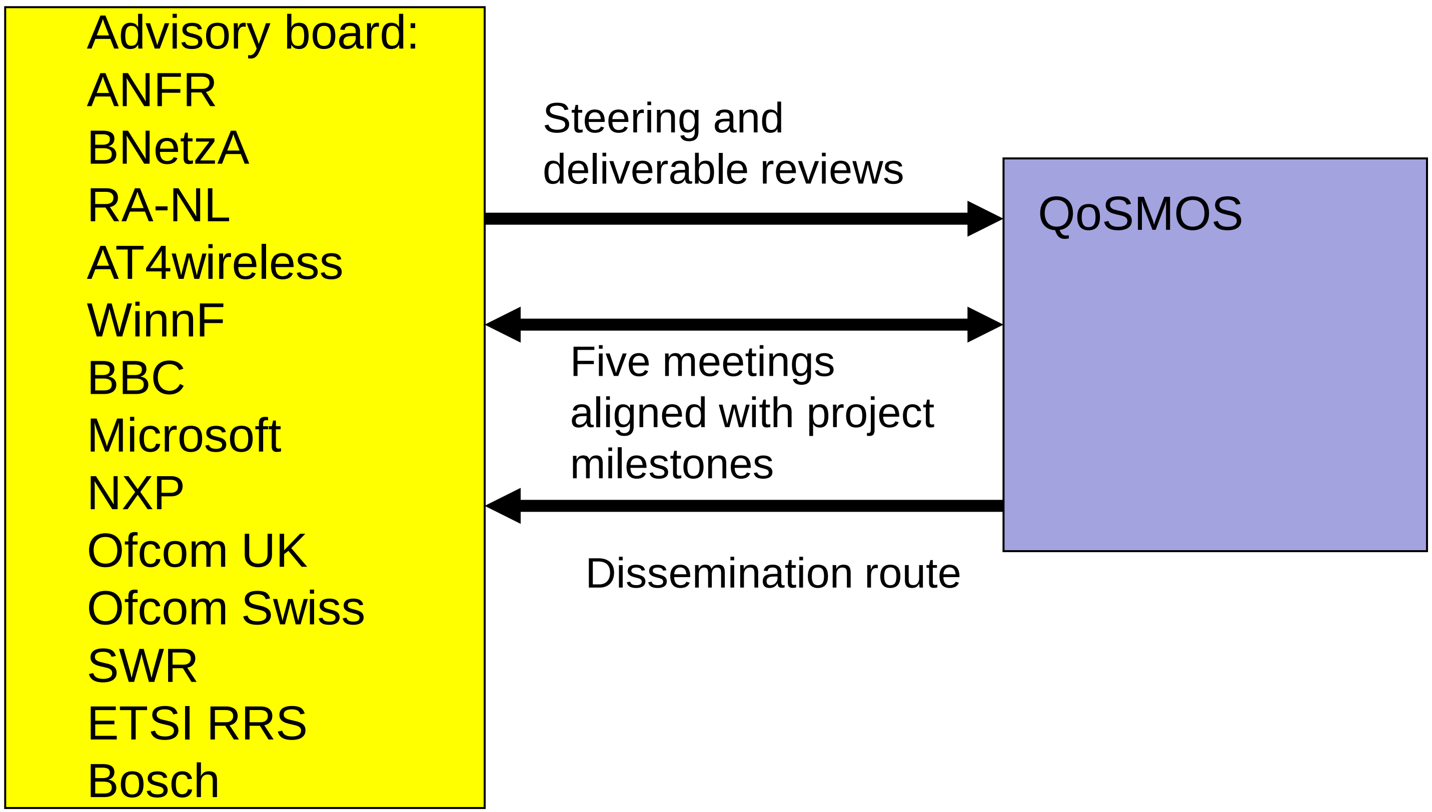
An upper cognitive manager that manages the allocation to wireless links

A lower cognitive manager that manages the spectrum portfolio

Wanted outcomes

- to develop the critical technologies to allow spectrum sharing
- to establish confidence of regulators, primary and other secondary users that spectrum sharing can be achieved without causing harmful interference
- to provide a forum that encourages framework alignment across Europe so that the market is big enough for equipment that give a high user satisfaction at the right price
- to give terminal deployment guidelines – antenna spacing etc
- to give network deployment guidelines – database integration etc

QoSMOS has an advisory board



Due to unpredicted popularity, the EAB membership is now closed

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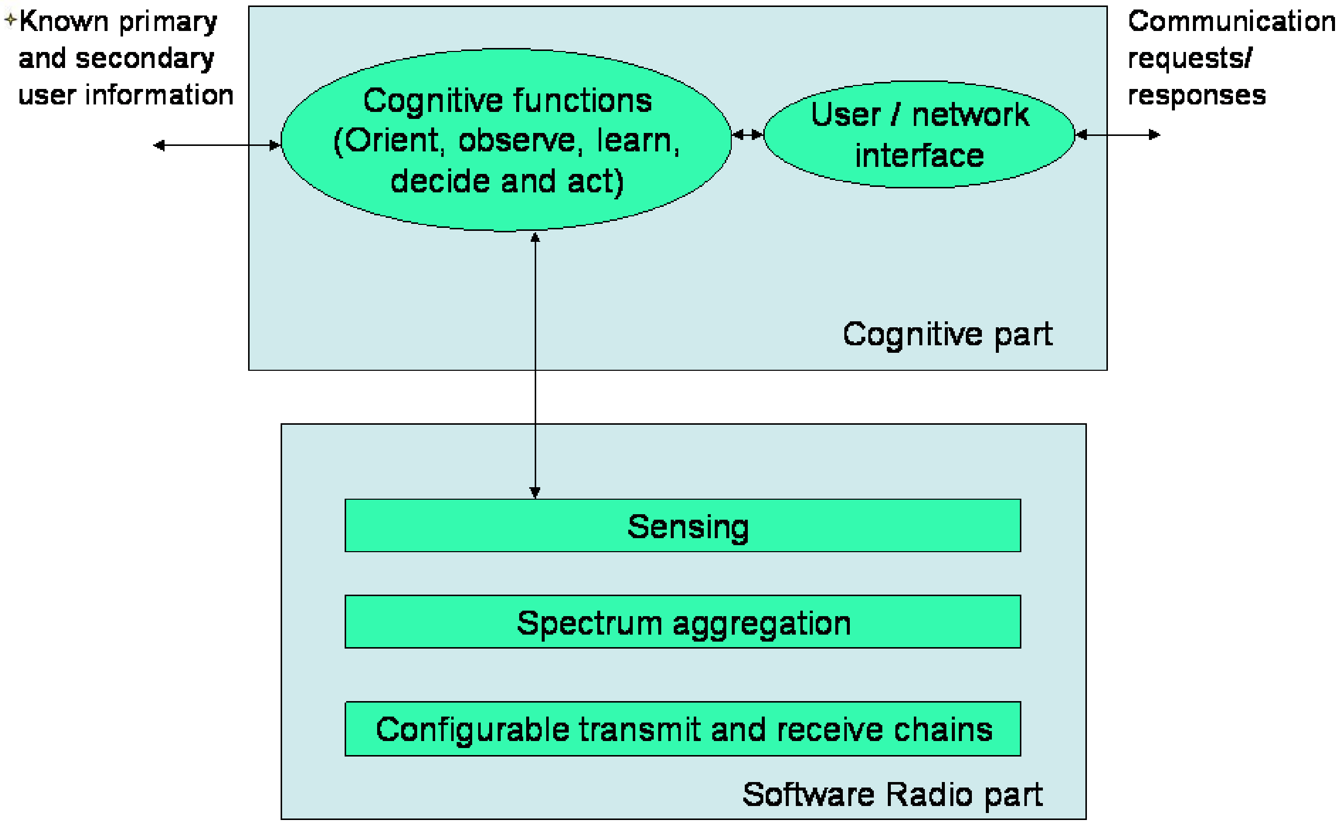
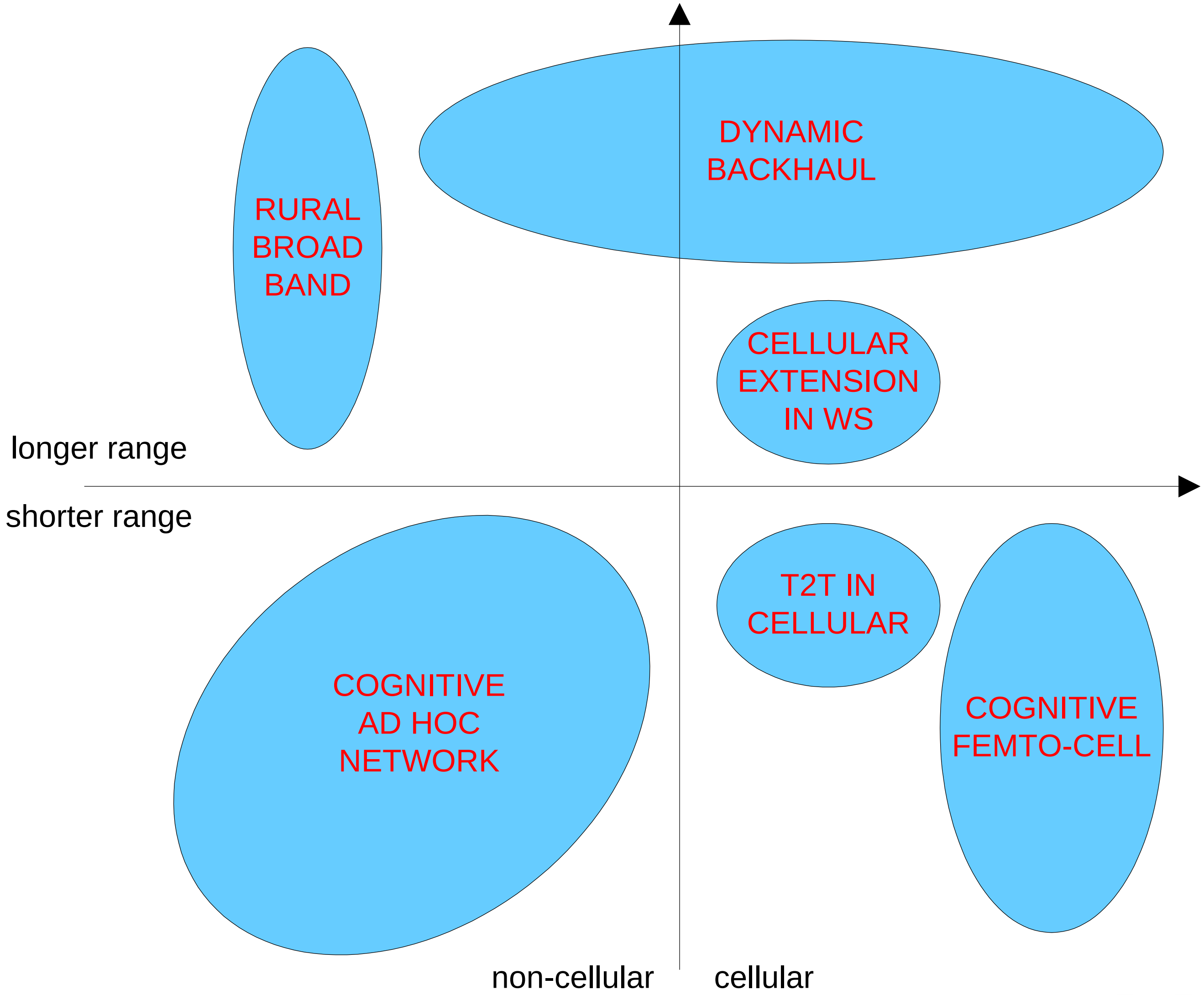


A CR device has two parts – a part that makes the decisions and a part that implements them. Information gathering is a pre-requisite.

QoSMOS scenarios



QoSMOS rationalised scenarios

Scenario	Range	LoS	Datarate	Mobile	Suitable Frequency
Dynamic backhaul	10 km	Maybe	High (10–50Mbit/s)	No	>2GHz if LoS, <1GHz if non-Los
Cellular extension in White Space	0.1 – 10 km	No	Med (2 – 10Mbit/s)	Yes	>1GHz if <1km
Rural Broadband	1 – 10 km	Maybe	Med	No	>2GHz if LoS, <1GHz if non-Los
Cognitive ad hoc Network	1 – 1000 m	No	Med	Yes	>2GHz if <50m
Direct Terminal-to-Terminal in Cellular	10 – 1000 m	No	Low (<2Mbit/s)	No	>2GHz if <50m
Cognitive femtocell	1 – 100 m	No	Med	Maybe	>2GHz if <50m

Rationalisation was carried out through questionnaires to stakeholders in the value chain and includes technical and commercial feasibility.

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Spectrum manager and resource manager database structure

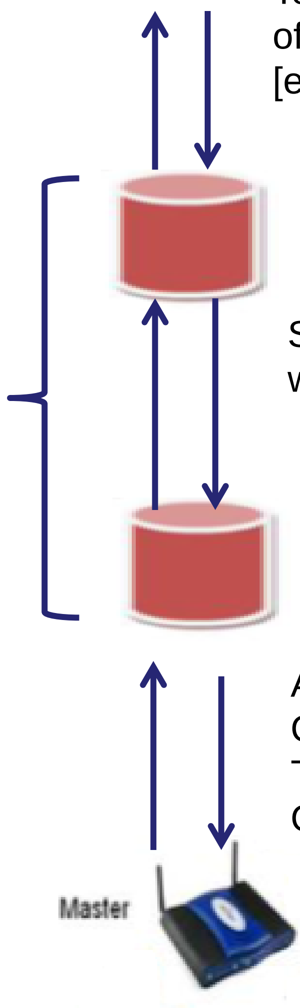
To and from repositories
of TV coverage, PMSE usage,
[emergency services etc]

Cognitive Manager
Spectrum manager (CM-SM)
(centralised)

Spectrum portfolio for region,
with quality measures

Database
in two steps

CM-Resource manager (CM-RM)
(distributed) – to cope with many systems



Available channels and powers
Quality of channels
Time of relevance
Others ?

Location of BS
Locations of end users
Confidence levels
Antenna characteristics
Sensing information
Quality requests
Mobility requests
What channels and powers
 are chosen
Others ?

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QoSMOS Innovation: Two-step database approach
With QoS and Mobility framework

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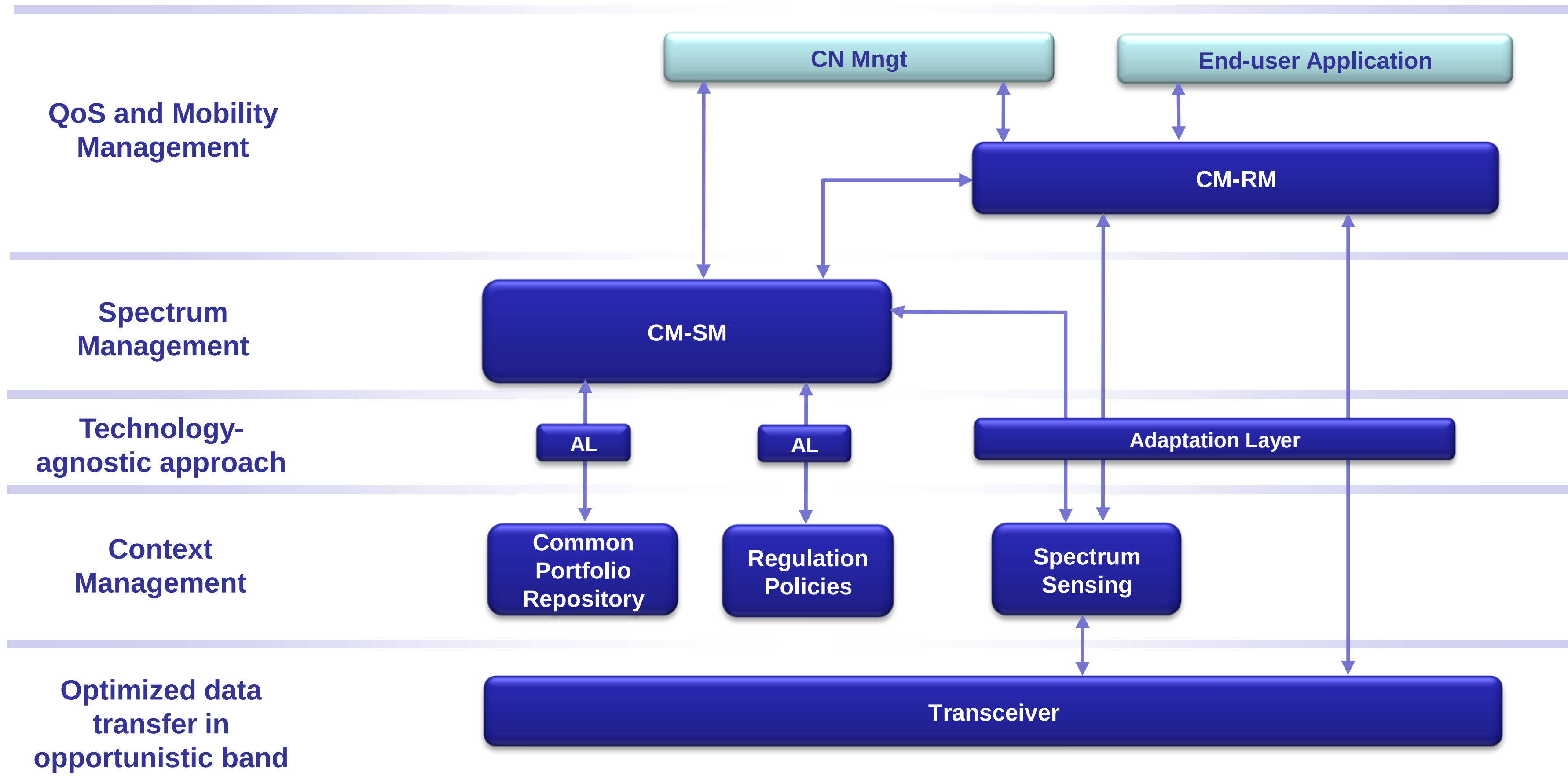
QoSMOS reference model

QoSMOS CHALLENGES

REFERENCE MODEL



QoSMOS innovation: Interfaces defined between these modules – and input to ETSI RRS

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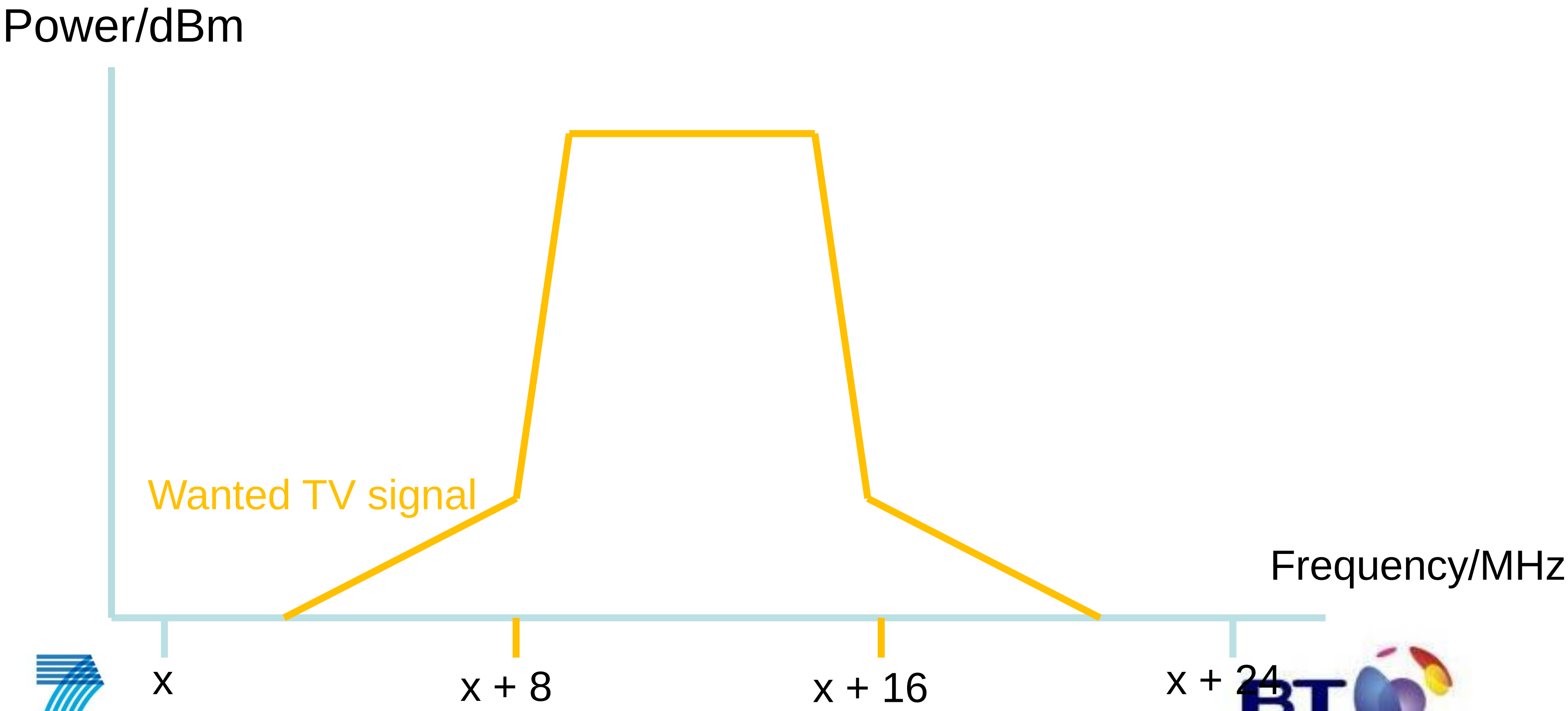
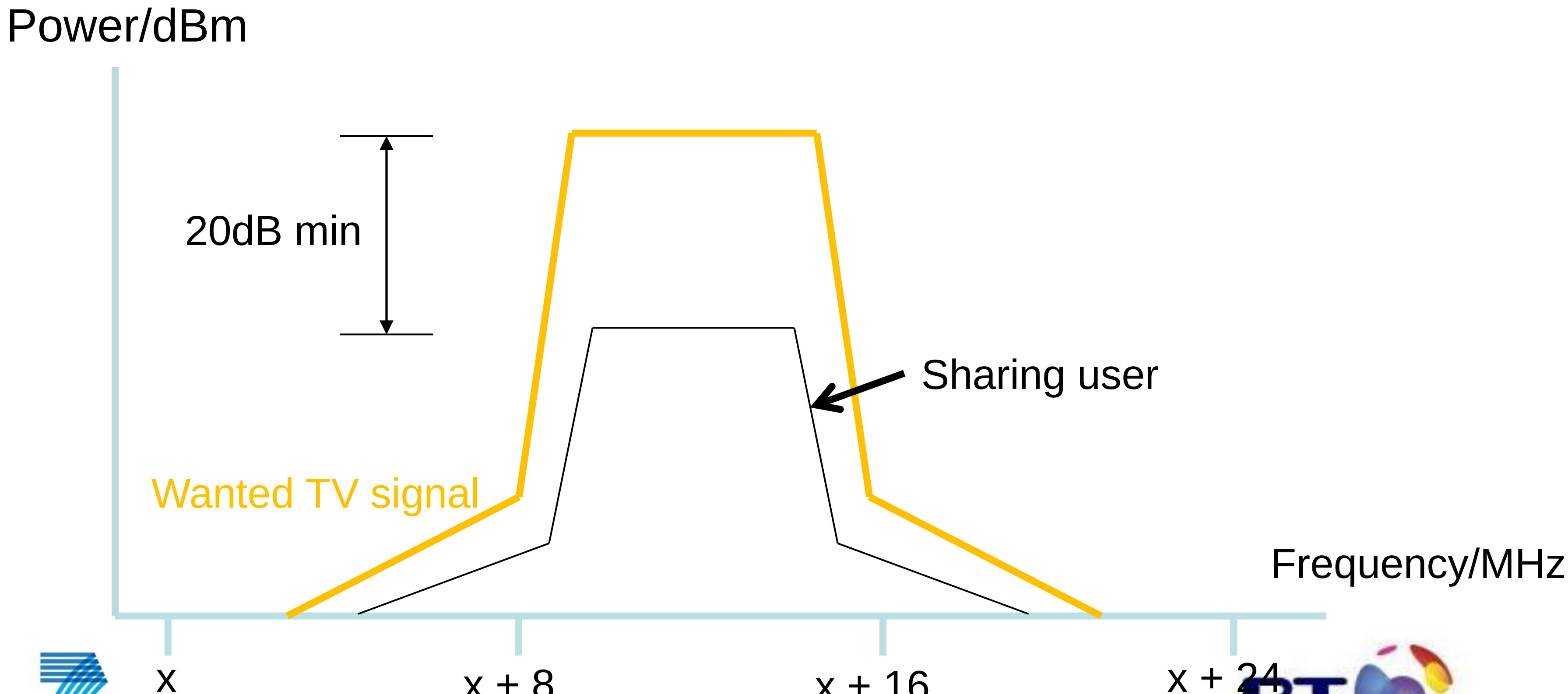
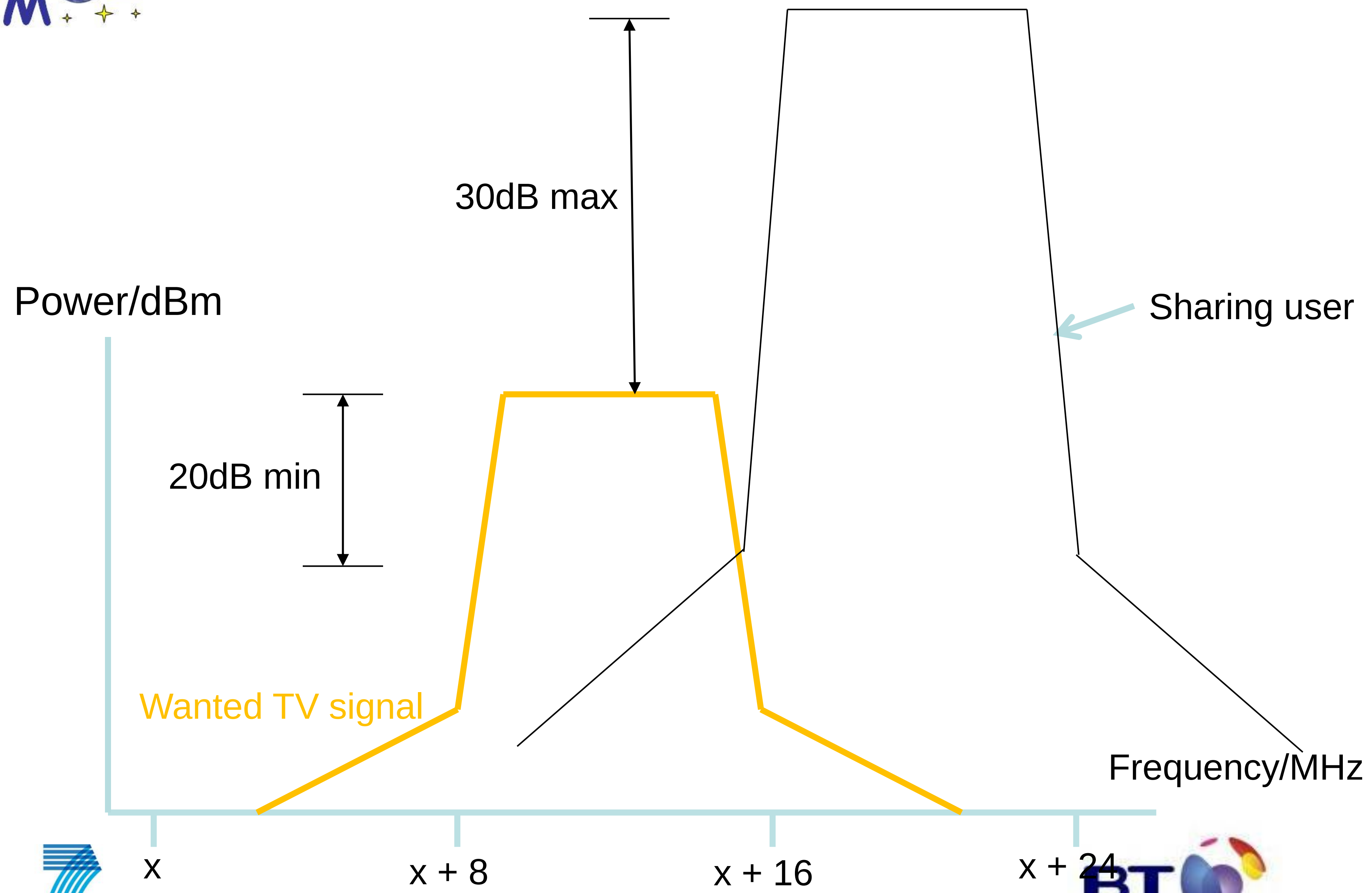
Air interface example: spectrum sharing with Digital Television (TV Whitespace). DTV uses OFDM in 8MHz channel



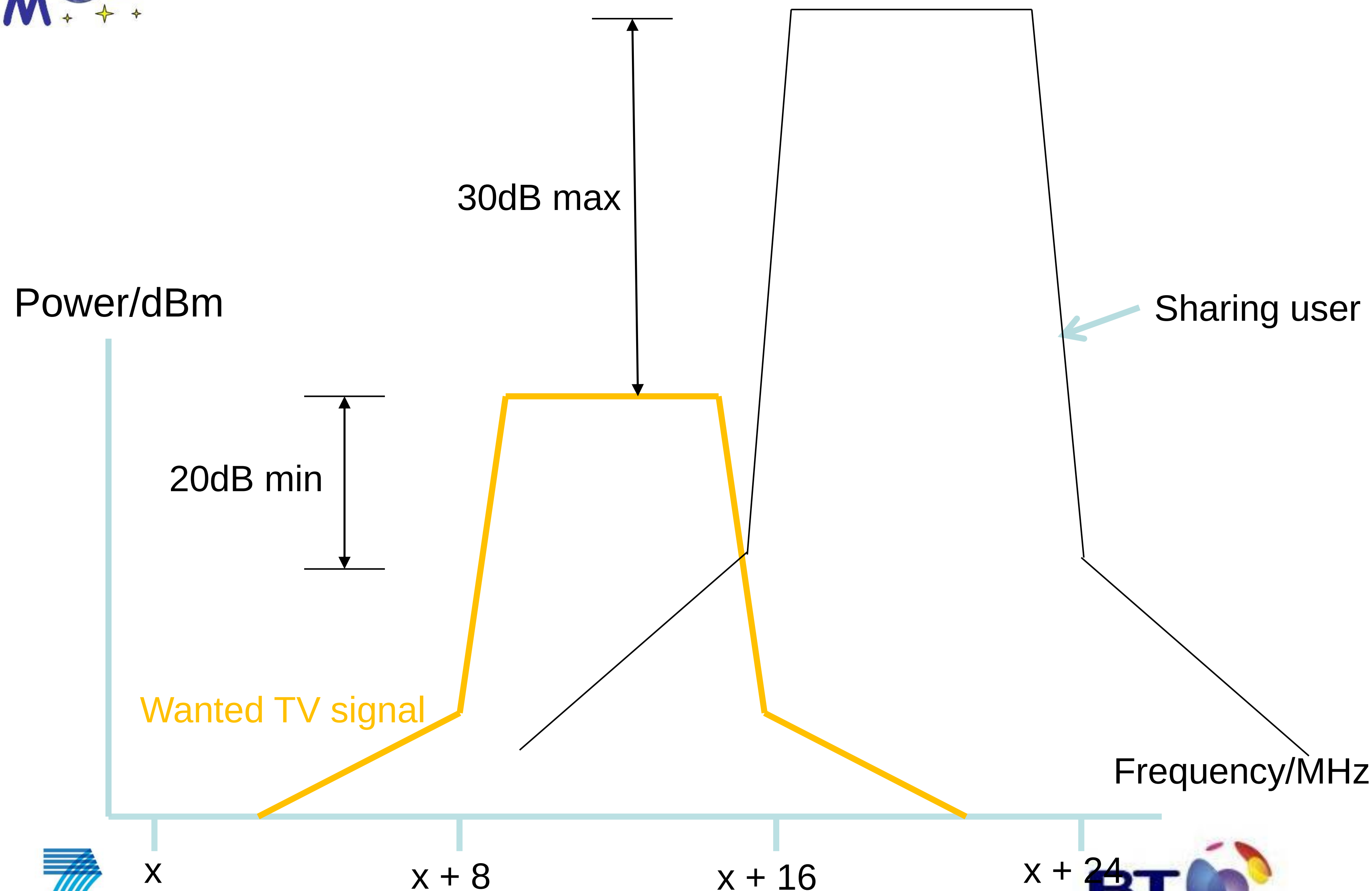
Co-channel interference limit



Adjacent-channel interference limit

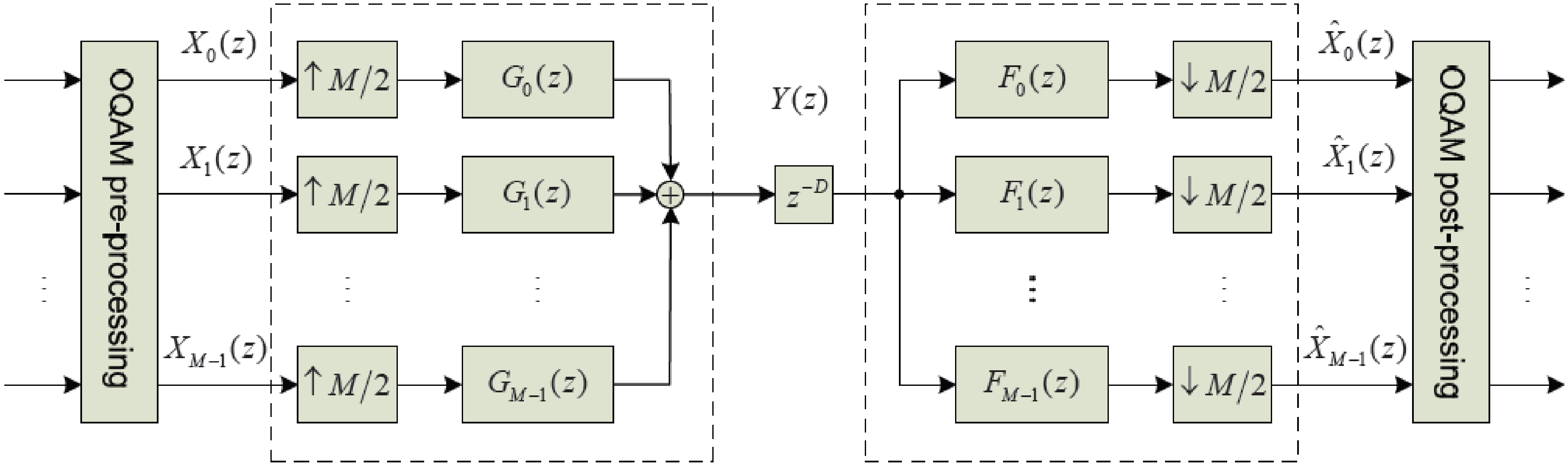


Adjacent-channel interference limit



FCC: Adjacent channel leakage of sharing user to be 55dB

A new way of generating OFDM: Filter bank multiple carrier



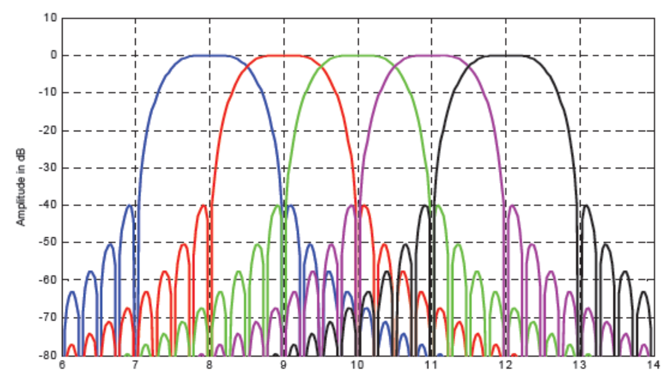
Synthesis filter bank

Analysis filter bank

Due to the overlapping of neighbouring sub-channels, orthogonality is needed.

$\Rightarrow$ Use of Offset-QAM model:

- Each QAM symbol is mapped to two consecutive subcarrier samples.
- Subcarrier sample sequences are oversampled by a factor of 2.



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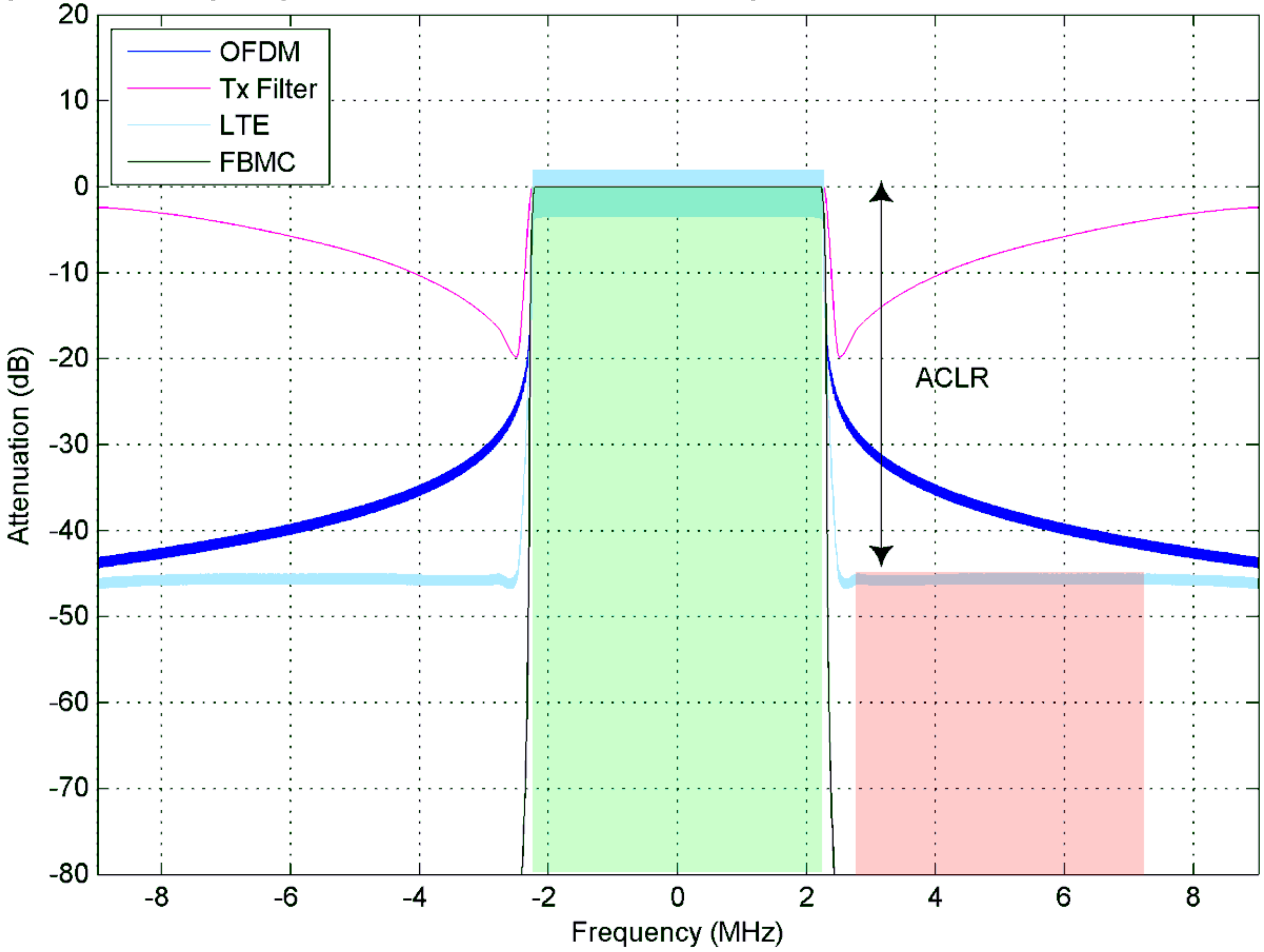
Spectral properties of LTE and FBMC

- Example 5 MHz Bandwidth
  - Requires shaping filter to meet ACLR specifications of LTE



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Spectral Properties of LTE

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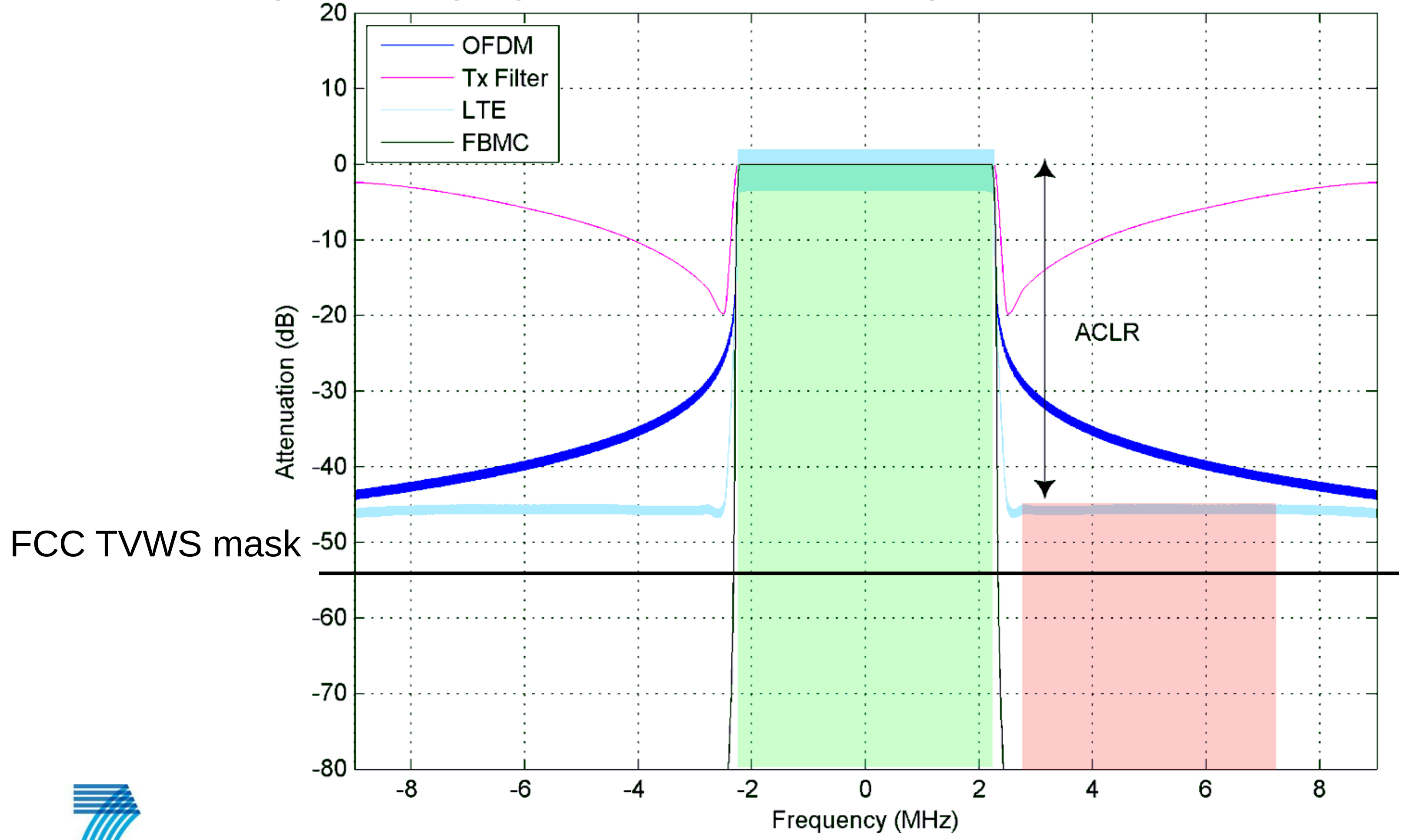
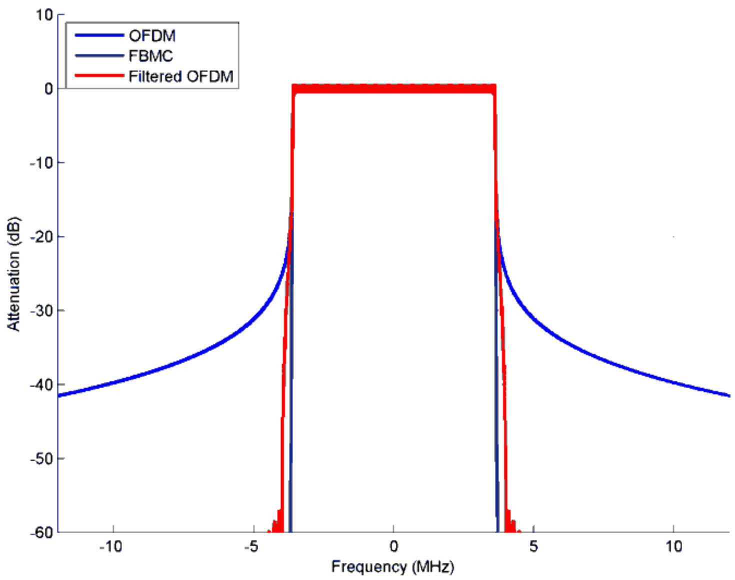
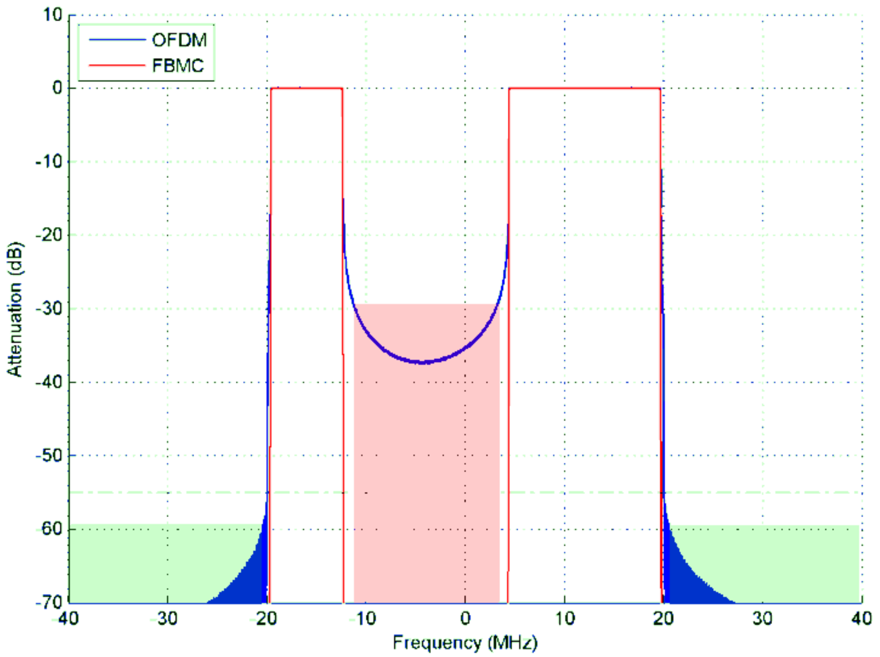


Fundamental Radio technology

- FBMC enables fragmented use of spectrum

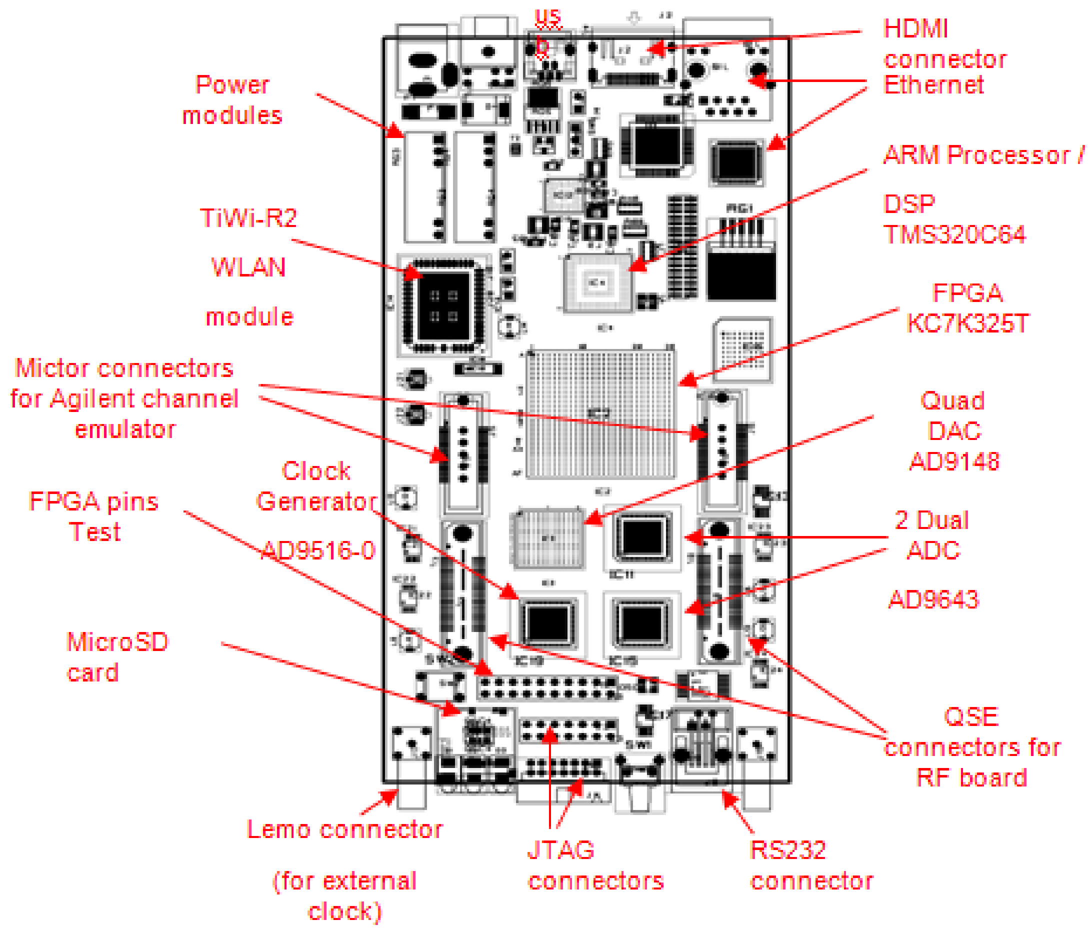


FBMC vs OFDM with 480 active carriers of LTE



Fragmented spectrum usage with FBMC

QoSMOS is building a prototype transceiver



QoSMOS innovation: FBMC prototype and patents around synchronisation..

Spectrum management, we have:

- System specifications considering functional blocks and interactions (eg CM-SM and CM-RM) – WP5 & 6
- Adaptation layer defined with associated MSCs, primitive layouts and data structures – WP2 & 5
- Basic functions such as load balancing and interference measurements also defined with MSCs and data structures – WP5
- Link budgets and selection of channel models – WP2 &4
- A reference incumbent environment of DTT and PMSE, to be used for performance evaluation in each scenario – WP3

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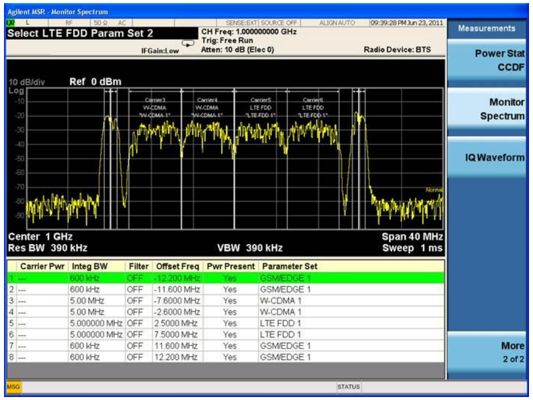
and…

- System performance metrics [1] – WP2
- Protocol stack for sensing – WP3
- Specification for context acquisition[2] – WP3 & 5
- Framework for end to end QoS and mobility management (CM-RM)[2] – WP5

[1]These are expanded in deliverable report D2.3 (November 2011)
[2] These are expanded in deliverable report D5.2 (March 2011)

Other innovations

- Sensing methods
  - Using data fusion and features of signals
  - This is hard because regulators want limits far below thermal noise
- Radio environment
  - Spectrum occupancy and quality metrics
  - Radio scene emulation
- MAC performance evaluation
  - Contention and scheduled methods for CR systems to support QoS and Mobility



	Carrier Pwr	Integ BW	Filter	Offset Freq	Pwr Present	Parameter Set
1	---	600 kHz	OFF	-12.200 MHz	Yes	GSM/EDGE 1
2	---	600 kHz	OFF	-11.600 MHz	Yes	GSM/EDGE 1
3	---	5.00 MHz	OFF	-7.6000 MHz	Yes	W-CDMA 1
4	---	5.00 MHz	OFF	-2.6000 MHz	Yes	W-CDMA 1
5	---	5.000000 MHz	OFF	2.5000 MHz	Yes	LTE FDD 1
6	---	5.000000 MHz	OFF	7.5000 MHz	Yes	LTE FDD 1
7	---	600 kHz	OFF	11.600 MHz	Yes	GSM/EDGE 1
8	---	600 kHz	OFF	12.200 MHz	Yes	GSM/EDGE 1

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Thank you for listening

Any questions ?

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