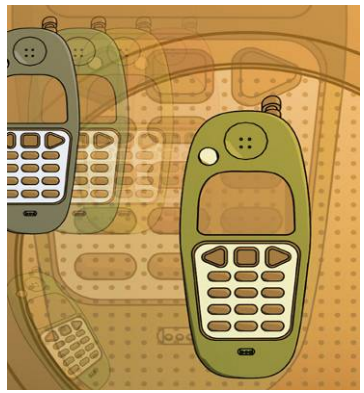
A CR-related concept: the Cognitive Pilot Channel (CPC)



Patricia Martigne,
France Telecom R&D

ITU-R Seminar on SDR/CR

04.02.08 – Geneva

Summary of the presentation

- CPC in the WRC-11 context
- CPC Framework in B3G systems
- CPC Technical Structure
- CPC Dimensioning
- Conclusion

CPC in the WRC-11 context

WRC-11 Agenda Item 1.19

- ✓ **refering to Resolution 956 [COM6/18] (WRC-07)**

  "Regulatory measures and their relevance to enable the introduction of software defined radio and cognitive radio systems":

g) […] without any information about the location and characteristics of other RATs within the covered frequency range reachable from the mobile terminal, it will be necessary to scan the whole tuning range in order to discover the local spectrum usage, which will result in a huge power and time consumption

h) […] without additional means, it may not be possible to discover receive-only usage

CPC in the WRC-11 context

i) […] usefulness to have means to assist in the determination of the local spectrum usage

j) […] need for a worldwide harmonized **cognitive supporting pilot channel** with a bandwidth less than 50 kHz

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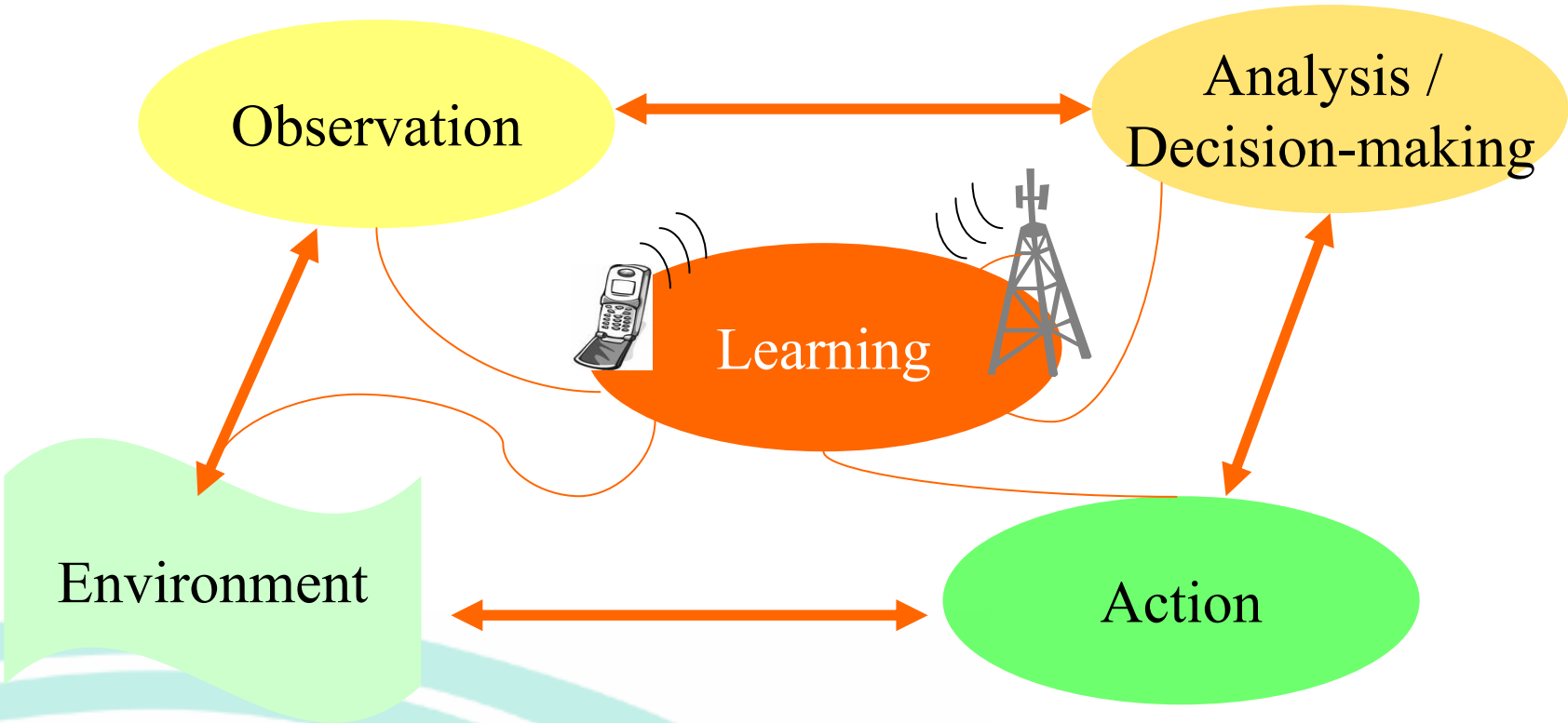
The CPC in the Cognition cycle

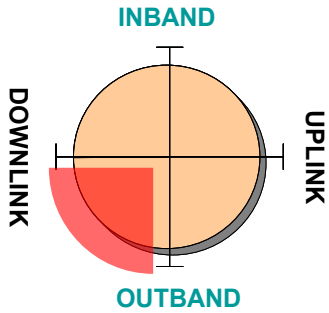


Simplified graph of the Cognition Cycle

The CPC:

- **an enabler for discovering the environment / the observation phase**
- **a radio enabler in the decision-making phase**

Radio Environment discovery



MENU

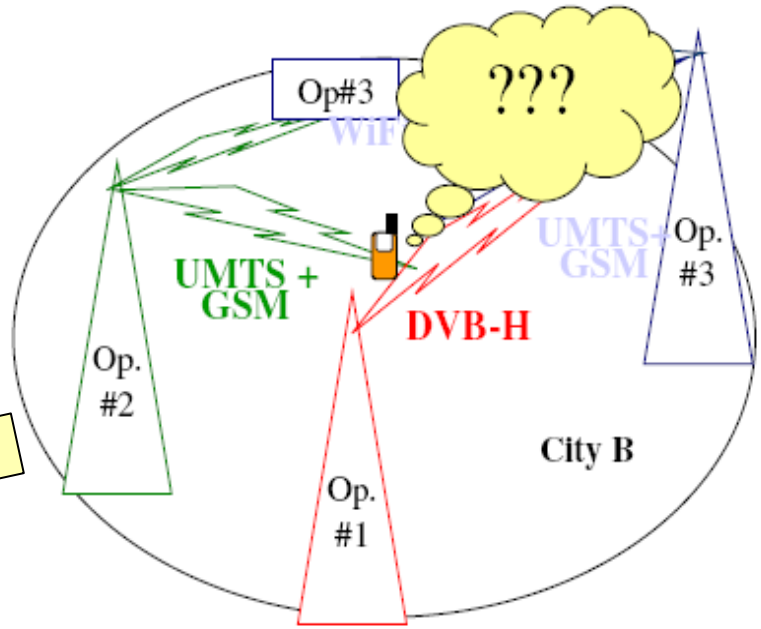
OP#1:
DVB-H, F1.1

OP#2:
GSM,F2.1
UMTS, F2.2

OP#3:
WIFI, F3.1
GSM, F3.2
UMTS, F3.3

At switch on:
the terminal does not know the "current" configurations of the various networks, in particular the frequency bands associated to the Radio Access Technologies (RAT)

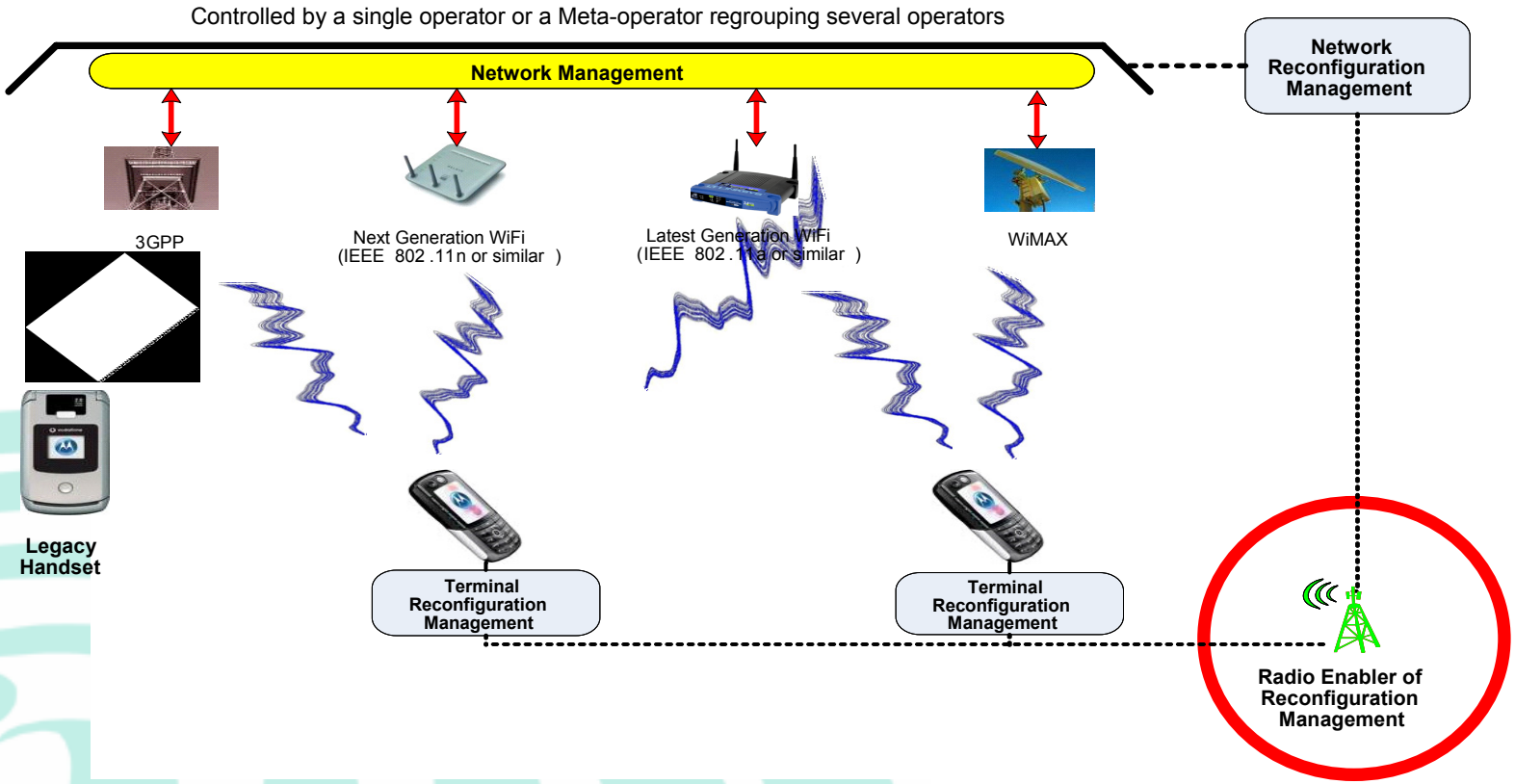
Here is the answer !



Outband CPC solution: To broadcast data allowing a terminal to select a network in a heterogeneous RATs environment: **JUST HAVE A LOOK AT THE MENU !**

Cognitive Pilot Channel as Radio Enabler

To support reconfiguration management in heterogeneous wireless environment between network and user terminals



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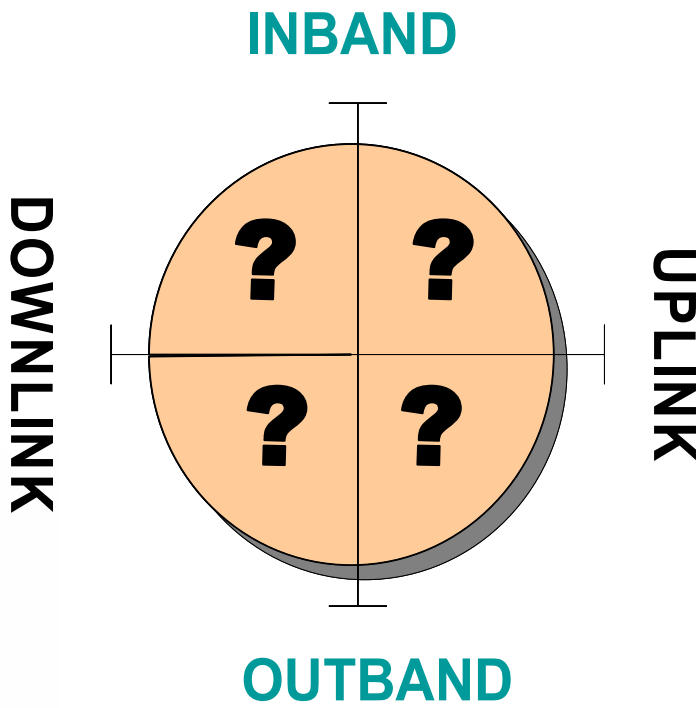
CPC structure approach in heterogeneous radio acces environment

CPC is anticipated to be a combination of two components: Outband CPC and the Inband CPC

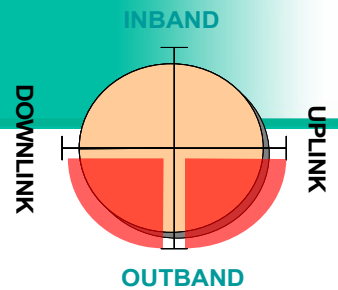
Outband is a Physical channel outside the component radio access technologies

Inband refers to logical channel within the component radio access technologies

As radio enabler, CPC is also anticipated to have both downlink and uplink components

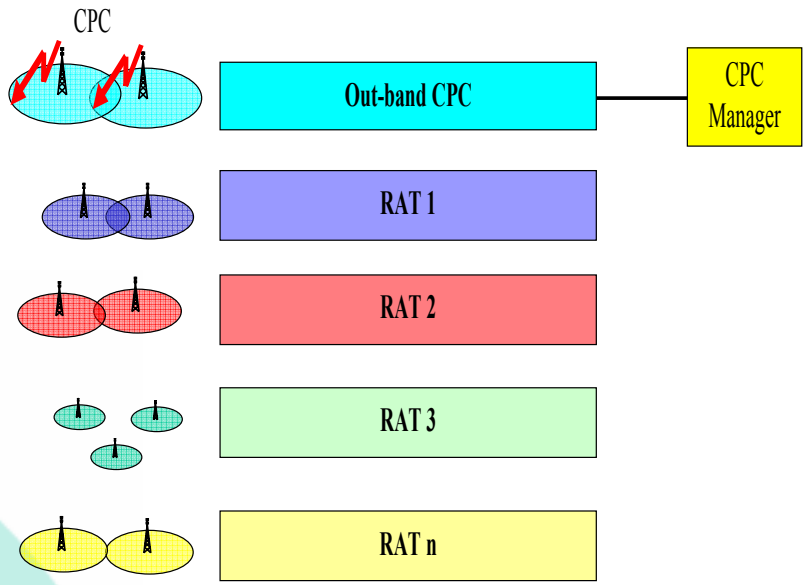


CPC structure approach for Out-band

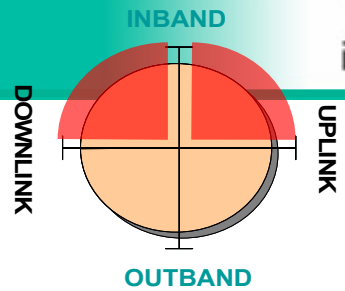


Out-band CPC is anticipated as applying on a **wide-area coverage**
Either uses a **new radio interface**, or possibly uses an **adaptation of legacy technology** with appropriate characteristics
Is not provided by bearers from a RAT in an operator's legacy system

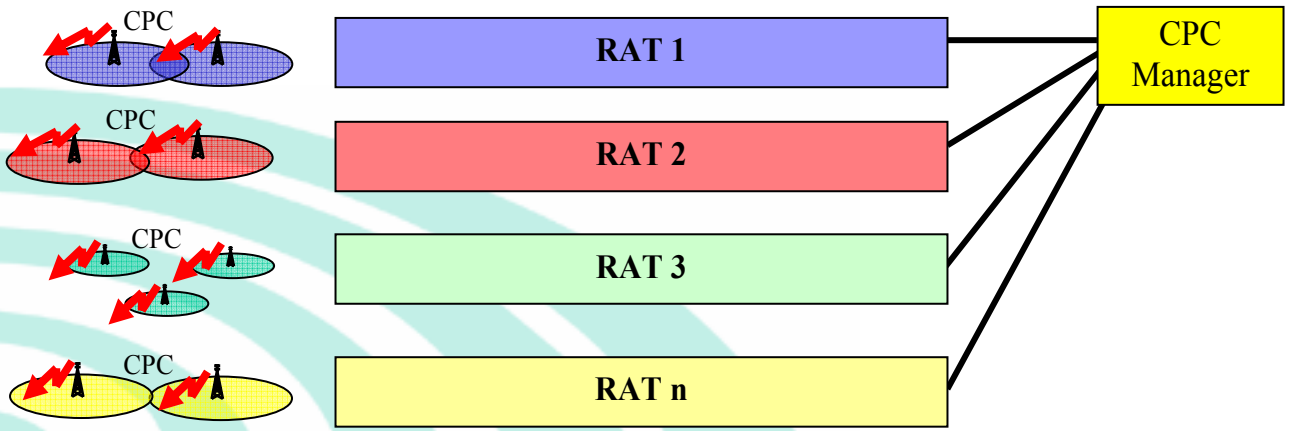
Requires some form of **harmonisation** (harmonised band)
Obtain **vital information** such as start-up information to devices (e.g. available networks at their location)
Once the **start-up** information is obtained, it is anticipated that the device will **switch to the in-band** CPC for **ongoing** information



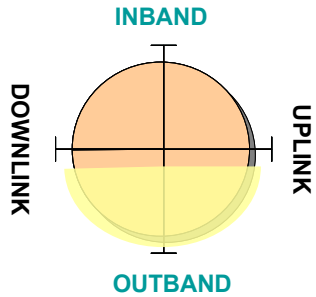
CPC structure approach for In band



In-band CPC uses channels of existing RATs and is provided by a bearer of an operator's network
Different bearers that can adapt to smaller "CPC cells"
Provide a higher bitrate without harmonisation constraints
More likely to provide uplink as well as downlink information transfer



CPC sequential use



2 distinct phases

Start-up information

use of the **Outband CPC**

Listen to out-band CPC in order to obtain basic parameters (e.g. available networks at that location)

Select and connect to a network using information from the out-band CPC; stop listening to the out-band CPC

To broadcast data allowing a terminal to select a network in an environment where several technologies, possibly provided by several operators, are available

Ongoing information

use of the **Inband CPC**

Connect to the in-band CPC within the registered network

Listen to ongoing information using the in-band CPC

e.g. much more detailed context information, policies for reconfiguration management

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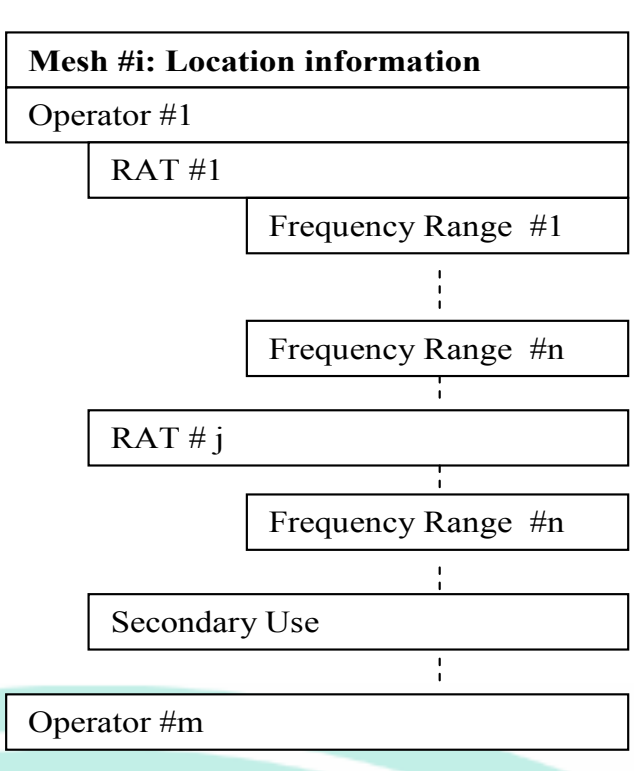
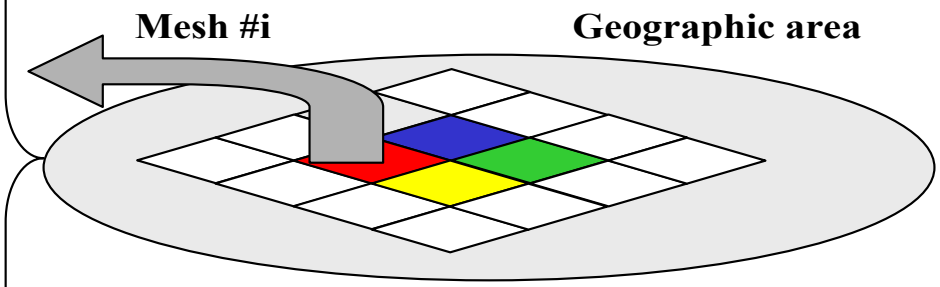
Example of CPC information for Radio Environment discovery





N_{OP}	N_{RAT}	N_{FREQ}	I_m (bits)
3	2	10	1097
3	5	10	2573
5	5	10	4253
5	10	10	8353
10	10	20	32653

Amount of bits to be transmitted per mesh for different conditions

How to implement the data delivery?:

1/ "Broadcast" approach

2/ "On-demand" approach

Dimensioning Out-band CPC

PARAMETERS COMMON TO ALL EXAMPLES

- **Amount of information per mesh:**

  Im = 4253 bits

- **Maximum allowed delay in retrieving the CPC information: Dmax = 5s**
- **Time slot duration: Ts = 10 ms (e.g. one UMTS frame or approximately two GSM frames)**
- **Each user or wireless device generates a total of λu = 0.0003 requests/s to access the CPC (i.e. around 1 request per hour)**
- **Retransmission probability of the on-demand approach: q = 0.2**

N_{OP}	N_{RAT}	N_{FREQ}	I_m (bits)
3	2	10	1097
3	5	10	2573
5	**5**	**10**	**4253**
5	10	10	8353
10	10	20	32653

Considered to be an upper bound for practical deployments

Typical value for network dimensioning in busy hour

Dimensioning Out-band CPC

EXAMPLE 1: URBAN SCENARIO WITH LARGE MESHES

η = 2000 users/km2 (~ large European city)

Cellular deployment, with R = 1 km as a representative cell range.

CPC transmitted over every cell site (R = 1 km)

Nm = 1 mesh per CPC transmitter (i.e. mesh resolution equal to cellular layout)

	DL net bit rate	DL PHY bit rate
Broadcast CPC	1.27 kb/s	3.81 kb/s
On-demand CPC	8.97 kb/s	26.91 kb/s

Bandwidth Reference values

EDGE : 144 kb/s in 200 kHz Bandwidth

UMTS : 384 kb/s in 3.84 MHz Bandwidth

Dimensioning Out-band CPC – some other examples

2. URBAN SCENARIO WITH SMALL MESHES

Nm = 315 meshes per CPC transmitter

	DL net bit rate	DL PHY bit rate
Broadcast CPC	134.82 kb/s	404.46 kb/s
On-demand CPC	8.97 kb/s	26.91 kb/s

3. RURAL SCENARIO

η=20 users/km2 (~ 100 times less than city centre)

Even wider range assumed for CPC transmitted (R=20 km)

Mesh size is assumed to be dm=5 km (then, Nm=51 meshes per CPC transmitter)

	DL net bit rate	DL Phy bit rate
Broadcast CPC	22.54 kb/s	67.62 kb/s
On-demand CPC	33.00 kb/s	99.00 kb/s

CONCLUSION (1/2)

CPC (Cognitive Pilot Channel)

- A combination of Outband/Inband, Uplink/Downlink components
- Outband CPC: suitable for Start-up information in a DSA context,
- Inband CPC: for delivering on-going information

For more details on the CPC:

E²R White Paper, December 2007

"The E2R II Flexible Spectrum Management (FSM) Framework and Cognitive Pilot Channel (CPC) Concept – Technical and Business Analysis and Recommendations"

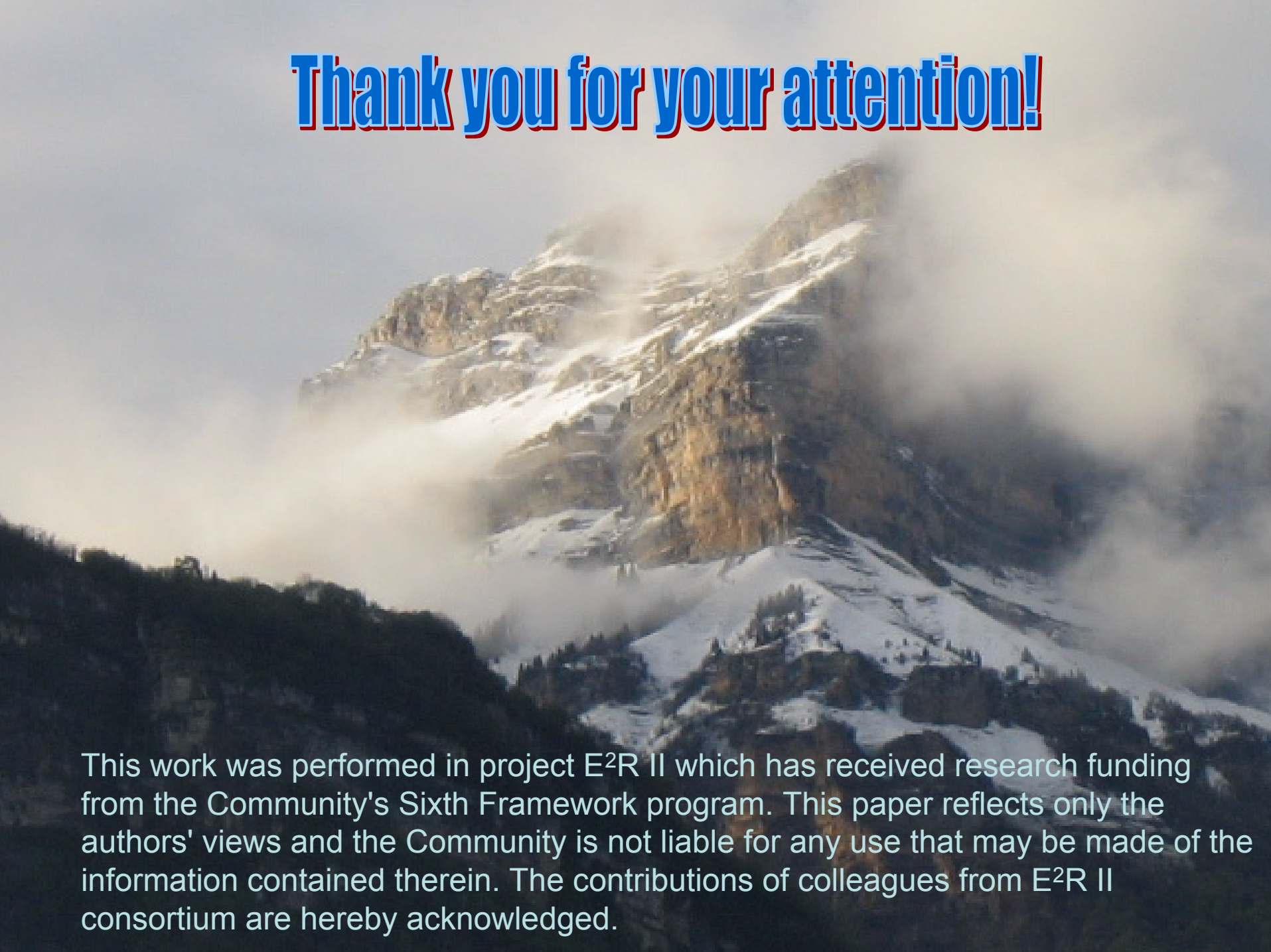
CONCLUSION (2/2)

CPC (Cognitive Pilot Channel)

Further studies on the CPC are being performed in the E3 Project…

Will be proposed for technical contributions to ITU-R WP5A with a view of assisting WP 1B in their regulatory work, in the framework of WRC-11 preparation.

Thank you for your attention!



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