COST-TERRA

COST Action IC0905 TERRA

Cognitive Radio is dead...

Long live Cognitive Radio!

Arturas Medeisis, COST-TERRA Chair &
Oliver Holland, COST-TERRA Vice-Chair

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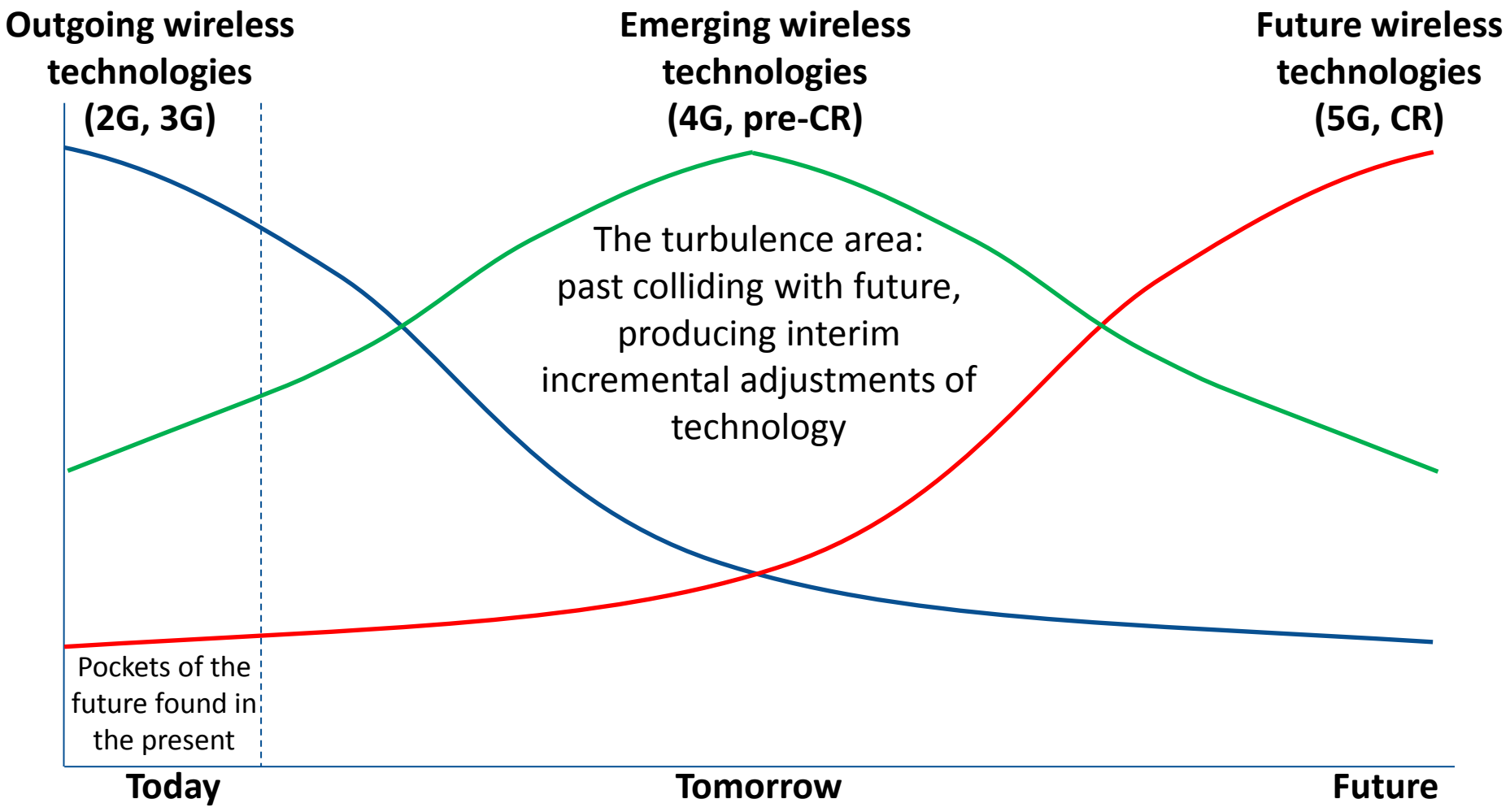
CR dead or alive?

- The CR concept was so much overhyped that for some time now, one could feel a certain gloom in the industry about the state and future prospects of CR
- We believe what was overhyped is really an expectation that CR will offer a disruptive innovative leap overnight – that idea is as good as dead
- Meanwhile CR is alive and well, and gradually advances into radiocommunications market via a plethora of incremental innovations

CR as part of future horizons

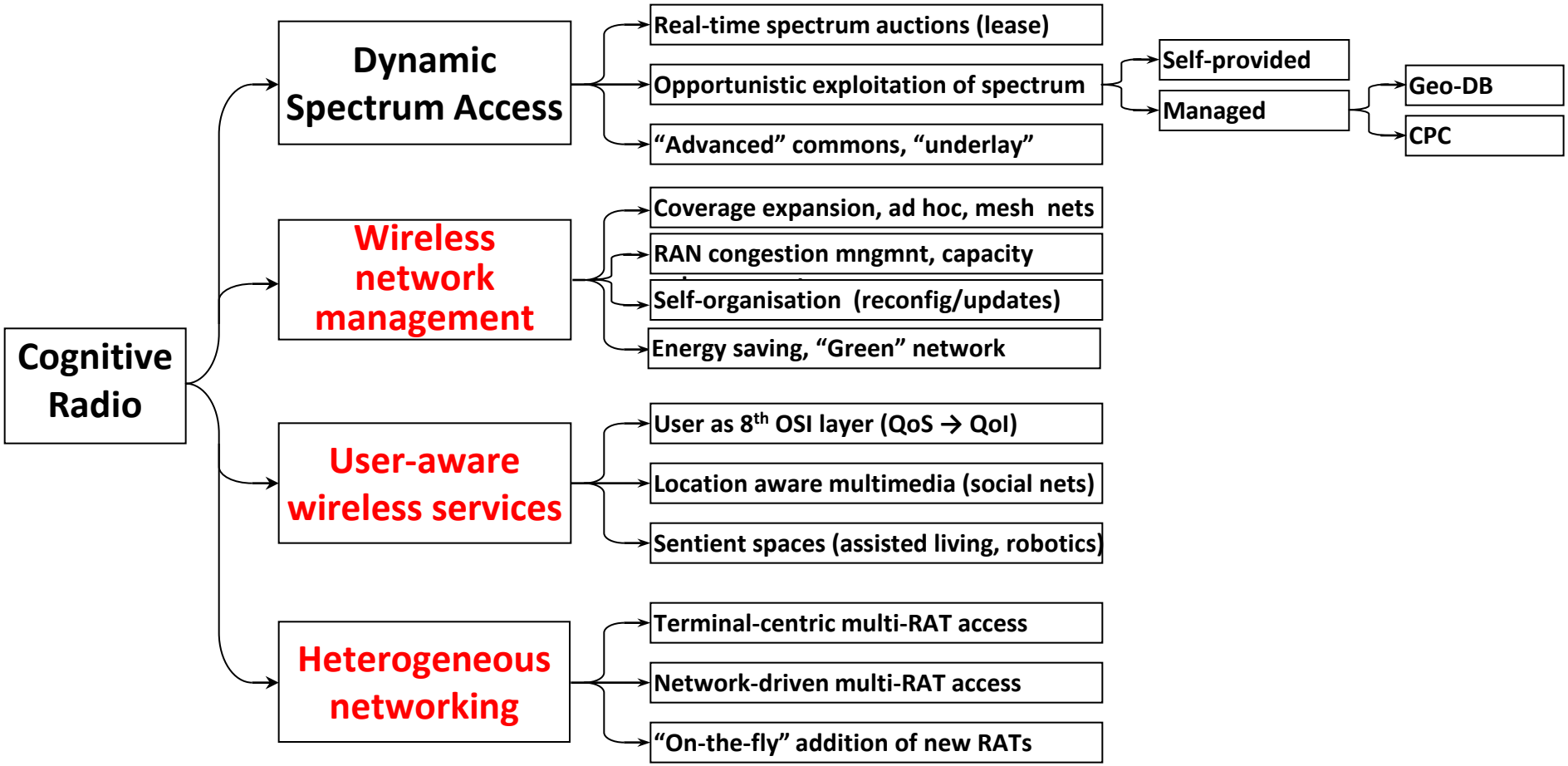


Ref. three horizons framework by Sharp, Curry, Hodgson

But what *is* CR?

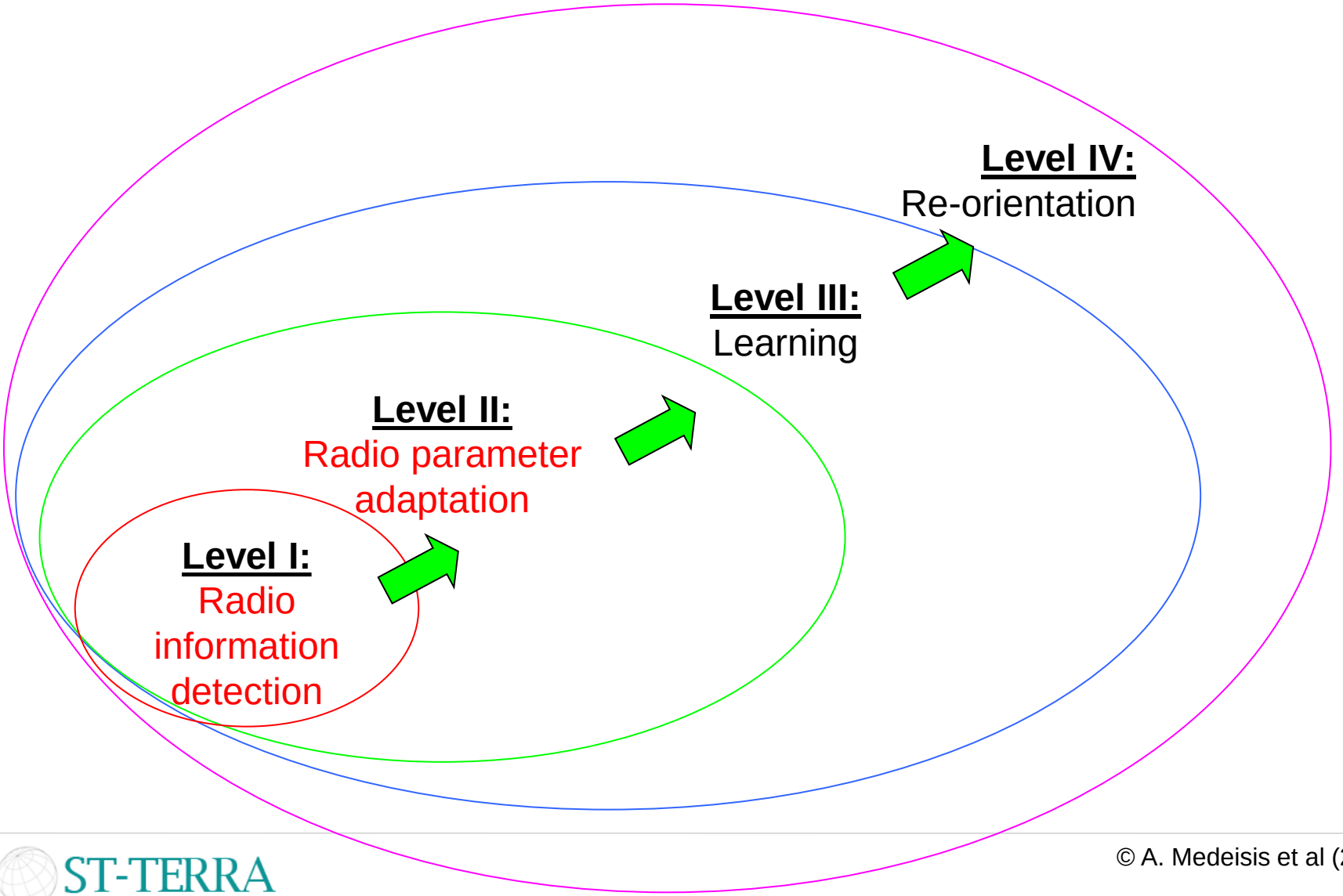
- The definitions many and vary widely
- The "philosopher's stone" of our industry, which presents itself differently depending on who looks into it
- So to understand the CR we really need to start with its definition, or rather the entire breadth of implementation examples and development paths of this complex concept…

CR implementation *paths*



Ref. A. Medeisis et al (2012)

CR technology path

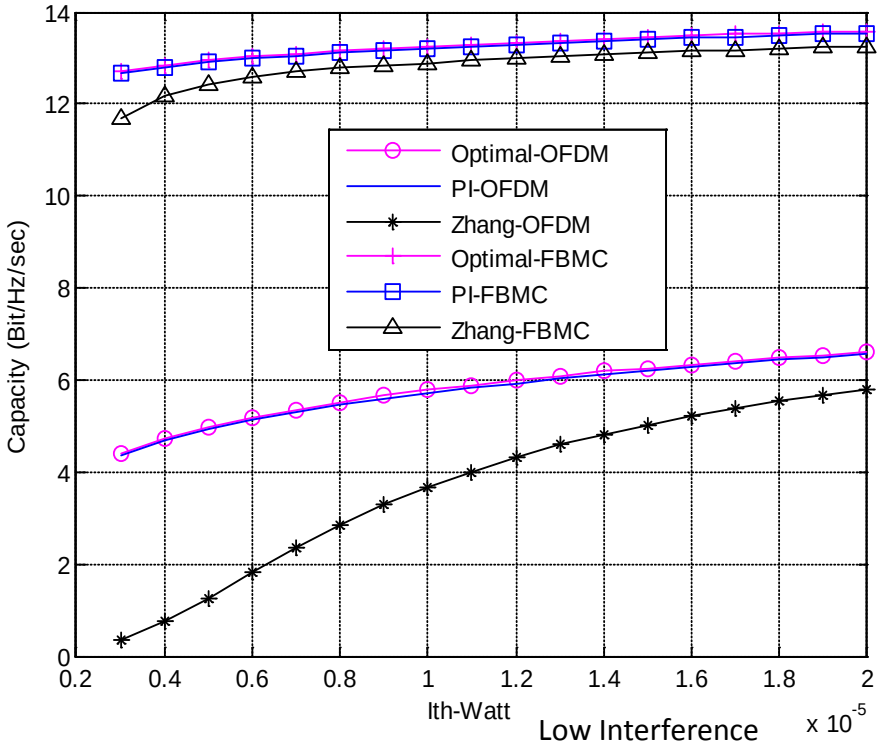


So the CR is already here

- In some applications, such as:
  - Wireless network management applications
  - User-aware wireless services
  - Heterogeneous networking
- And growing from the lowest technological levels towards the highest
- So the CR is alive, well, and growing, but how do we make it more pervasive?...
- The following shows some examples considered in COST-TERRA for progression of CR technologies

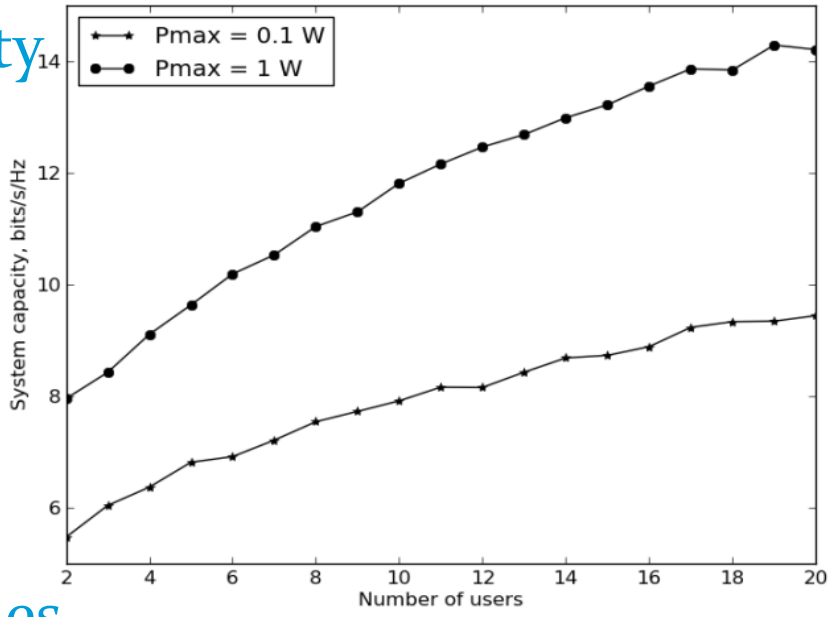
Physical layer

- Modulation advances - FBMC vs OFDM:
  - High spectral containment, reduced side lobes
  - No Cyclic Prefix, increased spectral efficiency
  - Increased robustness
  - When used in CR scenarios FBMC may provide significant boost of radio links resilience and capacity



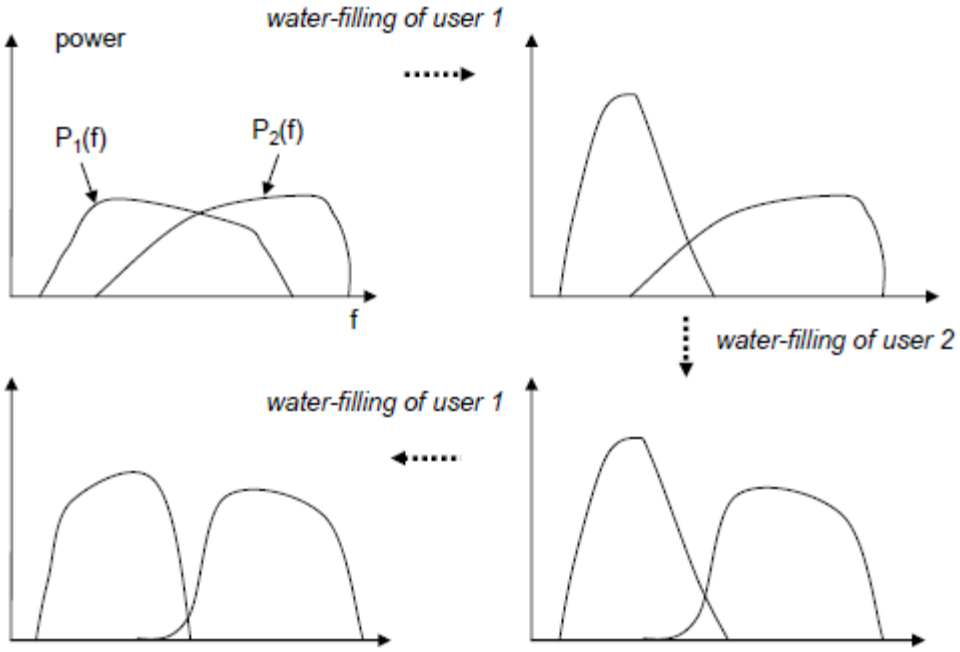
MAC: time for ISM-Advanced?

- Commons become increasingly important, including for mobile network traffic off-loading
- ISM-Advanced concept:
  - Increased spectrum use efficiency
  - Better throughput & stability
  - Waving EIRP limit
- Studied means:
  - Improved MAC protocols
  - Smart Antennas
  - Cooperative sensing/REM
  - Game-theoretical approaches



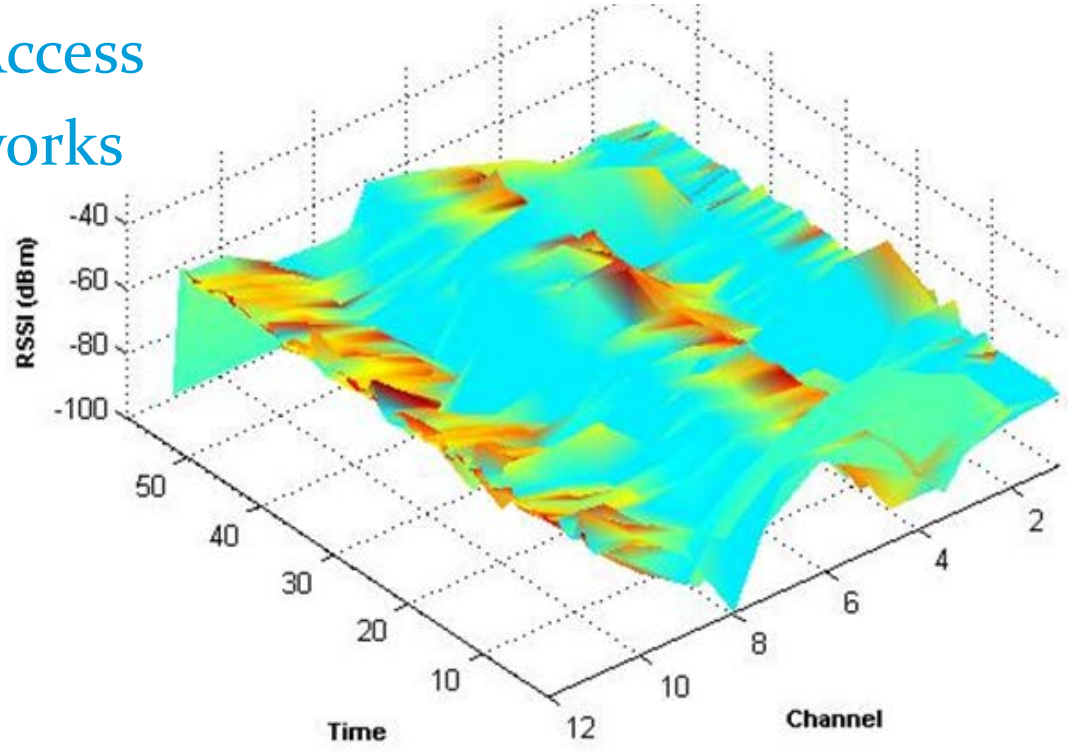
Adaptive channel access

- Water Filling Method, well known in the DSL world
- Allows to better exploit the varying channel characteristics:
  - Optimising Tx power consumption
  - Maximising throughput
  - Improved co-existence



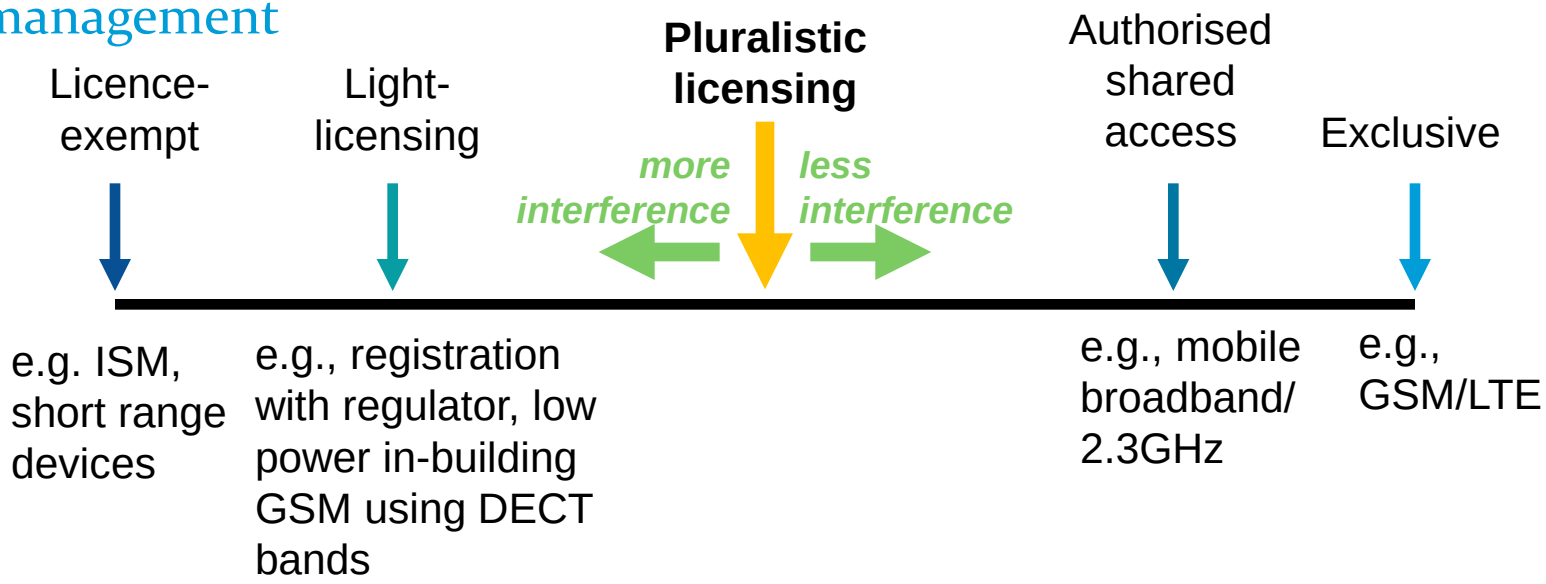
Radio Environment Mapping

- Essential *platform* for developing environmentally aware, robust CR systems:
  - White Space Devices
  - Authorised Shared Access
  - Self-Organised Networks
  - Etc.

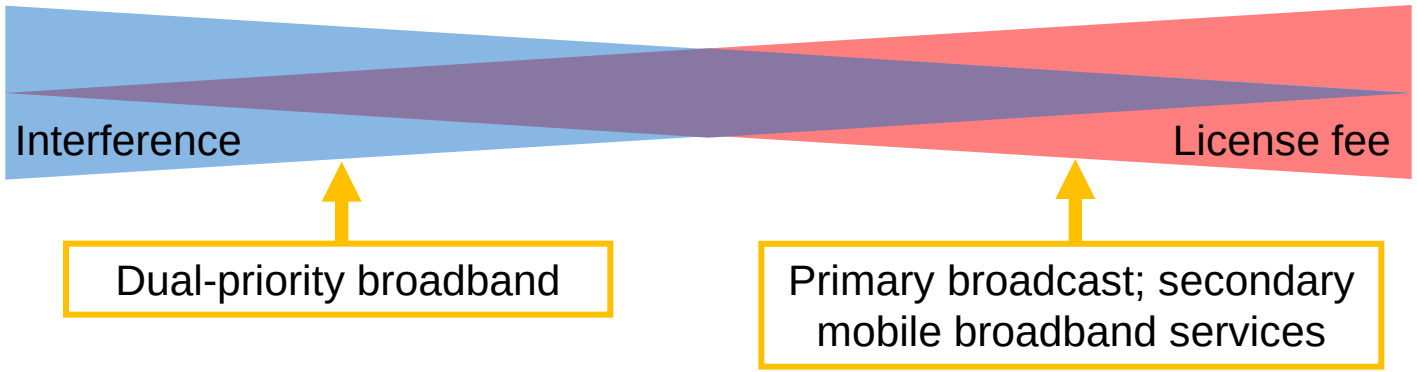


Interference management

- "Pluralistic Licensing" - an adaptable balance of interference management

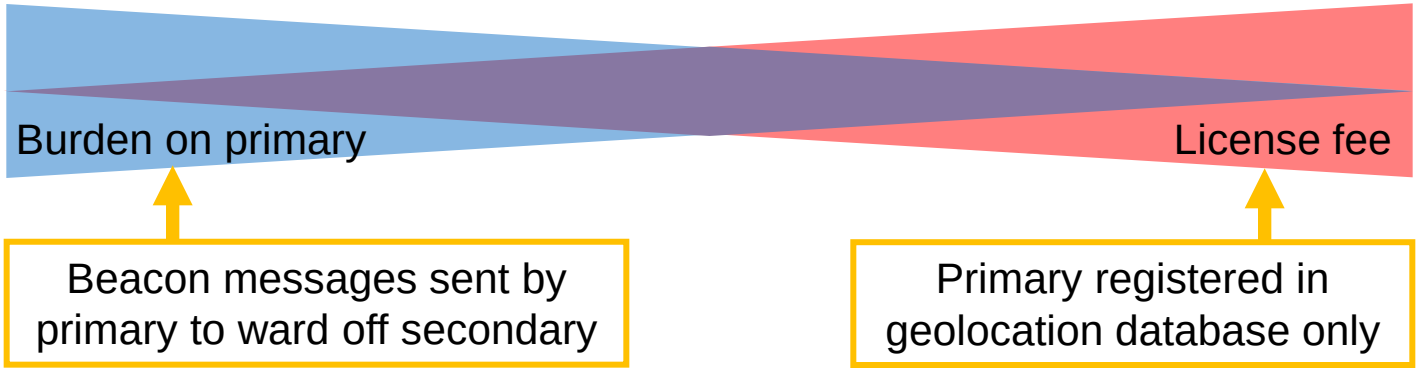


- Primary interference and license fee based on primary/secondary services

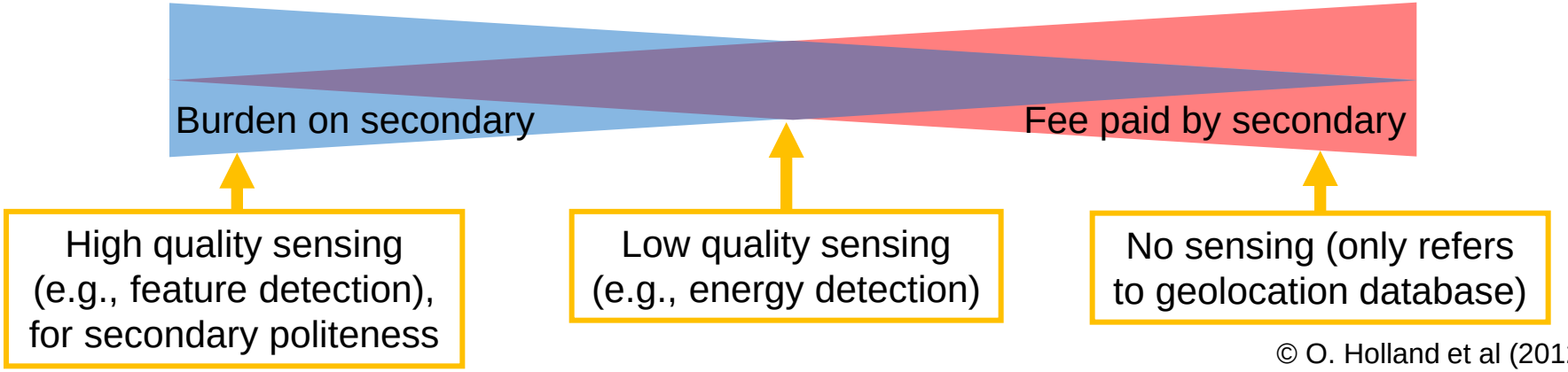


PL: technical details

- Proactive primary mechanisms and pricing

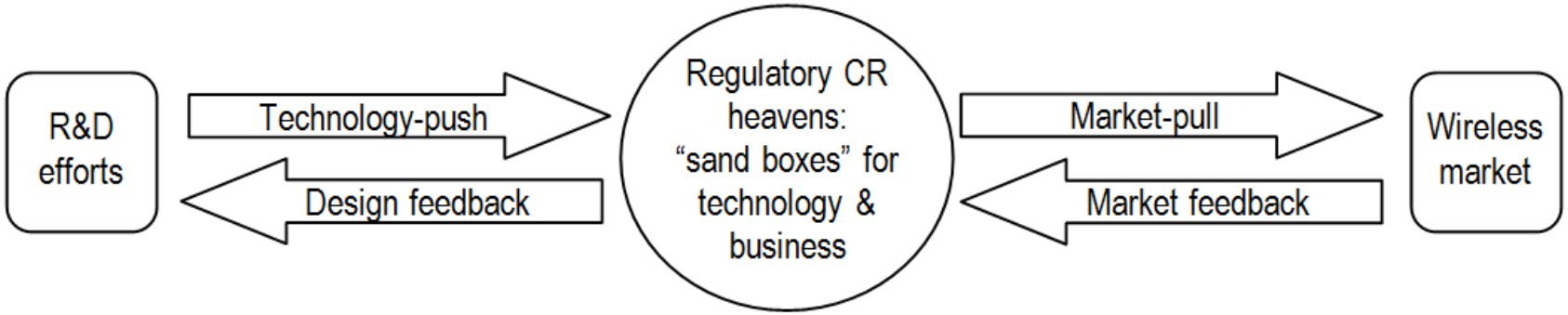


- Possible pricing example for secondary (relevant to secondary-secondary coexistence; could be relevant also to primary-secondary)



Conclusions

- Cognitive Radio is a complex term hiding many nascent wireless technologies, and rumours of it's death had been greatly exaggerated
- The regulatory establishment could greatly help the pace of technological innovation by creating favourable conditions that would be conducive to CR development and use



References

- COST Action IC0905 TERRA: www.cost-terra.org
- Sources of material reflected in this presentation:
  - Y. Zhang, "Resource allocation for OFDM-Based cognitive radio systems," Ph.D. dissertation, Univ. of British Columbia, Vancouver, December 2008;
  - C. F. Bader, "New Opportunities for Spectrum Sharing and Cognitive Radio", COST-TERRA, April 2013;
  - J. Sydor, "Report from Special Interest Group on ISM-Advanced", COST-TERRA, April 2013;
  - M. Bellanger, "Exploitation of DSL systems spectral efficiency for the benefit of CR and coexistence", COST-TERRA, November 2012;
  - O. Holland et al, "Pluralistic licensing", DySPAN'12, October 2012
  - A. Medeisis et al, "Taxonomy of Cognitive Radio applications", DySPAN'12, October 2012.
  - A. Medeisis et al, "ISM-Advanced: Improved Access Rules for Unlicensed Spectrum", submitted to DySPAN'14, April 2014