Where next for Cognitive Radio?

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Software-Defined Radio

- 1998: Joseph Mitola III conceived SDR
- September 2001: FCC issued its first Report and Order on SDR
- September 2003: Regulators Forum in UK
  - spectrum managers from Europe, USA and Asia
  - reviewed SDR approaches and the potential regulatory actions required
- “an enabling technology for more efficient spectrum utilisation”

SDR features

- Most early proposals were for multi-functional terminals
  - Public cellular/private radio systems/end-to-end IP
- Available technology was not the problem
  - hardware and software can be reconfigured
- But security presented a problem
  - how can user-equipment be certified to avoid harmful interference?
  - can malware and defective patches be detected?

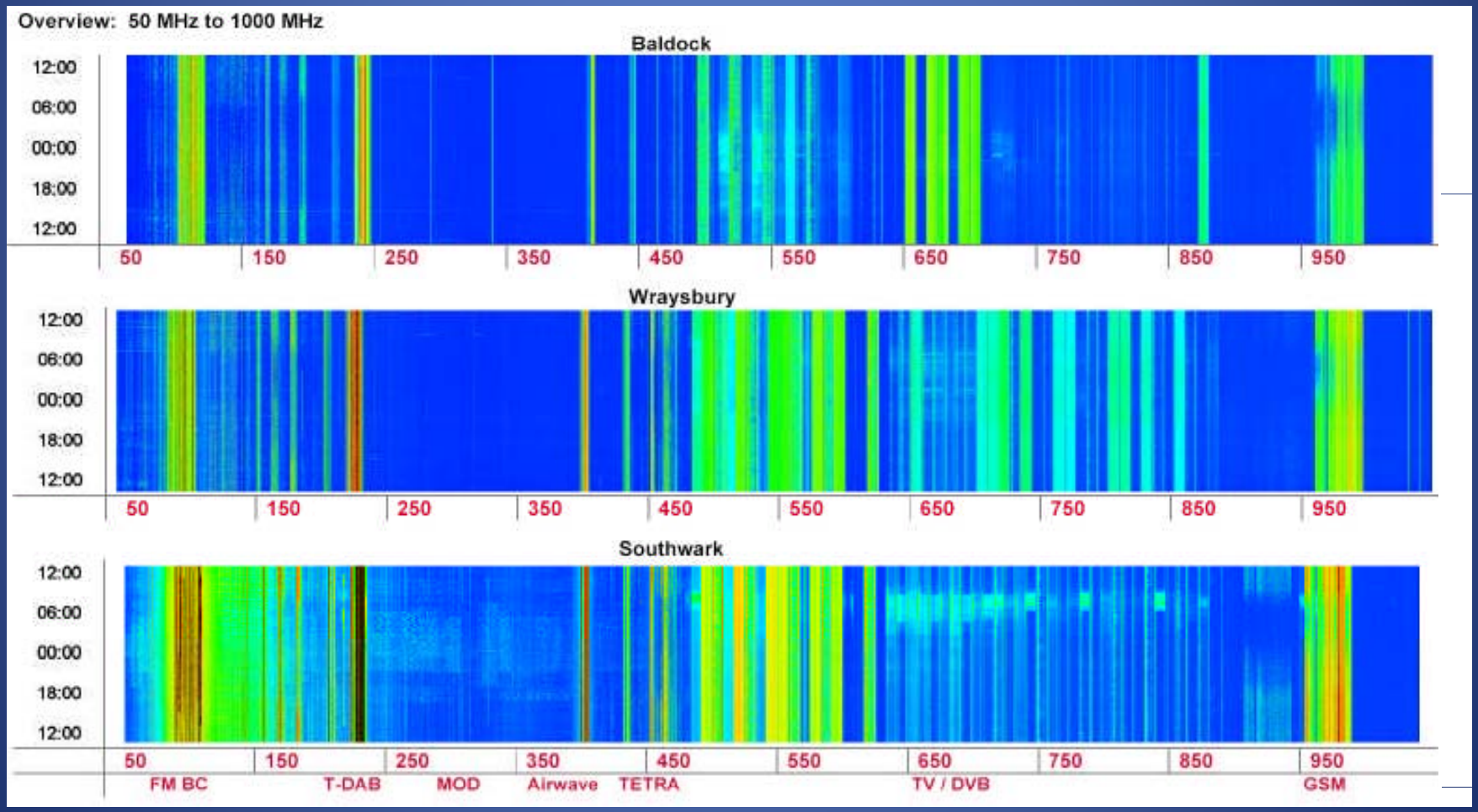
Cognitive Radio

- The need for better and more intensive use of the radio spectrum meant that SDR features could be exploited in cognitive radios
  - 'cognitive radio' implies that the radio senses its environment, being aware of other users and is location-aware
  - a full 'Mitola radio', which fully exploits space-time is for the future
  - cognitive radios currently use a limited set of features

How not to identify ‘free’ spectrum

aeronautical radionavigation
aeronautical mobile
radio astronomy

distress beacons
short-range devices
RFID tags



Is extra spectrum available?

- Spectrum refarming
  - an effective solution - flexible spectrum management
    - but long-term (several WRCs)
- Digital dividend
  - re-use analogue broadcast channels (in sweet-spot)
    - but mobile telephony could use much of this spectrum
- “White-spaces”
  - outside a broadcast transmitter’s coverage area or in the space between channels
  - exploits geographical spacing of transmitters which use the same frequency and ‘guard bands’
    - but interference with primary services must be avoided

Spectrum sharing

- ISM bands
  - static allocation
  - users compete equally for access
- White-spaces
  - dynamic allocation – priority for legacy users
  - white-space users compete equally for access
- Full sharing
  - dynamic allocation – fair access for users
  - arbitration rules when spectrum capacity reached

“White space” radio

- The FCC is well-advanced in developing a ‘white space’ radio allocation
  - learn from FCC’s experience – see FCC website
- In the UK, Ofcom have now largely followed the FCC model
  - this presentation follows the UK ‘white space’ model

TV bands are already assigned to broadcasters

- Ofcom: “We intend to proceed on the basis that WSDs are able to opportunistically access TV white spaces from 470MHz to 790MHz“
- white space use requires a radio to be location-aware or to be able to detect TV signals before transmitting

“White space” radio

- a client-hub architecture has been proposed
  - spectrum regulator manages an online database
    - server passes to a hub a list of frequencies which might be clear, based on its location and possibly, the type of cognitive device
  - private companies operate ‘hub’ databases
    - synchronising with regulator’s server (every two hours)
  - the hub manages local cognitive devices
- licence-exempt model
  - users will expect to use their devices anywhere

“White space” radio

- some of the ‘white space’ might be allocated to local TV in future
  - fewer channels available for ‘white space’ devices
- applications are mainly focused on broadband service delivery or an extended WiFi service
  - many customers are content with fixed service or their mobile broadband service (3G or 4G)
  - optical fibre services are being extended to rural areas
  - customer take-up is not guaranteed (cf. UWB projections and mesh radio trial)
- ‘white space’ radio may be short-term

More efficient spectrum sharing

A model developed in Europe

- E2R features a Cognitive Pilot Channel (CPC) which supports and facilitates end-to-end connectivity in a heterogeneous radio access environment with flexible and dynamic spectrum allocation

- E2R proposals for flexible spectrum management and CPC are part of an IEEE SCC41 P1900.4 standards proposal
- expected to be part of the ETSI standardization work on Reconfigurable Radio Systems (RRS)
- CPC was introduced during WRC07 as an agenda item to the WRC12, thus opening the way for global standardisation of E2R research

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E2R was followed by E3 (“Ecube”): a framing project for cognitive radio which:

- identified regulatory needs
- contributed to standardisation IEEE (P9100.4, P100.6) and ETSI RRS

Where next?

Acknowledgment: Ruprecht Niepold, European Commission

Regulators:

- select candidate bands and determine sharing model
- define usage conditions
- regulation of equipment (e.g. receiver characteristics)
- responsible for “predictable interference environment”
- monitor spectrum usage and maintain information
- define liabilities
- ensuring equitable access to spectrum

Equipment manufacturers:

- develop interference resistant receivers
- design cognitive radio equipment which meets regulatory conditions
- engage in standardisation effort
- agree equipment conformance

Conferences:

- IEEE DySPAN – dynamic spectrum access networks
- DySPAN 2012 from 3rd - 6th April 2012