

When and How to share the Frequency Spectrum - and when not

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Outline

- Why is there a Spectrum shortage (... or is there)?
- Dynamic Spectrum Access ("Cognitive Radio") to the rescue ?
- The (commercial) sweet spot of DSA
- Spectrum vs Infrastructure sharing
- Long-term spectrum policies for regulators (Africa)

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Why is there a Spectrum Shortage ... or is there ?





Traditional spectrum management: Fixed allocation (licensing)



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Low spectrum Occupancy =Available Spectrum ?



Source: L Khalid, A. Anpalagan. "Emerging cognitive radio technology: Principles, challenges and opportunities

Source: RWTH Aachen measurements





Reason for Low occupancy

- Spectrum allocation coupled to infrastructure investments and equipment – with long (economic) life times – not neccessary "bureaucracy"
- Lots of old equipment with poor spectrum efficiency still in use → lots of "white space" needed to protect old receivers

Low occupancy ≠ Availability

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- Many users require access not high utilization (Military, emergency etc)
- Receivers need to be protected not transmitters
- World wide harmonization in certain bands to bring down equipment cost → "crowding" in certain bands





Low spectrum Occupancy =Available Spectrum ?



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Flexible/Dynamic Spectrum Sharing to the rescue ?

Myth 1: Dynamic spectrum sharing is always best

Myth 2: Cognitive Radio is the solution

- Is there spectrum out there to be shared ?
- How should it be done (instead) ?
- Myth 3: Its only a matter of time until we see the commercial success of dynamic spectrum sharing
 - The commercial sweetspot of spectrum sharing
 - When should the spectrum be shared and when not ?

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Types of Spectrum sharing



Secondary Sharing

A *Primary User* already uses the spectrum and is unaware that new system want's to "borrow" some of the spectrum resources *Example: "TV-White Space"*

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Co-Primary sharing

Two or more new system share the spectrum aware of each other *Examples: WiFi, Licensed Shared Access*



Secondary Sharing (Cognitive Radio) - Finding the "Spectrum Holes" & Avoiding Interference



Challenges for secondary spectrum access:

How to find reuse opportunities and use them without exceeding tolerable limits

Co-channel interference

Adjacent channel interference Aggregate interference wireless@



Criteria for successful (secondary) sharing





Different usage patterns

 If primary and secondary systems compete for the same frequency in the same time & space, this will be a competition the secondary will loose.

(Detailed) Knowledge about the primary system behavior

- where are the primary transmitters, when and on which frequencies will they transmit..
- where are the primary receivers and what interference will they tolerate ?



- Inefficient spectrum utilization of the primary system spectrum
 - e.g. the efficiency of the primary system is limited by legacy technology

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Succesful sharing example: Microwave link – Indoor sharing scenario









Example: ATC radar spectrum shared indoor



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TV vs Cellular - not very successful



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Figure 4.25 Total available downlink WSD throughput capacity for mobile link using SE43 rules and with a separation distance of 100 m in Germany and Sweden.





Business aspects of Secondary Spectrum Sharing

Why is "Dynamic Spectrum" not taking off?





QUASAR Key question



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•Is there secondary spectrum out there that lends itself for commercial use ?

- Can it be detected efficiently ?
- Does it scale? Is there enough spectrum of "sufficient quality"?
- What are the applications that can benefit from secondary sharing ?

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Key technical findings



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- •Plenty of spectrum available but very scenario, time & location specific
- commercial success is where we can live with this
- $\bullet \mbox{Aggregate}$ interference critical for the scalability , i.e. For massive scale use of secondary spectrum
- Both co-channel & and adjacent channel interference has to be considered
- •Classical "Cognitive" sensing is not very effective in most of the scenarios geolocation based techniques are preferable
- Limited knowledge of victim receiver location
- Difficult to assess aggregate interference
- Sensing interesting to improve/calibrate database propagation models

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•Secondary user request "channel" at certain location – Data base grants access & maximum power level

- •"Instant licensing"
- Possibility to control aggregate interference



The Commercial Sweetspot of spectrum use





Short range/indoor high capacity systems

Success due to physics - not due to smart regulation or "cognitive" technology





Spectrum Sharing or Infrastructure Sharing ?





Old wireless paradigm:

- New service → New system → New radios
 → "New" spectrum
- Spectrum shared between multiple "one trick pony" systems

New wireless paradigm:

- New service \rightarrow Same system
 - \rightarrow Same radios/infrastructure \rightarrow "Same spectrum"
- Multipurpose, shared infrastructure
- Example: IP Networking Mobile Broadband (IP) Access

Internet radio vs traditional radio broadcasting







((†))



Infrastructure sharing

Multiple competing parallel infrastructures



Multimode shared infrastructure

- Explicit sharing
- Coopetition



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Where is Europe heading - spectrumwise?

Wide area access

Spectrum needed to lower infrastructure cost Block-licensed spectrum to match long-term RF-specific investment (<3 GHz) Repurposing of UHF from TV -> IP access

• Digital dividends 800, 700, 600 MHz etc Millimeter-waves to get exclusive spectrum?





Short range access

Plenty of potential spectrum <10 GHz Higher frequencies (>3 GHz) for high capacity (lower interference)

Local & temporal spectrum regimes (National Block-licensing inefficient)

Unlicensed, Secondary, LSA, "Instant licensing"





Spectrum strategies for Regulators

- Efficient long-term use of spectrum
- Which spectrum allocations are more "future proof" than others ?
- Which infrastructures allow for multiple services ?
- Example: TV Broadcasting vs IP access in homes

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Some concluding thoughts



- Spectrum allocation is tightly coupled to infrastructure investments – infrastructures with long life-time need long licensing periods
- Dynamic (Secondary) Spectrum is **not** the long term solution to spectrum shortage – there is a commercial sweet spot, but the main benifits are in **providing rapid access for new applications**
- Infrastructure sharing using multipurpose systems may be more efficient in the long run

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wireless.kth.se



johannesbergsummit.com

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