Secondary Spectrum Availability: Techno-economical Assessment

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20.06.2013

The 1000x Mobile Data Challenge

- Explosive data demands largely driven by video
  - Doubling each year [Cisco]
  - 1000x more mobile traffic by 2020 [Nokia Siemens Networks]
- Massive spectrum deficit
- Technical, political and regulatory breakthroughs will be needed to serve the huge data demands
Ongoing Trends

- Searching for more spectrum
  - Cognitive radio, dynamic spectrum access (TVWS)
  - 3.5 GHz
  - 60 GHz and above
- MIMO techniques
  - Scalability and implementation issues
- Smaller, denser, smarter cell networks

Spectrum Scarcity

- Several measurement campaigns have shown that numerous spectrum bands are vacant although licenses have been issued by the regulatory agencies.
- Spectrum access and not spectrum scarcity per se is a issue to address.
- More flexible spectrum allocation and management schemes can improve spectrum efficiency.
- Opportunistic spectrum access can be deployed if no harmful interference is caused to the license holder.
- Spectrum opportunities are location dependent.
- TV bands have a high potential to host the first secondary wireless networks.
Availability of TV White Spaces in Europe

- First detailed study of how much white space there would be in Europe, focusing on the 470 – 790 MHz UHF band.
  - The 800-892 MHz has been reserved for licensed mobile broadband services in Europe.
  - 40-8 MHz wide channels
- Covered 11 European countries, using TV station information obtained through regulators of the different countries
- In addition to white space availability analysis using “standard” ITU propagation model, several further analysis:
  - Influence of choice of propagation model: statistical v. terrain model
  - Study of differences between channels in terms of utility for secondary use
  - Estimates on capacities achievable with different network deployments


Availability of TV White Spaces in Europe

- Overall smaller number of available white space than in studies on US data sets
- On average 22.5 channels available per area, or 19.8 when weighted by population density
- Significant variability across countries (over 10 channels)
Low Spectrum Occupancy = Available Spectrum?

QUASAR Objectives
- Remove the “hype” from CRS and DSA discussion
- Justified and quantified spectrum opportunity models
- Enable real business and deployment decisions

QUASAR = QUantitative Assessment of SecondARy spectrum

QUASAR at a Glance

The Project
- FP7 STREP (Future Networks)
- 30 Month (Jan 2010 – June 2012)
- 5 M€uro / 3 M€uro
- KTH - Coordinator

The Output
- Tools & Methods
- Regulatory input (>10)
- Publications (>100)
- Workshops (3 + 1)
Key Question

- 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 business applications that can benefit from secondary sharing?

Objectives

- Develop methods and tools for quantitative assessment of the spectrum available for secondary use
  - Evaluate the “white spaces” from data-capacity point of view in TV and radar bands
  - To help in estimating the potential and the economical viability of “white space” networks based on case studies

- Build a framework for integration of assessment methods and tools such as spectrum sharing, interference models, protection rules, etc. to easily calculate spectrum availability and spectrum opportunity
Scenarios

Secondary sharing with legacy systems

1. Cellular use of white spaces
2. WiFi-like use of white spaces
3. Secondary wireless backhaul
4. Secondary spectrum commons in radar band
5. Indoor broadband in aeronautical spectrum
6. Cognitive machine-to-machine

Key Technical Issues Addressed

- Impact of legacy receiver performance and adjacent channel interference
- Assessment of aggregate interference for massive use of secondary spectrum
- Multiuser sharing of secondary resources
- Review of current models for sharing (e.g. FCC, SE 43)
- Evaluation of methods for sensing & database techniques
How Much Can a Wi-Fi-like Network Deliver in TVWS?

Rate vs. range performance for a network of Wi-Fi-like APs (each transmitting at power of 20 dBm) operating in different frequency bands, for the (a) outdoor urban and (b) indoor urban deployment scenario.

Key Findings (1/2)

- Plenty of spectrum available – but very scenario, time & location specific - commercial success is where we can live with this

- 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
Key Findings (2/2)

- **TV bands**
  - "Wi-Fi like deployments in outdoor" in densely populated urban areas the interference rapidly limits the capacity
  - "Wi-Fi like short range/indoor high capacity which will benefit the better propagation characteristics of the lower frequency bands"
  - **Macro cellular deployments**: contiguous coverage is difficult to achieve in urban area. Thus, TVWS can be better utilized as a capacity booster in selected areas

- **Radar bands**: Still underexplored! Co-channel usage challenging due to strict protection rules but a substantial opportunity is expected for the secondary access to adjacent channels in urban areas even with conservative parameters

The "Commercial Sweetspot":
**Short range/indoor high capacity systems** where large demand and technical availability of spectrum meet

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