Use of TV white space for mobile broadband access - Analysis of business opportunities of secondary use of spectrum

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Business opportunity

● Business opportunity depends on the specific scenario / use case
  ● The type of service
  ● The user density, demand and willingness to pay
  ● The type of radio network deployment
  ● If the spectrum is used as the “only” resource or as a complement
  ● The business cases of competing solutions
A Multitude of Multitudes - QUASAR Service Scenarios

- Cellular Use of White Spaces
- WiFi-like Use of White Spaces
- Secondary Wireless Backhaul
- Secondary Spectrum Commons in Radar Band
- Indoor Broadband in Aeronautical Spectrum
- Cognitive Machine-to-Machine (Infrastructured)
- Cognitive Machine-to-Machine (Ad hoc)

Scope and motivation

- Research question:
  How to evaluate the business opportunities of technical solutions and mechanisms that support the secondary use of spectrum allocated to a primary user?

- Project challenge:
  To connect the technical and business analysis
**Agenda items**

- Note on Methodology for cost & capacity analysis
- What can we observe if we look into wide area MBB access for capacity enhancement in urban areas
- What can we observe if we look into indoor MBB access services in offices and hot spot areas
- Summary

**General about the methodology**

- The analysis is done for specific sub scenarios
- Links are established between the technical performance and the business case
- Key characteristics of the cost structure are identified and included in the analysis
- We can do the analysis without knowledge about the exact availability of spectrum, bandwidth, distribution in time and space
  - We start to do a "what IF" analysis (sensitivity analysis)
  - When detailed technical data (spectrum availability and performance) are available we can include this
Bandwidth and spectral efficiency

The available frequency "channel" has a bandwidth
In the general case some average width and some variation in time and space

The frequency "channel" has a spectral efficiency (SE)
In the general case some average SE and some variation in time and space

Spectral efficiency

- We will assume an equivalent "usable" bandwidth and an "average" spectral efficiency
- This will be used as the "resource" used for dimensioning of the wireless capacity
The spectral efficiency depends on:

- The type of system used for secondary usage
- The deployment and location of primary and secondary system

Peak data rate ~10 - 20 bps per Hz
Cell border rate < 0.10 bps per Hz
Average data rate ~1 - 2 bps per Hz

As a first step approximation this average value representative for the whole usage area is used. Sensitivity analysis can be made with higher/lower values of spectral efficiency.
First approximation model

- With this description we can model
  - Sharing of bands between multiple actors
  - Variations in availability, interference levels or signal quality

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Network capacity, amount of spectrum and site density

- High bandwidth means high capacity per site, i.e. fewer sites and the other way around.

Licensed

White space

Licensed
Impact of amount of spectrum
Case: New urban office area with many users

![Graph showing number of base station sites vs. used spectrum (MHz) for different spectral efficiencies and Swedish operators using 2.6 GHz band.]

Cases for different Swedish operators using 2.6 GHz band:
- Spectral eff = 1.70 (LTE type)
- Spectral eff = 0.70 (HSPA type)

Number of sites

0 10 20 30 40 50

0 10 20 30 40 50 60 70 80 90 100

Used spectrum (MHz)

0 10 20 30 40 50

June 21, 2011
Markendahl, Mäkitalo Mölleryd COST-TERRA meeting, Brussels

Peak data rate is very important

- Marketing by Swedish mobile operators

"The fastest Mobile broadband in Sweden - according to information retrieved from Bredbandskollen.se, November 25, 2010" (Telenor)\(^5\)

"Today the best Mobile broadband in Sweden was nominated and the winner is Tele2. This means that you can do web surfing at higher speeds with Tele2 compared to any other operator. " (Tele2)\(^5\)

"For the fourth year in a row the magazine 'Mobil' did nominate our mobile broad band to be the best in Sweden (HI3G)"

"4G. The fastest mobile broadband in the world for just 15€ per month until the Easter holiday, ordinary price 60€ per month." (Telia)\(^5\)
Telenors löften helt orealistiska

KTH-professor dömer ut kampanj om nya mobilnetet
Av: Helen Ahlbom
Publicerad 20 maj 2009 00:00

Telenor lovar hastigheter på 150 megabit/s till nästan hela svenska folket i sin senaste reklamkampanj. Det är fullständigt orealistiskt om man inte bygger 100 000-tals nya basstationer, anser Jens Zander, professor i radioteknik på KTH.


"Offered" bit rate vs coverage & load

"promised" data rate at "low" level

"promised" data rate at "higher" level
Data rate, bandwidth and aggregation of carriers or bands

- The higher bandwidth the higher the data rate

Higher bandwidth by use of aggregation

TV WS combined with 800MHz

1800 MHz  2100 MHz  2600 MHz
### Base station site locations in urban areas

From PTS “Transmitter map” web page.

#### Downtown Stockholm

#### Kista Industry Area

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### Capacity, cost and cost structure of operator business cases

Assuming 3 sector site

- 20 MHz of bandwidth
- And cell average
- Spectral efficiency
  - 0.7 bps per Hz (HSPA)
  - 1.7 bps per Hz (LTE)

#### Table

<table>
<thead>
<tr>
<th>Site and Trans</th>
<th>Radio Site</th>
<th>Total cost for new site</th>
<th>Capacity of radio base station site</th>
<th>Capacity of radio base station site</th>
<th>Cost for upgrading an existing site</th>
</tr>
</thead>
<tbody>
<tr>
<td>X €</td>
<td>~ 200k€</td>
<td>~ 200k€</td>
<td>~ 40 Mbps</td>
<td>~ 100 Mbps</td>
<td>~ 30k€</td>
</tr>
<tr>
<td>~ 30k€</td>
<td>~ 110k€</td>
<td>~ 200k€</td>
<td>~ 100 Mbps</td>
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</tr>
</tbody>
</table>

**New TV WS operator**  
**Greenfield MNO**  
**Existing MNO**
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Femtocells
Different solutions for indoor coverage

- DAS: Distributed Antenna System
- Indoor base stations
- Repeater

Wireless indoor solutions

- Indoor solutions are not only used in order to compensate for wall penetration losses
- Other reasons may be:
  - Companies want ensured and dedicated capacity
  - Companies use mobile phones as office phone
  - Mobile operators want to increase customer loyalty
  - Mobile operators want to offload data traffic from outdoor (more expensive?) macro networks
Indoor wireless solutions are used in two different business settings

1. To ensure public access in shopping malls, subways, sport arenas
   - The users are subscribers of the operators that visit the shopping mall, etc
   - The operators have agreements with the owners of the mall, the arena, etc
   - The service IS the ensured indoor coverage

2. To provide indoor “private” access at company offices etc as part of a complete offer
   - The users are the employees of the “company”, etc
   - The indoor coverage is just one part of the offer
   - Other components can be outdoor coverage, handsets, IT support and services, call centers

Options for femtocell deployment

- **Parallel single-operator networks**
  - Less feasible due to cost and operation

- **Multi-operator access points**
  - Cheap? not on 3GPP agenda

- **Single operator femtocell network**

- **One multi-operator network**
  - Based on national indoor roaming
Shared indoor infrastructure

- Red Operator
  - Payments and billing
  - Customer rel mgmt

- Blue Operator
  - Payments and billing
  - Customer rel mgmt

- Facility owner

Business feasibility of femtocells

- Femtocells are feasible for deployment at offices
  - Scalable solution, access for a specific user group

- Open issues for femtocells deployed for public access
  - Difficult with multiple femtocell networks
  - Cost benefits compared to macro networks is unclear
  - Interference problems and spectrum allocation issues
Example of deployment costs for indoor demand

Deployment costs

Network CAPEX (M€)

Capacity (Gbps)

- Macronew sites
- Femto - 4 users
- Macreused denser_5_times
- DAS
- Macro-reused
- Femto-32 users

The dead zone problem

- Femtocell base station cause interference in the downlink for UEs connected to macro base stations, i.e. for closed access

- Areas without any coverage (dead zones, coverage holes) appear in the vicinity of the femto base stations
The dead zone problem

- Occurs for closed access femtocells
- Dead zones are largest at cell borders
- ~20 m for co-channel operation (WCDMA)
- 1-2 m for adjacent channels (WCDMA)

Macrocell-femtocell interference

- Co-channel operation
- Adjacent channel with guard band
- "Small" separation
- "Large" separation
Deployment of Upgrading of Deployment of
new macro sites existing macro sites Femtocells

Site capacity ~100 Mbps

Radio

And

Trans

Site And

Trans

Site capacity
~100 Mbps

Cost for upgrading existing site ~ 20k€

Radio

Trans

Capacity per
access point
10 – 40 Mbps

Cost per
access point ~ 1 k€

Total cost ~ 110k€

Radio

And

Trans

Deployment of new macro sites

Upgrading of existing macro sites

Deployment of Femtocells

Cost and capacity for macrocellular and femtocell deployment

Local operator using TV WS to offer “indoor capacity”

- A local operator can deploy a femtocell network where only a fraction of the femtocell capacity is used
  - A “few” available MHz can satisfy even very high demand levels
    - Example 1:
      One 5 MHz femtocell with Spectral eff = 8 bps/Hz can “capacity wise” serve 400 “10 GB per month users”
    - Example 2:
      1 MHz is enough to serve 40 users (with spectral efficiency =4 bps/Hz)
      => One 8 MHz channel can be used for several 1 MHz femtocells
  - This makes all bands and also “a few MHz” of white space interesting
Conclusions

- You need to compare solutions using TV WS with existing solutions and business cases; i.e. the offers and cost structure of competitors

- Example mobile using TV WS for Mobile broadband
  
  BUT! Also consider other solutions
  - WLAN
  - Licensed > 3 GHz
  
  - New actors with "TV WS spectrum only" offering wide area mobile broad band access services will have problems
  - Local operators can use TV (or radar) WS to offer indoor access

- Exploit benefits of TV WS for existing solutions and actors
  
  Capacity => delay or reduce need for deployment of new sites
  Data rate => with aggregation higher data rates can be offered


Capacity, cost and cost structure of operator business cases

Assuming 3 sector site
20 MHz of bandwidth and cell average spectral efficiency
0.7 bps per Hz (HSPA)
1.7 bps per Hz (LTE)
Thanks for your attention

- My e-mail: janmar@kth.se

  Mobile Network operators and cooperation
  - A tele-economic study of infrastructure sharing and mobile payment services
  http://www.impgroup.org/dissertations.php