Business Panel:
(Academic) Economist Perspective on Spectrum Sharing

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11th Annual International Symposium on Advanced Radio Technologies
ISART – Spectrum Sharing Technologies
July 27-30, 2010
Boulder, CO
Need to focus on demand for shared spectrum

- Spectrum reform: from C&C → Markets
  - Allocation determined Top down v. Bottom up
  - Market sharing….many (potential) models
  - (C&C: mobile operators wrt their licensed spectrum → consumers)

- Markets have 2-sides
  - Supply: additional spectrum for new allocations?
    - Spectrum hoarding (future needs)
    - Market power (foreclosure of new technologies)
  - Demand: what business wants to use shared spectrum??
    - (Any business if quality-price trade-off is appropriate…)
    - BUT, more help so policymakers can see the beef would be nice…

- What is the “good” being traded? Property rights..
  - Right to access (obligation to share)
  - Right to interference protection (obligation to tolerate)
### Willingness/ability to pay for interference protection?

#### User/Use …

<table>
<thead>
<tr>
<th>Transaction Costs for acquiring (relative to value)</th>
<th>Interference Protection Rights Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weak</td>
<td>Strong</td>
</tr>
<tr>
<td>High</td>
<td>Unlicensed</td>
</tr>
<tr>
<td>Low</td>
<td>Licensed/Unlicensed ??</td>
</tr>
<tr>
<td></td>
<td>Licensed</td>
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</tbody>
</table>

**Smart radio systems:**
- Greater interference robustness
- More sharing options

**Market success:**
- More congestion
- Fast innovation

Off-diagonal cases more common? Weak/low or Strong/high
- Dynamic shared spectrum options
- Multiple, complementary regulatory options

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## Business models for spectrum sharing

### Spectrum access regime $\leftrightarrow$ Technical Design & Use
* Quality: predictability availability, interference protection
* CAPEX & OPEX (includes cost of acquiring spectrum)

<table>
<thead>
<tr>
<th></th>
<th>Non-Cooperative</th>
<th>Cooperative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Sharing</strong></td>
<td>Permission of primary user not needed. No explicit coordination. Other signals look like noise.</td>
<td>Permission of primary user needed. Explicit coordination. Other signals recognizable.</td>
</tr>
<tr>
<td></td>
<td>Unlicensed, e.g., WiFi, Bluetooth</td>
<td>Secondary markets, e.g., leasing</td>
</tr>
<tr>
<td></td>
<td>Secondary markets (trading licenses)</td>
<td>Bandwidth Manager (real-time) Closed commons</td>
</tr>
<tr>
<td><strong>Secondary Sharing</strong></td>
<td>Easements: -- underlay, e.g. UWB -- overlay, e.g., TV White space (LBT)</td>
<td>Cooperative Mesh</td>
</tr>
</tbody>
</table>

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DSA: more flexible sharing models for future

Spectrum Markets

<table>
<thead>
<tr>
<th>Time scale</th>
<th>Real-time ↔ Special events/emergency ↔ Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>What traded</td>
<td>Primary or secondary rights</td>
</tr>
<tr>
<td>Administered</td>
<td>Private (NYSE) or Public (T-bill auctions)</td>
</tr>
</tbody>
</table>

Cooperative (contracts) and non-cooperative (easements) sharing between primary and secondary users

What spectrum?
- White space access to broadcast spectrum (location/time)
- Low-power underlays (UWB)
- Preemptible spectrum (govt./public safety sharing)
- etc.

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Need multiplicity of regulatory frameworks

- Need innovation, but reform happens only slowly. Partially for good reasons (protection of legacy systems, regulatory commitment); and partially for bad reasons (inability to overcome logjams, regulatory inertia)

- Different models, different economics
  - Strong/weak interference protection
  - Cooperative/non-cooperative sharing models
  - Open v. partially open v. closed access models
  - Predictable v. unpredictable spectrum access needs (burstiness)

- Examples
  - Opportunistic mobile broadband (upload pictures, download media)
  - Better-than-contracted video
  - Maybe-never access, but when I need it…
  - ????
Thanks

Questions/comments?

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