Part I

Current approach

Policy issues

- **Overarching goals**
  - Avoid interference (or reduce it to an acceptable level)
  - Maximize the value of spectrum to society

- **Spectrum management**
  - **Allocation**, the dedication of frequencies (or bands) for specific services or uses
  - **Allotment** of spectrum to locations
  - **Assignment** to specific users or classes of users

- **Satellite orbit management**
Principal policy options

- **Traditional approach**
  - Spectrum is scarce
  - Interference is a transmission phenomenon
  - Requires exclusive assignment of channels

- **A radically different view**
  - Spectrum is abundant
  - Transmission is a receiver phenomenon
  - Sophisticated equipment (ultra-wideband, spread spectrum) allows open access

Legal foundations

- **Spectrum considered public resource**
- **Public interest mandate of FCC in spectrum management**
- **Joint federal-state jurisdiction**
- **Constitutional framework:**
  - Electronic speech principally protected by First Amendment
  - FCC power to license upheld with scarcity rationale. When will it be challenged?

Jurisdiction

<table>
<thead>
<tr>
<th>Level</th>
<th>Agency</th>
<th>Powers</th>
</tr>
</thead>
<tbody>
<tr>
<td>International</td>
<td>International Telecommunication Union (ITU)</td>
<td>International frequency allocation, satellite orbit allocation, standard-setting, emergency communications</td>
</tr>
<tr>
<td>Federal</td>
<td>FCC (WTB): private use</td>
<td>Frequency allocation and assignment (definition of services and geographic markets, limited conduct regulation)</td>
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<td></td>
<td>NTIA: government use</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td>State PUCs</td>
<td>1993 legislation shifted power to FCC. States can petition to regulate (14 states do not regulate wireless, rest certain aspects)</td>
</tr>
<tr>
<td>Local</td>
<td>Cities, municipalities</td>
<td>Siting of wireless towers and antennas, Limited by Telecom Act 1996</td>
</tr>
</tbody>
</table>
Frequency allocation

- **Block allocation** assigns certain blocks of services
- **Flexible allocation** allows the licensee to use for an application (voice, data, etc)
- **Open allocations** do not predetermine use
- **Refarming** is the reallocation of spectrum

### Selected band allocations

- **IVDS**: 1 MHz in 218-219 MHz band.
- **SMR**: Total of 19 MHz in 800+900 MHz bands.
- **Broadband PCS**: 140 MHz in 1850-1990 MHz band.
- **Narrowband PCS**: 3 MHz in 901-902, 930-931, and 940-941 MHz bands.
- **WCS**: 15 MHz in 2205-2220 and 2345-2360 MHz bands.
- **GWCS**: 25 MHz in 4660-4685 MHz band.
- **DBS**: Several bands, uplinks 5.925-30 GHz, downlinks 3.7-20.2 GHz.
- **LMDS**: 28 GHz band.
- **Advanced fixed wireless**: 38 GHz band.

Dynamic spectrum management

- **Need to adjust spectrum use to economic and technical development**
  - Incumbent users have limited incentive to release spectrum, except when compensated
  - Spectrum markets would likely facilitate adjustment
- **Limited flexibility**: In certain bands (e.g., PCS), licensees can aggregate and dis-aggregate spectrum
- **Private spectrum managers**

Geographic licensing schemes

- **Geographic market definition**:
  - Nationwide and regional licenses
  - 493 Basic Trading Areas (BTAs), make up ...
  - 51 Major Trading Areas (MTAs)
  - 734 Cellular Market Areas (CMAs) aka Metropolitan Statistical Areas (MSAs) or Rural Service Areas (RSAs)
  - 175 Economic Areas (EAs)
- **Use varies by service**
Universal Licensing System

- **Adopted in R&O in November 1998** (WT Docket Nos. 98-20, 96-188)
- **Dynamic, browser-based system to manage license applications and modifications**
  - Reduced number of application forms from >40 to 4
  - Consolidates service-specific rules into one set of rules
  - Mandatory for auctioned services

Licensing methods

- **Administration**
  - License awarded to proposal that serves the public interest best
  - Time-consuming and often contested
- **Random assignment (e.g., lotteries)**
  - License awarded in equal chance drawing among applicants with minimum qualifications
- **Auctions**
  - Award license to highest bidder

Unlicensed spectrum

- **400 MHz of spectrum are unlicensed**
  - Industrial, Scientific and Medical Band (ISM) in 2.4 GHz
  - Unlicensed National Information Infrastructure (U-NII) in 5 GHz band
- **Etiquette rules** (Part 15 CFR)
  - Maximum power levels
  - "Listen first" principle
- **Very innovative segment** (e.g., WLANs)
Part II

Alternative approaches to spectrum management

Elementary features

<table>
<thead>
<tr>
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<th>Exclusive rights</th>
<th>Quasi-exclusive</th>
<th>Non-exclusive</th>
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<tbody>
<tr>
<td>Licensing</td>
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<tr>
<td>Licensing+</td>
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<td>Ownership</td>
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<td>Commons</td>
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<td>Open access</td>
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<tr>
<td>Allocation</td>
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</table>

Property rights

- Spectrum regimes define sets of legal rights

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<thead>
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<th>Commons</th>
<th>Open access</th>
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</table>

- Legal rights entail different economic property rights and thus incentives
Rights specification

- Influences efficiency of spectrum use
  - Given the state of technology, utilization of spectrum for most valuable use (static)
  - Incentives to improve technology
- Affects level of transaction costs
- Has consequences for non-market goals
- Effects the overall evolution of the wireless industries

Licensing+

- Market based assignment and flexibility
- Spectrum auctions
  - Shorten licensing process (US: 48→4 months)
  - Assign market value to spectrum
  - Depend critically on spectrum allocation
  - Have hitherto ignored costs (may increase concentration, costs affect market evolution)
- Secondary markets and spectrum trading
  - Flexibilization can solve some but not all problems of current licensing approach

Spectrum ownership

- Proposed solution
  - Creation of full ownership rights in spectrum
  - Minimal restrictions on spectrum use
  - Initial assignment by auction
  - Subsequent adjustments via market transactions of spectrum
- Different options to specify rights
Ownership pros and cons

- **Attractive features of spectrum ownership**
  - Creates decentralized control structure
  - Adjustment of spectrum use based on market valuation and costs to change existing uses
  - Forces policy-makers to recognize costs of non-market policy goals

- **Potential problems of ownership**
  - Imperfections and flaws of spectrum markets
  - Owners may withhold unused spectrum
  - Specification of property rights (interference)

Spectrum commons

- **Notion of a “commons”**
  - Commons ≠ free open access
  - Tragedy of unmanaged commons
  - Commons are jointly used resources
  - No exclusive individual ownership

- **Principles for an alternative framework**
  - Establishment of governance structure
  - Rules for access, use, management etc.
  - Promulgation of standards and coordination

Open access

- **Promoted by many engineers** (e.g., D. Reed, MIT) and lawyers (e.g., Y. Benkler, Yale)
  - Assumption that technology will facilitate coordination of spectrum uses
  - Agile radio, smart antennas, spread-spectrum, ultra-wideband, mesh and ad hoc networks

- **Innovation activity shifted from network to equipment manufacturer**
Comparative analysis

<table>
<thead>
<tr>
<th>Entry costs</th>
<th>Licensing*</th>
<th>Ownership</th>
<th>Commons</th>
<th>UI Open access</th>
<th>Real time lease</th>
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Comparative analysis ...

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Pending initiatives

- Spectrum Management Task Force established Fall 2001
- Reviewed alternative approaches to spectrum management
  - Full privatization of spectrum, for example in “Big Bang” auction of all available spectrum
  - Use of private sector spectrum managers, who would lease spectrum to third parties
  - Creation of spectrum “commons” (e.g., wireless grids, meshed networks)