Advanced Wireless Technologies and Spectrum Management

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Radio-spectrum Management
for a Converging World

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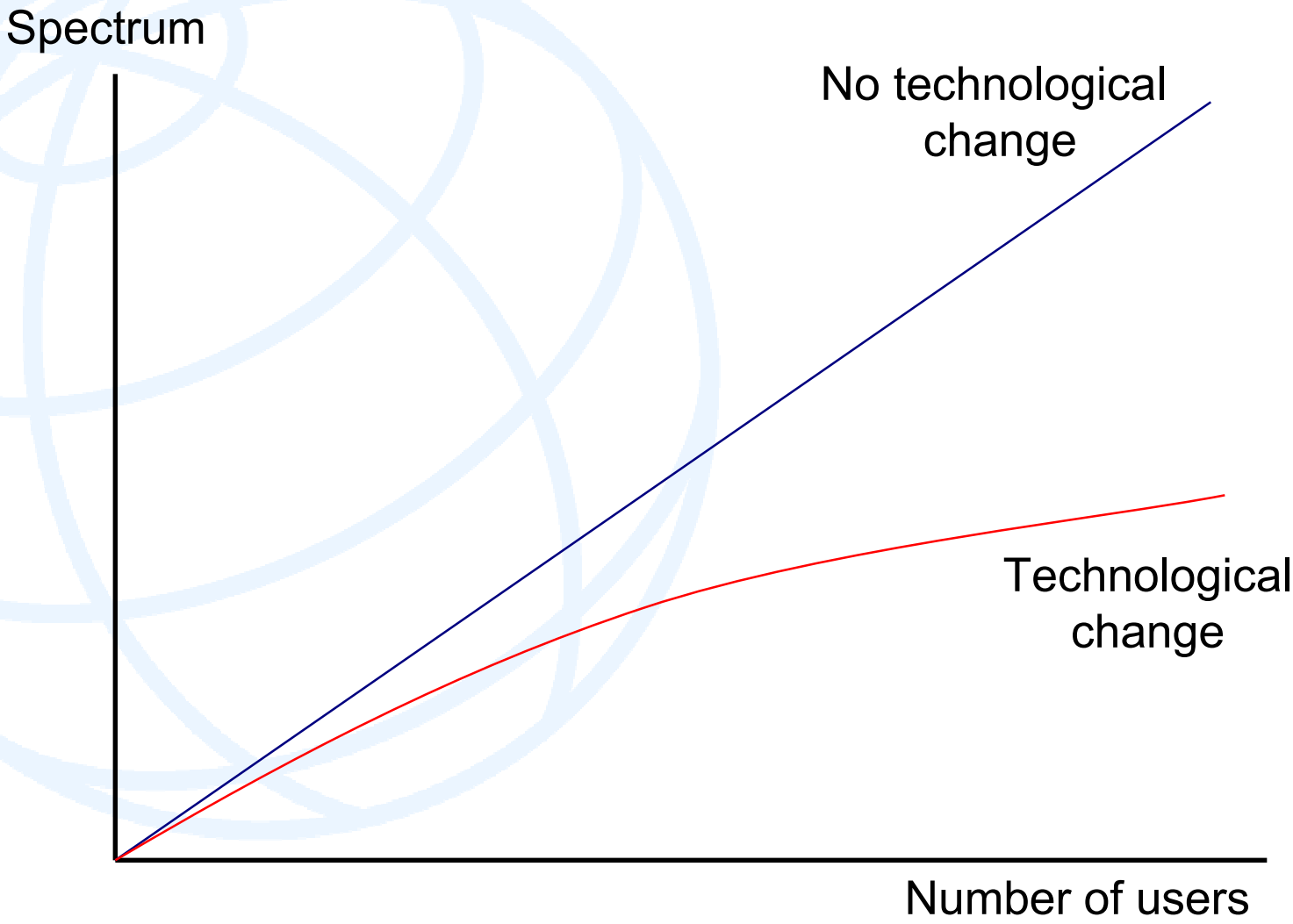
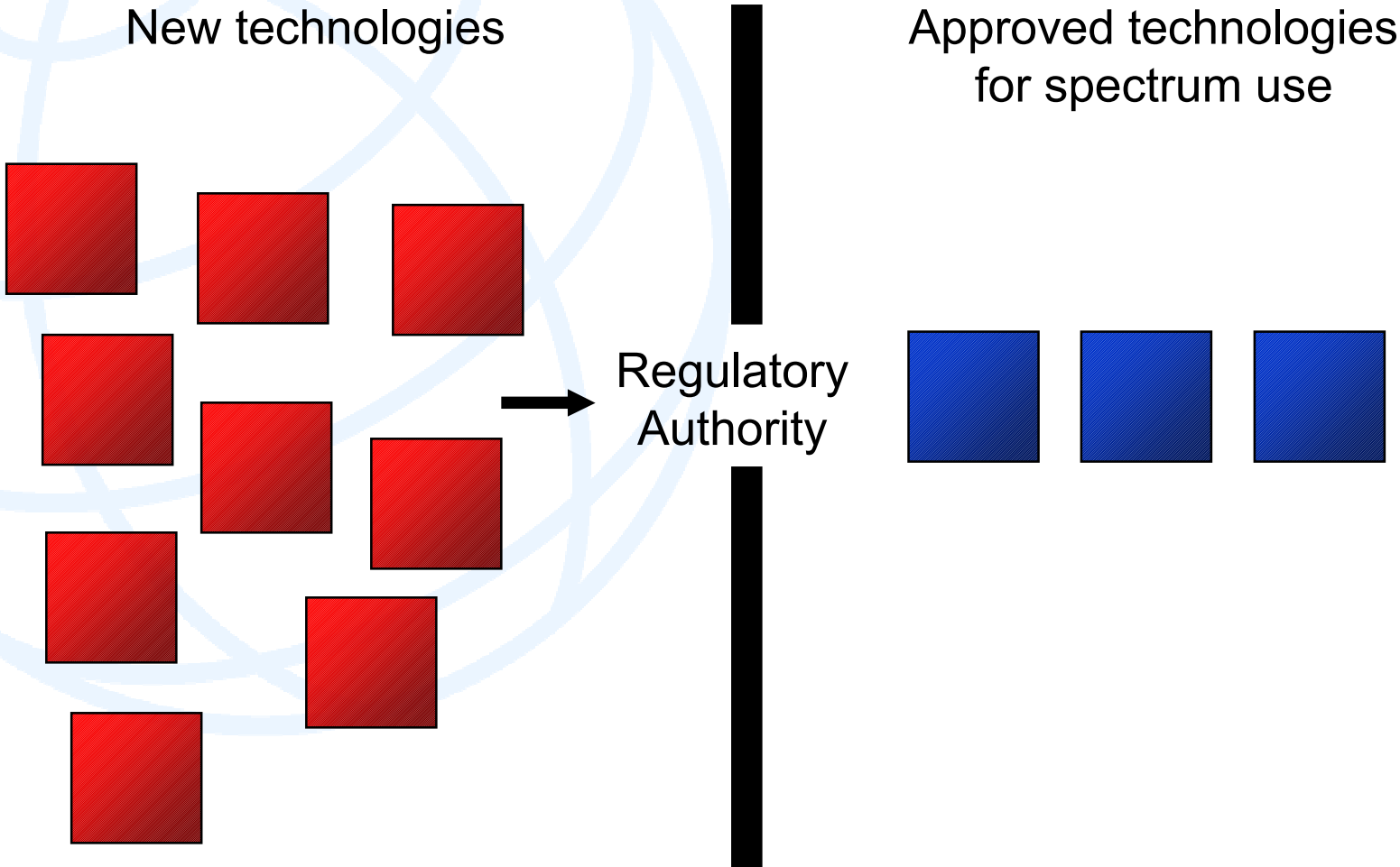
Spectrum scarcity



Role of technology & policy



Policy has been lagging

- **Regulation (1930)**
  - **Built on the assumption of "dumb" radios**
  - **Tightly regulated use for licensees**
  - **Very limited provisions for reclaiming inefficiently used spectrum**
- **Technology (2004)**
  - **Fast processing power and intelligent radios**
  - **Highly controlled transmission power**
  - **New technologies**
    - Spread spectrum
    - Smart antenna
    - Mesh networks
    - Software defined radios

Spectrum management is changing

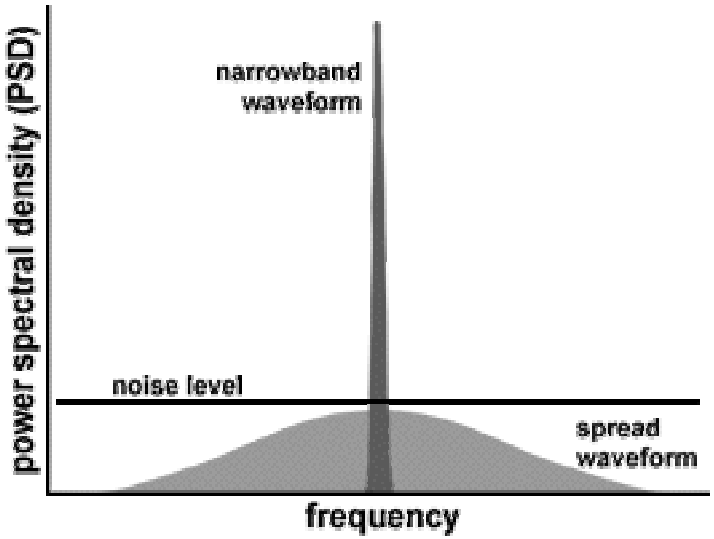
- Policy makers realize the traditional system is inefficient.
- Non-traditional spectrum allocations
  - Unlicensed spectrum: very successful
  - Auctions: mixed results
- Policy makers facing difficult decisions
  - Integrate new technologies under the traditional scheme
  - Revamp the entire system.

What regulators are facing

- The task of overhauling the spectrum allocation system
- The need to understand advances in wireless technologies.

Spread Spectrum

Spread spectrum technologies send information over a much wider band than the actual bandwidth of the information by using a code to either modify the carrier wave or to define a hopping pattern for frequencies.



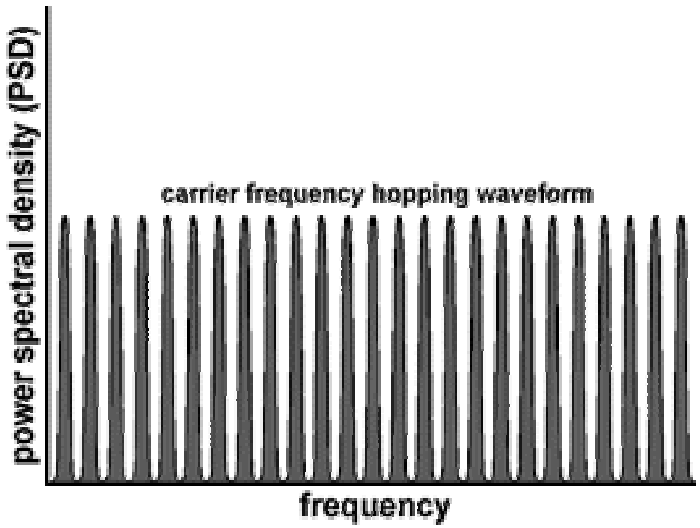


Image source: http://www.futaba.com/IRC/ircteclib.htm

Ultra-wide band (UWB)

- **Ultra-wide band is a spread spectrum technology that transmits data at very high speeds by sending the transmission over a wide range of frequencies but at very low power levels.**

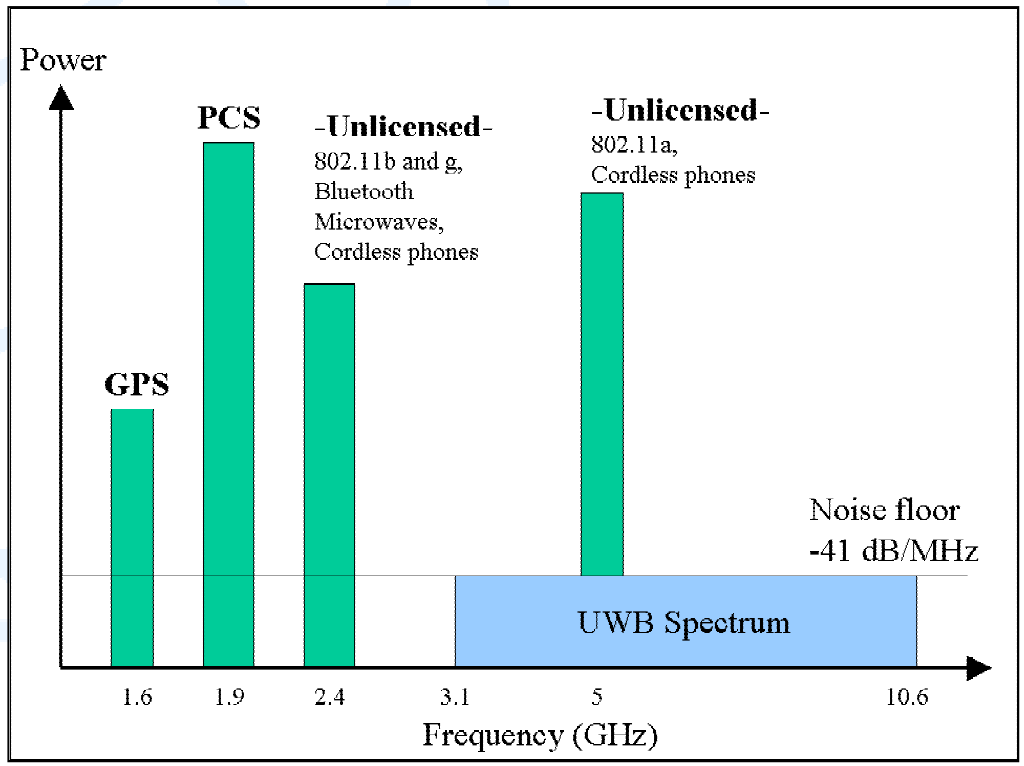
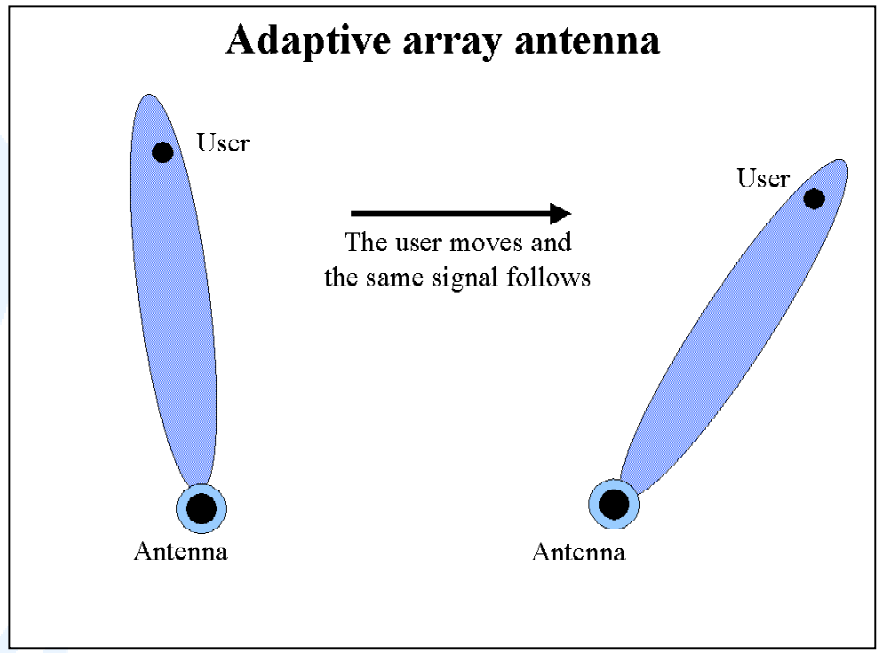


Image source: ITU adapted fromIntel

Smart antennas

Smart antennas use digital signal processing to pinpoint the location of users. This allows them to send and receive targeted transmissions and reduce interference.



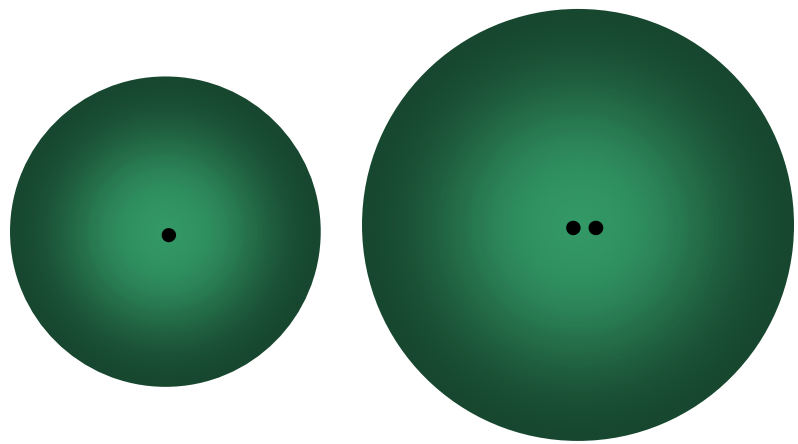
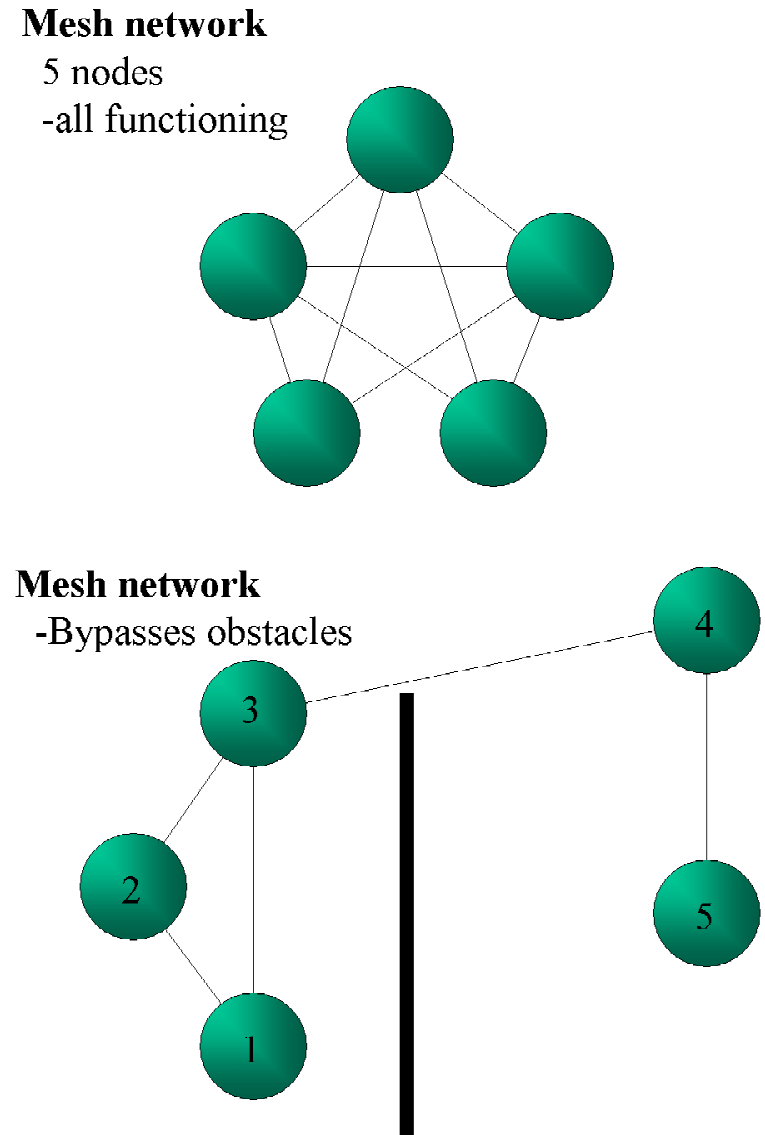


Image source: ITU adapted from IEC

Mesh networks

- A local area network (or LAN) where each device on the network simultaneously connects to and communicates with all devices in range. Devices communicate with each over by passing transmissions using other devices as intermediaries.



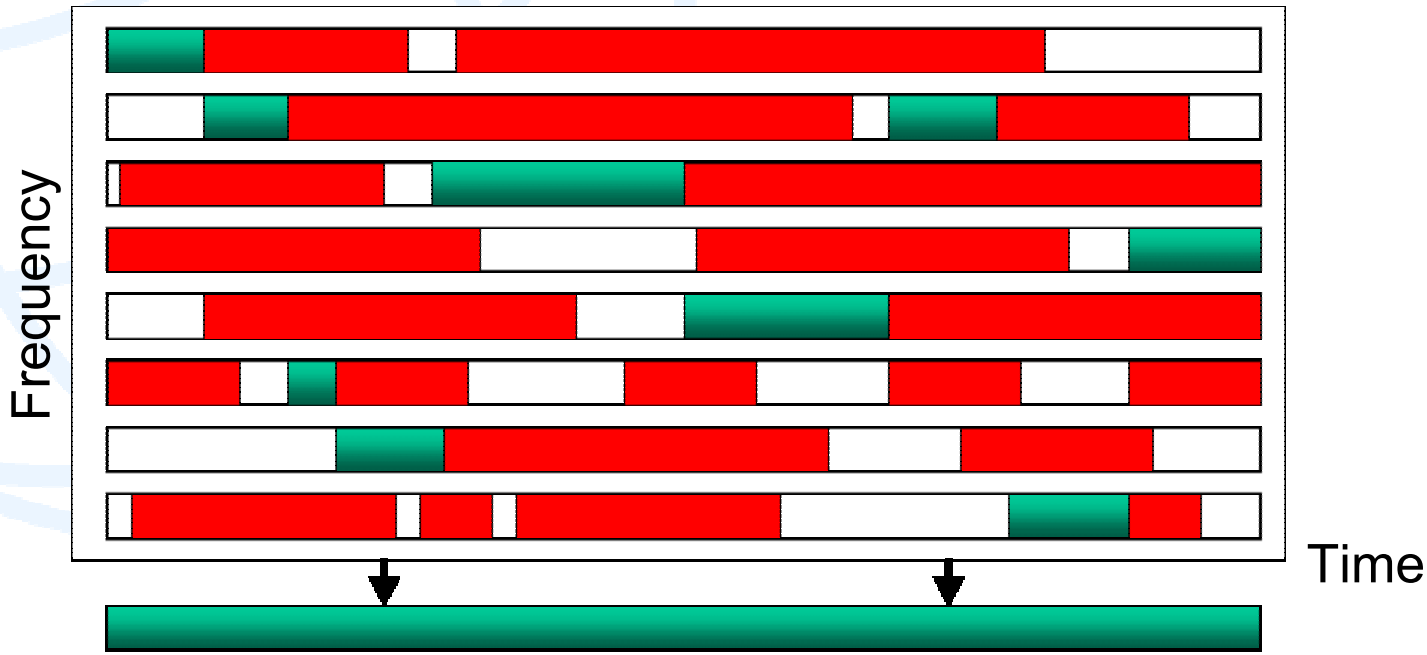
Software-defined radio

- **A wireless communication device where a computer controls the transmitter modulation. They can be re-programmed on the fly**

- **Promising applications:**
  - **Multiple uses from generic radio terminal**
    - Mobile phone
    - Cordless phone
    - Pager
    - WLAN
  - **Quick software upgrades to adapt to regulatory changes**
  - **Agile radios**

Agile radios

Agile radios act as frequency scavengers. They can broadcast on an unused frequency until the agile radio "senses" another radio trying to use the same frequency. At that moment, the radio "hops" frequency to another temporarily unused portion of the radio spectrum.



Key policy decisions

- Allowing underlays
- Developing interference temperature measures
- Allowing coexistence models
- Creating more unlicensed spectrum
- Cleaning up unused spectrum
- Developing a regulatory model for mesh networks

Allowing underlays

- **Benefits**
  - UWB allows highly efficient use of the noise floor, without affecting licensed uses
  - The wider the usable band, the lower the power needed to transmit
  - Could form the foundation of future mesh networks
- **Drawbacks**
  - Strong resistance from current licensees
  - Adding more UWB devices raises overall noise

Interference temperature

- **Benefits**
  - Allows for a dynamic use of spectrum in a given location, based on the current use
  - Radios could use higher power in “quiet areas” and reduce power or switch frequencies in “noisy environments”
- **Drawbacks**
  - Difficult to initially coordinate a system that all devices would follow

Coexistence models

- **Benefits**
  - **Can greatly increase the use of fallow spectrum**
    - Studies have found only 19-40% usage throughout the day on even the most populated frequencies.
  - **Unlicensed devices could scavenge for frequencies, subject to equipment and regulatory controls**
- **Drawbacks**
  - **Strong opposition from current licensees**
  - **May require upgrades of equipment for licensees.**

Unlicensed spectrum

- **Benefits**
  - Creates a fertile test bed for new wireless technologies.
  - Decreases the costs to technology developers
  - Provides incentives to create devices with high tolerance to interference (e.g. spread spectrum)
- **Drawbacks**
  - Spectrum bands can become congested
  - Difficulty clearing new bands
  - Loss of direct revenues to governments if spectrum is not auctioned

Multi-use, software defined radios

- **Benefits**
  - Software-defined radios can reduce the number of wireless technologies people need to carry.
  - Radios could be updated on-the-fly to conform to new regulations
- **Drawbacks**
  - Regulation will need to start moving away from hardware to software.
  - Software can be hacked out of compliance

Mesh networks

- **Benefits**
  - Reduce distance each radio needs to broadcast
  - Bandwidth increases with the number of users on the network
  - Excellent network for using UWB and smart antennas
- **Drawbacks**
  - Battery life
  - Security concerns
  - Regulatory implications

Key recommendations

- Regulatory authorities should strongly consider allowing UWB, at least at low power levels.
- Spectrum authorities should consider setting aside frequencies for testing agile radios.
- Regulators should begin looking into the ramifications of mesh networks.
- Regulators should create a technical advisory group to follow new technologies.

Thank you

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