The Second Wireless Revolution

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Tragedy of the Titanic in 1912

- Physical defects in the structure of the ship
- Communication failure to understand ignition signals
- Communication failure to understand SOS signals
- About 50% capacity of lifeboats to the capable passengers

The Titanic Syndrome

Domestic U.S. spectrum policy and regulation began 90 years ago. Largely as a consequence of the communications failures associated with the sinking of the Titanic, the Federal government established control of the electromagnetic spectrum.

The first international radio conference took place in 1903, followed by another in 1906. The second conference adopted a convention requiring receipt of priority distress calls from ships and created the first two radio frequency service categories: general public service in the 187-500 kHz band and long-range or other services for assignment in other frequencies.

Source: FCC-SPTF [2002]

Three Different Histories?

Yochai Benkler refers to this history of radio regulation, which justifies governmental control of spectrum as the necessary response to conflicting uses, as the "official history." He contrasts this with the revisionist history told by the private property rights theorists. This revision attributes government control not to necessity, but to the coinciding interests of government, which wanted control, and incumbent broadcasters, who wanted protection from competition. A third history, which Benkler himself tells, is a story not of technical or political necessity, but of network architecture. According to Benkler, it was the particular and historically contingent business arrangements of broadcasters and equipment manufacturers that necessitated the regulatory structure Congress adopted in 1927 and 1934.

Source: Goodman[2004]

Four Parameters

The Commission must clearly define the following basic spectrum rights parameters for all licensed and unlicensed spectrum uses:

- Designated frequency range and bandwidth;
- Geographic scope of right to operate;
- Maximum RF output, both in-band and out-of-band; and
- Interference protection, *i.e.* the maximum level of noise/interference that the spectrum user must accept from other RF sources.

Source: FCC-SPTF [2002]

Three Spectrum Usage Models

- “Command-and-control” model. The traditional process of spectrum management in the United States, currently used for most spectrum within the Commission’s jurisdiction, allocates and assigns frequencies to limited categories of spectrum users for specific government-defined uses. Service rules for the band specify eligibility and service restrictions, power limits, build-out requirements, and other rules.

- “Exclusive use” model. A licensing model in which a licensee has exclusive and transferable rights to the use of specified spectrum within a defined geographic area, with flexible use rights that are governed primarily by technical rules to protect spectrum users against interference. Under this model, exclusive rights resemble property rights in spectrum, but this model does not imply or require creation of “full” private property rights in spectrum.

- “Commons” or “open access” model. Allows unlimited numbers of unlicensed users to share frequencies, with usage rights that are governed by technical standards or etiquettes but with no right to protection from interference. Spectrum is available to all users that comply with established technical “etiquettes” or standards that set power limits and other criteria for operation of unlicensed devices to mitigate potential interference.

Source: FCC-SPTF [2002]

The 3rd or 4th Way?

1. The holders of frequency licences can use their spectrum for all purposes, and lease it to others. In some cases, a payment or auction might be required first. This should satisfy the property rights proponents. (Property Right)

2. Unused spectrum can be utilised without a licence, subject to limitations of transmission power and time. (Commons)

2⁄5

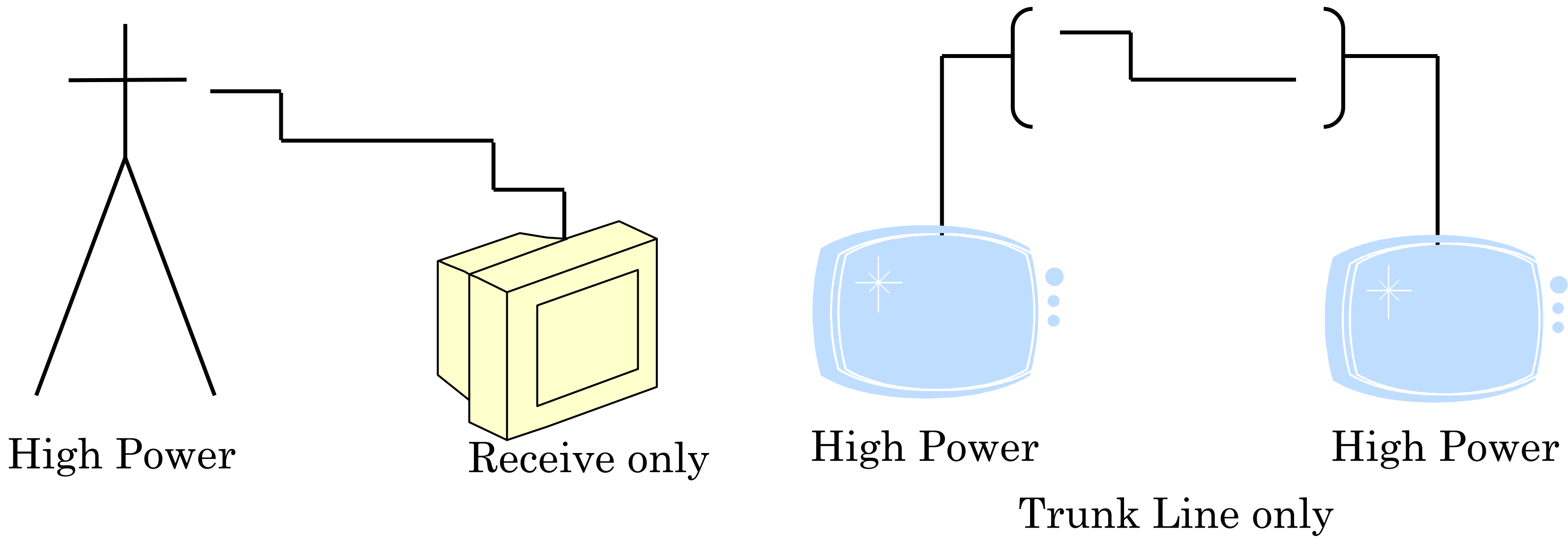
3. Unlicensed users must pay a usage fee.

   Low-power devices would not be included. But for those radiating a stronger signal, usage could be metered by a chip in the transmission equipment, and monthly totals transmitted to sites run by credit card companies, which would take care of the payment. The allocation of the collected revenues would be set according to the sampled usage of different frequency bands and distributed to the licence holders. (Right of Way)

* "Command and Control" is out of question.

Source: Noam [2003]

Broadcasting v. Interactive Comm.



＜Broadcasting ＞ ＜Interactive Comm.＞

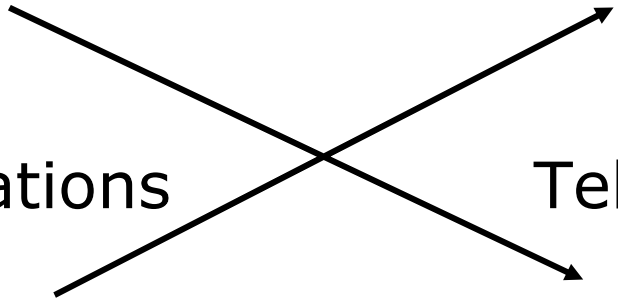
Wireless Dominant Wireline Dominant

Negroponte Switch

<Past>

Broadcasting
=Wireless

Telecommunications
=Wireline



<Future>

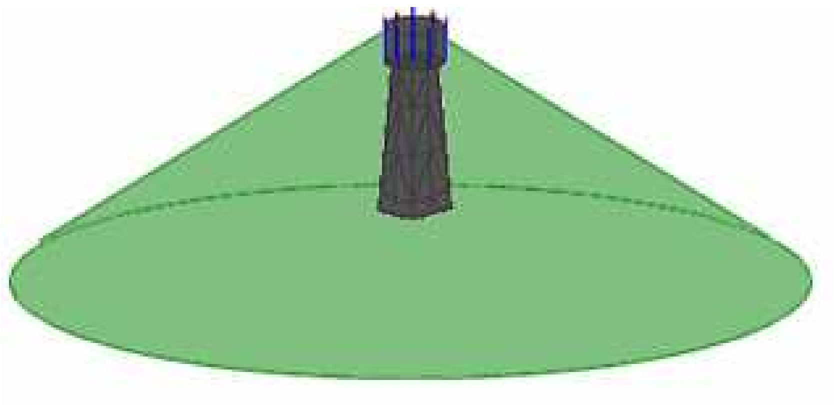
Broadcasting
=Wireline

Telecommunications
=Wireless

Source: Negroponte[1995]

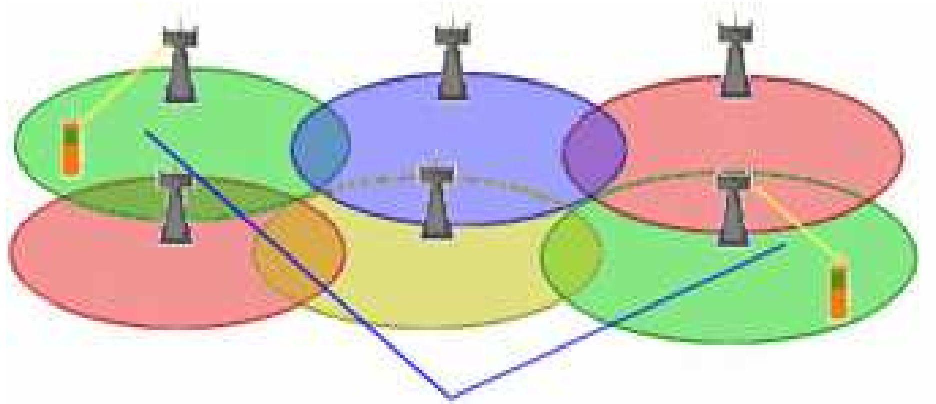
Cell Phones: The First Revolution

<Big Zone>



All available spectrum
used within a big zone

<Cell>



All available spectrum repeatedly
used among many cells

Enabler of Negroponte Switch

- Space Segmentation：cell, etc.
- Time Division：TDMA, packet, etc.

And more to come!!

More to come

Smart Terminal: Carrier Sense

(1) SDR (Software Defined Radio): Smart radio, agile radio, cognitive radio

(2) Mesh Network

Spread Spectrum

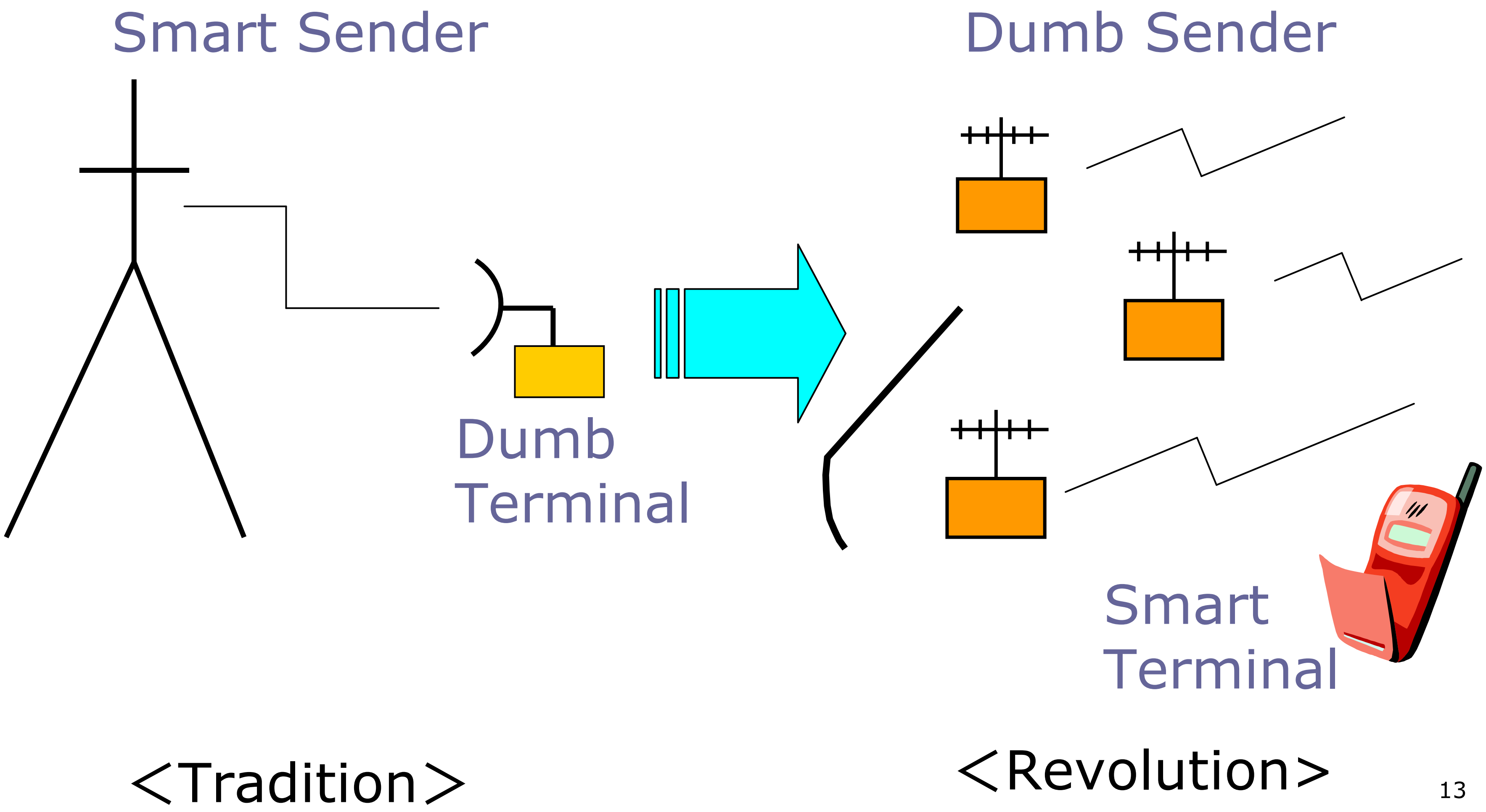
(1) Direct sequence: IEEE 802.11 series

(2) Frequency hopping : Bluetooth

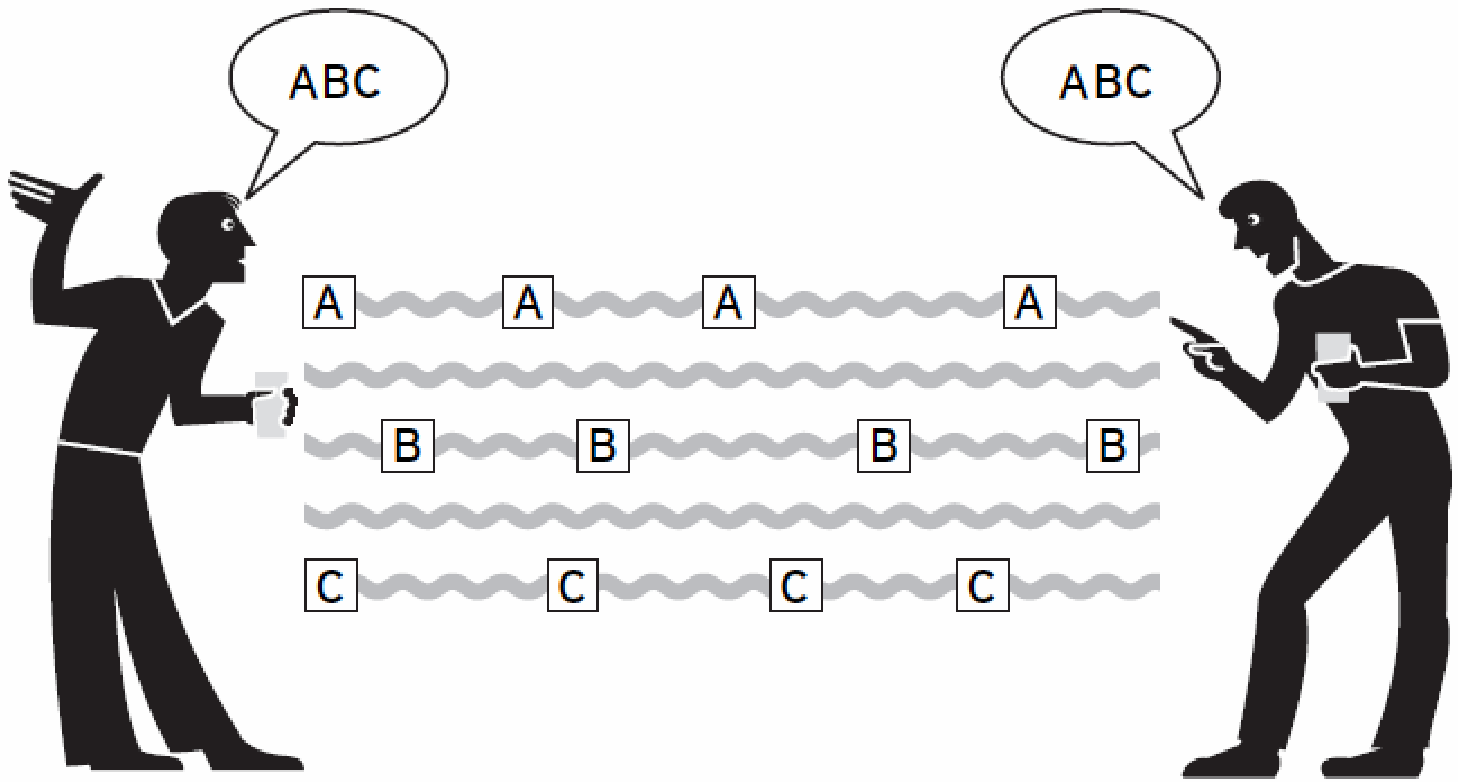
(3) CDMA

(4) UWB (Ultra Wide Band)

Smart Terminal



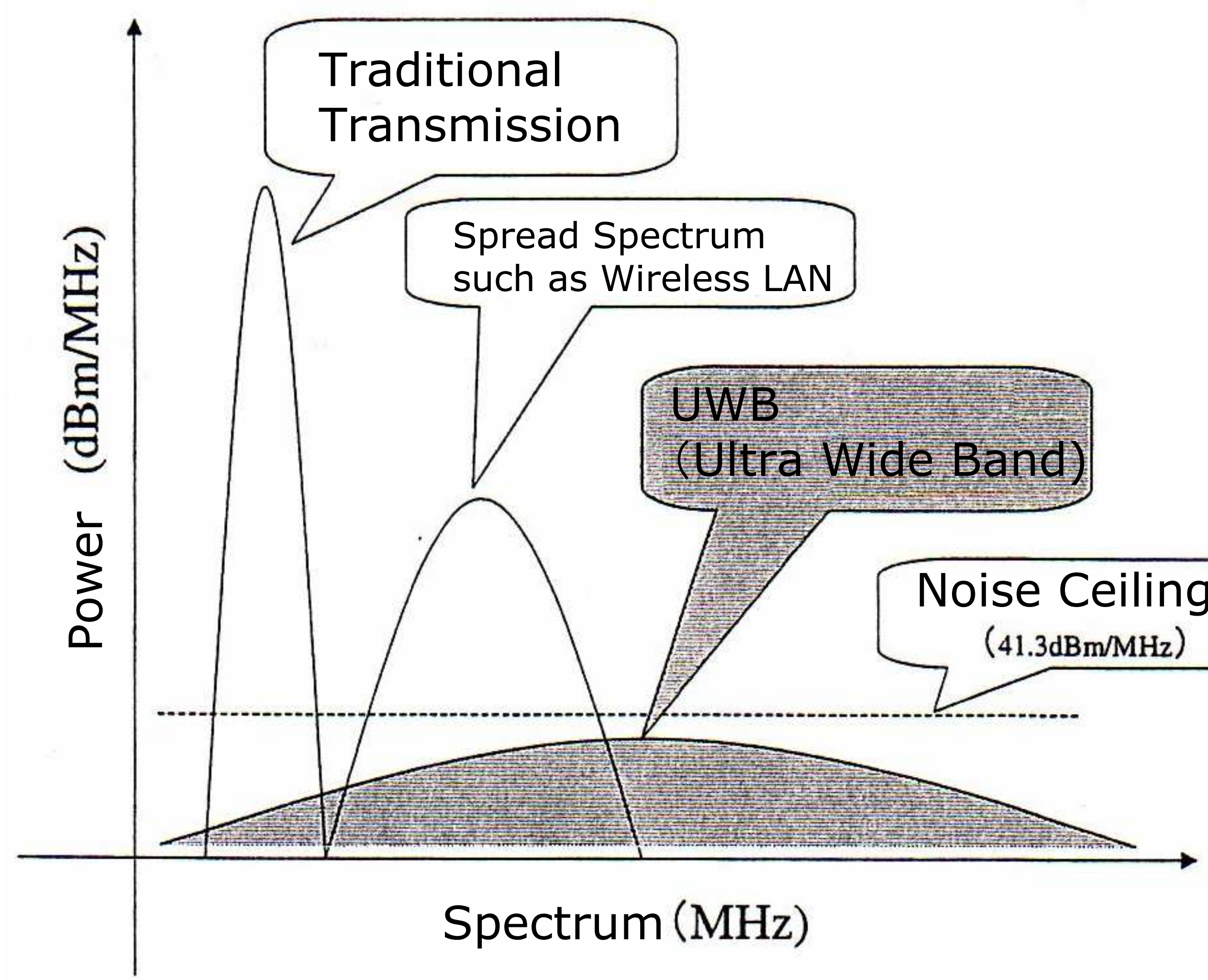
Spread Spectrum (1)



In spread-spectrum communications, low-power radio transmitters divide their signals into coded packets across a range of frequencies and receivers reconstruct the message.

Source:Werbach[2002]

Spread Spectrum (2)



Source: Yamada & Fujii[2004]

Interference still matters:

- "Interference" is defined as follows, according to the Commission's rules: "The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio-communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy." 47 C.F.R. § 2.1.
- "Harmful interference" is defined as follows: "Interference which endangers the functioning of a radionavigation service or other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with these [international] Radio Regulations." 47 C.F.R. § 2.1.

New Methodology

- Interference temperature, expressed in units of degrees Kelvin, can be calculated as the power received by an antenna in watts divided by the associated RF bandwidth in Hertz and a term known as Boltzman's Constant (equal to 1.3807 watt-sec/ºKelvin). Alternatively, interference temperature can be calculated as the power flux density available at an antenna in watts per meter squared multiplied by the effective capture area of the receiving antenna in meters squared divided by both the associated RF bandwidth in Hertz and Boltzman's constant. An "interference temperature density" can also be defined as the interference temperature per unit area, expressed in units of ºKelvin per meter squared, and calculated as the interference temperature divided by the effective capture area of the receiving antenna. This quantity could be measured for particular frequencies using a reference antenna and, thereafter, would be independent of receiving antenna characteristics.

Source : FCC-SPTF[2002]

Too Political

Given the substantial agreement on policy direction, the greatest obstacles to reform are likely to arise from incumbents deploying political pressure to resist change in the status quo. In recognition of this reality, many of the policy ideas floated at the conference creatively combine mechanisms that should enhance effectiveness in spectrum management and ease the political pathway toward reform. Participants hoped that political leaders will find the will to seize on the considerable agreement that exists among policy specialists across the political spectrum to bring about reform in managing across the electromagnetic spectrum.

Source: Aspen Institute[2004]

How to measure Efficiency (1)

The Task Force identified three variations on and definitions for the term "efficiency," as applicable to spectrum management: spectrum efficiency, technical efficiency, and economic efficiency. Spectrum efficiency occurs when the maximum amount of information is transmitted within the least amount of spectrum. Technical efficiency occurs when inputs, such as spectrum, equipment, capital, and labor, are deployed in a manner that generates the most output for the least cost. Economic efficiency occurs when all inputs are deployed in a manner that generates the most value for consumers. The Task Force found that spectrum and technical efficiency are components of economic efficiency, but that measuring spectrum and technical efficiency does not necessarily provide any meaningful information with respect to economic efficiency.

Source:FCC-SPTF [2002]

How to measure Efficiency (2)

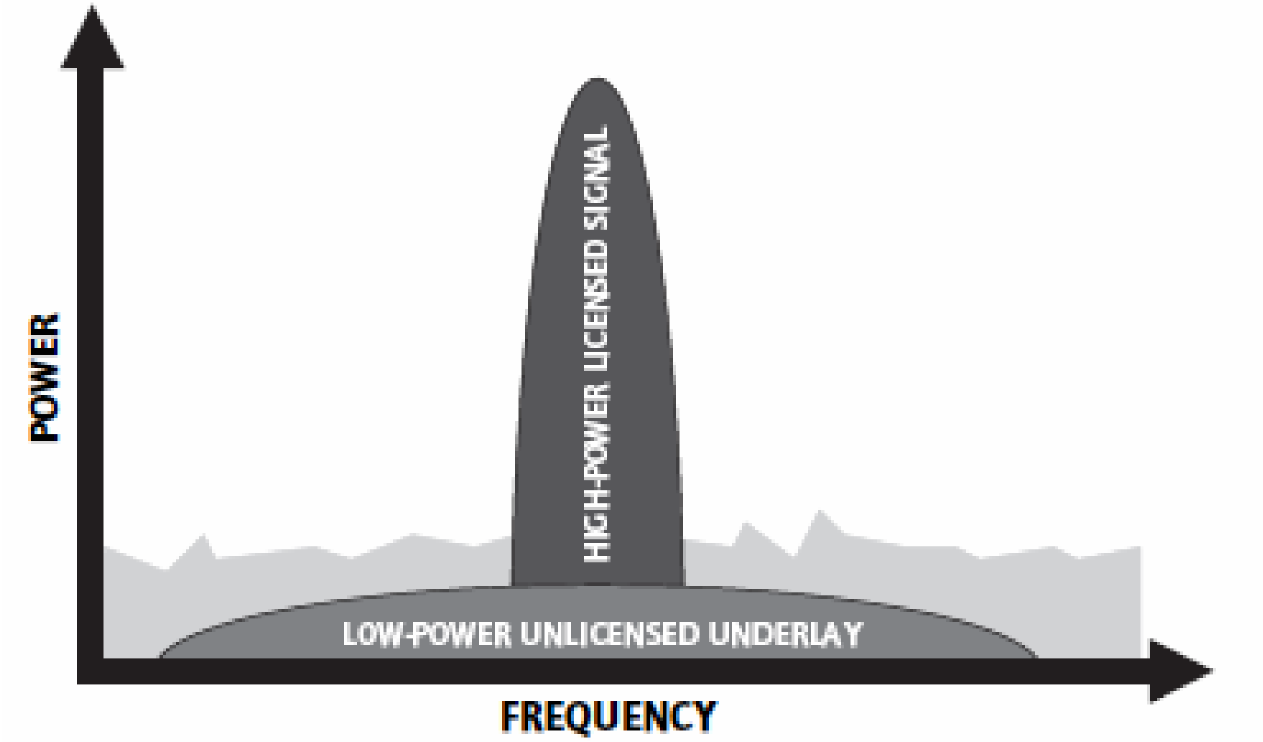
The Task Force concluded that the Commission can best promote economic efficiency by providing spectrum users with flexibility of spectrum use and ease of transferability in order to allow maximization of the value of the services provided. Flexibility provides incentives for economically efficient use and discourages economically inefficient use by ensuring that spectrum users will face the opportunity cost of their spectrum use. In most instances, the application of flexible service rules and efficient secondary market mechanisms are the best means of achieving this goal.

Source:FCC-SPTF [2002]

Immediately applicable･･･

- Mandatory for (at will of or unconscious of) the Incumbent
  - (1) Secondary Market
  - (2) Easement
  - (3) Underlay/Overlay
- Narrowing the Guardband
- Digitization with less Bandwidth
- Expansion of unlicensed Spectrum

Underlay Sharing



In underlay sharing, low-power, unlicensed devices share frequencies and avoid interference by operating beneath the noise threshold of high-power devices in the band.

Source:Werbach[2002]

Gimme some spectrum says Son

Softbank in Japanese mobile row
By Tony Dennis

- **AN UNCHARACTERISTIC PUBLIC** row has broken out in Japan over spectrum allocated for mobile phone networks. Masayoshi Son, Softbank's president, has effectively accused the Japanese telecoms regulator of bias. The Japanese telecoms ministry has just allocated more bandwidth at 800 MHz to two existing operators - NTT DoCoMo and KDDI. But Softbank was hoping that new entrants would get the allocation when bandwidth became available.
- Softbank has already shaken up the Japanese broadband market and is hoping to do the same thing with wireless. Significantly Softbank was interested in using TD-CDMA (sometimes known as Wideband TDD) for deploying a wireless IP network. While TD-CDMA fits nicely alongside other 3G technologies – such as W-CDMA and CDMA2000 – it doesn't easily lend itself to voice. Hence Softbank's interest in 800 MHz which is ideal for voice.
- The Japanese ministry's attitude seems to be that DoCoMo and KDDI already had 800 MHz base stations so they might as well have the new bandwidth.
- Although there are already four Japanese mobile operators – DoCoMo, KDDI, Tu-Ka and Vodafone – Japanese mobile calls are still relatively expensive. NTT in particular would be loathe to see a low cost mobile phone operator since around 70 per cent of its profits come from DoCoMo – its mobile arm.

Source: "the Inquirer" September 7, 2004
http://www.theinquirer.net/?article=18294

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