Radio Spectrum Policy in Europe

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Abstract

Radio spectrum is a valuable and scarce resource, and therefore has to be managed and coordinated carefully. Spectrum management and policy is currently facing new challenges, as the rapid development of radio technologies is opening up possibilities for new and advanced applications and services.

Spectrum policy in Europe has been traditionally based on a so-called "command-and-control" approach, where government institutions decide both on spectrum allocation and assignment, i.e. which services and technologies are allowed to be used, and who has the rights to utilize the bands. Currently, there is an active discussion going on about the benefits and drawbacks of introducing more market-based approaches to spectrum management. In these approaches, spectrum licensed could be traded, and the spectrum licensees would have more freedom in choosing which services to provide and which technologies to utilize.

Transition from the command-and-control approach towards a market-based approach should happen in stages, and care should be taken not to lose the benefits of the current system in the process. Furthermore, the choice between the regimes is not black-and-white; there are many different parameters that can be decided on independently. Especially, spectrum trading and service/technology neutrality issues should be discussed and decided on independently from each other.

Key Words

Spectrum management, Spectrum policy, Spectrum trading, Innovation, Competition, Europe

1. Introduction

Radio spectrum is a valuable resource and a pre-requisite for all wireless communication systems, including e.g. radio and television broadcast systems, mobile networks, satellite and radar systems, and fixed radio links. It is estimated that the economic value generated for consumers of services derived from radio spectrum is around 2% - 2.5% of EU's gross domestic product (GDP) (Analysys 2004). Mobile communication and broadcasting services are the most important from this perspective, and according to a Danish study (Falch & Tadayoni 2004) account for 85% of the total contribution to GDP.

Radio spectrum is also a scarce resource. The use of radio frequencies must be regulated to ensure that there is no interference between different systems and users. Although the utilized radio spectrum spans from around 10 kHz up to 100 GHz and above, only a fraction of the frequency bands are in practice usable for e.g. mobile communication systems. As the frequency increases, the achievable link lengths decrease and requirements on e.g. the line-of-sight conditions between the communicating ends become stricter. Higher-frequency systems are also more expensive. Thus, today's mobile systems are operating around 0.5 - 2 GHz spectrum bands.

The rapid development of new radio technologies has resulted in a number of new systems being introduced to the market. In addition to third generation (3G) mobile systems, digital television systems as well as broadband wireless systems such as WLANs and WiMAX are being deployed around Europe at an increasingly fast pace. In the future, the number of different radio systems and standards is likely to increase further, putting pressure on the flexibility and adaptability of the spectrum management process.

The current development regarding radio spectrum policy in Europe is based on the Radio Spectrum Decision (European Parliament 2002) and the Radio Spectrum Policy Group Decision (European Commission 2002) which established the Radio Spectrum Committee (RSC) and Radio Spectrum Policy Group (RSPG), respectively. The RSC provides the European Commission with advice on technical implementation measures, while the RSPG provides advice on policy and strategic issues. The Radio Spectrum Decision also established a policy and legal framework for radio spectrum issues in the European Community.

The most recent report on the activities undertaken under the RSC states that "*current inefficiencies in the distribution and use of spectrum create costs, lead to wasted opportunities for business and reduce the take-up of innovative services to the detriment of consumers*" (European Commission 2005). Efficient spectrum policy is clearly seen as important for the innovativeness and competitiveness of Europe as whole.

The purpose of this paper is to introduce and compare different spectrum management approaches, and to recognize their potential impacts on the European markets. The focus is on mobile and broadcasting technologies and services, and on the different options of market-based spectrum management approaches.

2. Radio spectrum today and tomorrow

In all markets, spectrum allocation is very fragmented, with several hundred different uses allocated for the frequencies between 3 kHz and 300 GHz. However, as the primary focus of this paper is on mobile communication and broadcasting systems, this general overview of spectrum usage will focus on the frequency ranges used by these technologies, VHF (30-300 MHz) and UHF (300-3000 MHz).

2.1 Spectrum for broadcasting

The frequencies used for analogue television broadcasting in Europe today were originally allocated in the European Broadcasting Conference held in Stockholm in 1961 (hereafter ST61). The revised ST61 frequency plan allocated five bands for television broadcasting, divided into 8 MHz wide channels, as listed in Table 1 (Hai 2004).

Table 1: Revised ST61 frequency bands

Freq. band	ST61 band	Freq. range	Channel #
VHF	Band I	47 – 68 MHz	2 – 4
	Band II	87.5 – 100 MHz	
	Band III	174 – 230 MHz	5 – 12
UHF	Band IV	470 – 582 MHz	21 – 69
	Band V	582 – 862 MHz	

Finnish analogue television broadcasts use bands III – V, whereas digital television broadcasts are limited to IV and V (Finlex 2002).

The frequency band 87.5 – 108 MHz was allocated to FM radio in Geneva, 1984 (Hai 2004).

The Regional Radio Conference, set to be held in Geneva during May and June 2006, will re-evaluate the spectrum requirements for broadcasting in light of the new features and possibilities of digital broadcasting, resulting in a new plan to replace ST61. Due to the increased efficiency in bandwidth utilization by digital systems, up to six channels, multiplexed into one signal, can be broadcasted in the same amount of spectrum as one analogue channel (Burns 2004). The forthcoming conference will also address the length of the transitional period; CEPT wants to end analogue broadcasts by 2015, but Russia and the Arab countries have proposed later dates (Kangas 2004).

2.2 Spectrum for mobile communication

Mobile communication technologies currently used in Europe are GSM, UMTS and TETRA. A recent development is the deployment of a Flash-OFDM network in Finland, using the frequency band left empty by NMT 450. WLANs providing more limited mobility can be deployed in the 2.4 GHz and 5 GHz unlicensed frequency bands. Furthermore, WiMAX networks are being made available all over Europe. The frequencies used by these systems in Finland are listed in Table 2 (Finlex 2002, Finlex 2006).

Table 2: Frequency bands allocated to mobile and portable communications in Finland

Technology	Frequencies
GSM	880 – 915 MHz 925 – 960 MHz 1710 – 1785 MHz 1805 – 1880 MHz
UMTS	1900 – 1980 MHz 2020 – 2025 MHz 2110 – 2170 MHz
TETRA	380 – 386 MHz 390 – 396 MHz
Flash-OFDM	453,700 – 456,925 MHz 463,700 – 466,925 MHz
WLAN	2400 – 2483,5 MHz 5150 – 5350 MHz 5470 – 5725 MHz
WiMAX	3410 - 3590 MHz

2.3 The Digital Dividend

Digital Dividend (or *Spectrum Dividend*) is a term coined to describe the frequencies left unused after the transition to digital television is complete and analogue broadcasts are shut off. The spectrum required by digital television for an equivalent amount of content is estimated to be between a third and half of that required by analogue television (Burns 2004).

The following alternatives have been outlined for new uses of the freed spectrum (RSPG 2004):

1. Increasing the amount of content
2. Enhancing the content (e.g. multiple angles in sports events)
3. Higher quality content (HDTV)
4. Other electronic communication services (e.g. new frequencies for UMTS)

Determining how to distribute the freed spectrum will pose a problem for regulators, as they need to determine if prioritizing broadcasters as users of the spectrum is in public interest, or if they should be treated equally with other potential users. Burns (2004) suggests that, due to the convergence between broadcasting and communication, broadcasters should not be treated differently, and so the spectrum could be auctioned to the highest bidder. This is the approach taken in the US,

where the FCC has already reallocated the upper part of the television broadcast spectrum to other wireless services (Burns 2004). The alternative approaches to spectrum management are discussed in detail in the following section.

3. Spectrum management approaches

Spectrum policy decisions are related to the following three broad issues (Analysys 2004):

1. *Spectrum allocation*: What types of uses should be allowed?
2. *Spectrum assignment*: Who should be allowed to operate the frequencies?
3. *Centralized vs. decentralized decision-making*: Should decisions on allocation and assignment be made by the state or be devolved to users?

In a centralized approach, also referred to as *command-and-control*, both allocation and assignment decisions are made by the government. *Spectrum trading* would allow the transfer of spectrum usage rights between parties in a secondary market. *Service and technology neutrality*, or spectrum liberalization, on the other hand, would devolve decisions over spectrum allocation to users, allowing the market to determine how spectrum is used. (Analysys 2004)

In the following sub-sections, three different spectrum management approaches are briefly introduced. More detailed discussion can be found e.g. in a report by Analysys (2004).

3.1 Command-and-control approach

The command-and-control approach, also known as the centralized or institutional approach, is the traditional and currently dominant way to distribute spectrum usage rights. In this approach, government institutions (e.g. National Regulatory Authority NRA or Spectrum Management Authority SMA) decide both on spectrum allocation and assignment. The spectrum assignments typically specify in some detail the systems that can be used, and secondary spectrum trading is not allowed.

After a certain part of the radio spectrum has been allocated to a certain service and/or technology, the spectrum assignment decision can be made in many ways. The most important assignment mechanisms include *first-come-first-served*, *beauty contests*, and *auctions*.

First-come-first-served assignment mechanism is typically used for those services, where spectrum demand does not exceed supply. The government has set the license prices in advance, and grants the licenses in the order they receive applications. This mechanism is typically used for fixed radio links, and is used e.g. in granting the 3.5 GHz spectrum licenses for WiMAX systems in Finland.

Beauty contests, or comparative selections, are traditionally used to assign spectrum licenses in situations where demand exceeds supply. The governments select the licensees from among the candidates, and are not bound to grant the licenses only on the basis of their willingness to pay. Beauty contests are typically used e.g. when granting licenses for TV and radio broadcasting, but also for mobile systems in many European countries, including Finland.

The third alternative assignment mechanism, auctions, was used when granting the 3G licenses in e.g. U.K., Germany, and Italy in the early 2000's. In auctions, the spectrum is simply assigned to those companies who value it the most; other criteria are less important.

Even lottery has been used in the USA, but this approach gives no guarantee that the most efficient operator is chosen.

3.2 Market-based approach

In the market-based approach, the governments are only responsible for the primary spectrum assignment using e.g. auctions or other assignment mechanisms. After the primary assignment, secondary spectrum trading allows the usage rights to be sold to others. The users can also be given some degree of freedom in selecting how to utilize the spectrum, although some technical rules are still necessary to protect neighbors (geographical and spectrum-wise) from interference. Generally, spectrum trading and service / technology neutrality issues can and should be treated separately.

The European Commission is currently planning to shift its spectrum policy from the traditional command-and-control approach towards a more market-based approach. In EU's view, the principles of technology and service neutrality should be applied to spectrum management, and users should be given more power in deciding how to use the spectrum. This freedom may still be limited by some technical considerations, such as avoiding interference. Regarding spectrum trading, the Commission proposes to introduce spectrum markets in the EU by 2010. (European Commission 2005)

3.3 Commons approach

In the commons approach, the government allocates license-exempt spectrum for some service or technology. After an allocation has been made, anyone can utilize the spectrum without the need for a license. In order to avoid interference, transmission power levels are typically limited, and the spectrum can also be allocated for some specific technologies only. Examples of technologies utilizing unlicensed frequency bands include e.g. wireless LANs and Bluetooth operating in the 2.4 GHz frequency band.

Spectrum licensing is generally justified by avoiding harmful interference, but in the past few years unlicensed spectrum has proved to provide a fertile ground for innovations (demonstrated by e.g. the evolution of WLANs). In the EU, the use of license-exempt spectrum is considered to be further extended and harmonized between the countries. The European Commission's view is that in the regulatory framework, individual authorizations (i.e. licenses) should be the

exception rather than the rule (European Commission 2005).

Table 3 summarizes the differences between the different spectrum management approaches.

Table 3: Comparison of spectrum management approaches (adapted from Analysys 2004)

Approach	Spectrum allocation	Spectrum assignment
Command-and-control approach	Centralized, use of spectrum pre-defined	Centralized, trading not allowed
Market-based approach	Liberalized, license holders may choose how to utilize the spectrum	Primary assignment centralized, secondary trading allowed
Commons approach	Centralized, restrictions on technology and Tx power levels	Unlicensed spectrum, no assignments

In addition to the approaches discussed above, technology development may open up new possibilities for spectrum management in the future. The role of technologies such as ultra-wideband (UWB) and software-based radios is currently under discussion.

Each of the three spectrum management approaches has its strengths and weaknesses, and they will undoubtedly all be used to some extent in the near future. Accordingly, the interesting question is which parts of the spectrum should be opened for trading / liberalization, which should be unlicensed, and which should be managed by the traditional command-and-control approach. An EU-wide balanced approach is currently sought after, and the optimal "mix" of spectrum management approaches will depend on various criteria, such as protection of systems from harmful interference, quality of service, and fostering the internal market and innovation (European Commission 2005). In Commission's view, the terrestrial bands used for broadcasting, mobile services, and fixed services are best suited for spectrum trading (Reding 2006).

4. Impacts of spectrum policy on competition and innovation in Europe

The shift towards market-based spectrum management approaches is often argued to increase the innovativeness and competitiveness of the markets. In this section, we try to identify some of these mechanisms and cause-effect relationships. The analysis is limited to qualitative reasoning and e.g. correlations between the identified variables are not measured.

The great success of GSM-based mobile communication systems results largely from the harmonized spectrum allocations and technology development in Europe. In 3G, the spectrum was also harmonized, not only in Europe but more or less globally. The wide variation in spectrum allocation approaches between European countries and the enormous sums paid for the licenses in e.g. Germany and U.K. have, however, raised concerns about the suitability of the current spectrum policy to meet the demands of today's marketplace.

In this analysis, we focus only on the market-based spectrum management approach, and scope the commons approach and e.g. UWB out of the discussion. In order to construct a balanced view of the benefits and drawbacks of market-based approach, we have studied the responses given by different European organizations to the *"Public consultation on secondary trading of rights to use radio spectrum"* issued by the European Commission (2004). Positive and negative comments were identified and collected, and the most important of those linked together as shown in Figure 1.

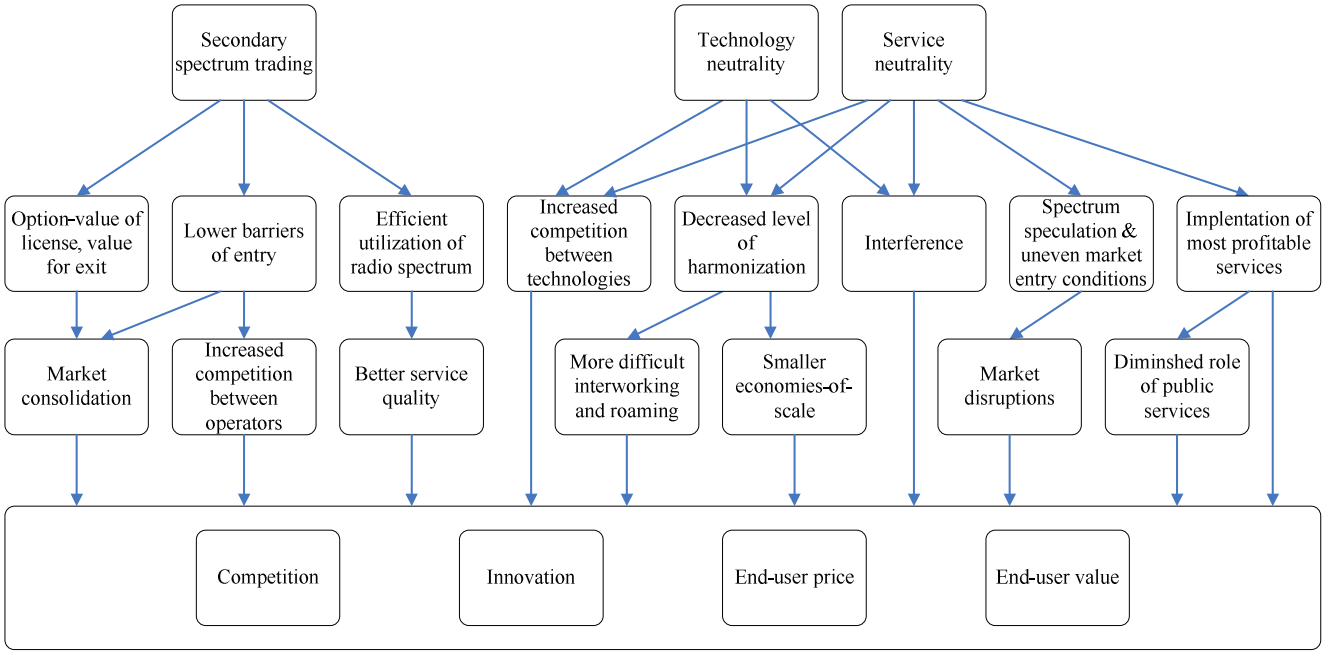

Figure 1: Possible impacts of spectrum policy choices on competition and innovation

Overall, the responses often shared many of the same concerns and perceived benefits. The respondents generally took either a positive or a negative view, and only a few covered concerns and benefits equally, indicating that the responses were motivated by the responding company's business interests. Of the respondents, one group stood out in particular; the satellite operators opposed any change to the current spectrum management policy. Often, spectrum trading without the right to change-of-use (service / technology neutrality) was considered to be a better choice than full spectrum liberalization, at least on the early stages of the development.

Proponents of secondary trading of radio spectrum mostly perceived the same benefits. Secondary trading would primarily increase competition by lowering barriers of entry into existing markets. Traditionally frequencies have been licensed in one-off events, making later entry into the market possible only by acquiring a company with a license. The easier exit from and entry to the markets was also seen as a driver for market consolidation. Another major benefit of secondary trading would be the increased efficiency of spectrum usage. Respondents envisioned operators selling surplus capacity to each other, or leasing capacity for other services in sparsely populated regions.

The effects of service neutrality and technology neutrality were other issues under consideration. Service neutrality was seen to maximise the economic value of spectrum, in that the services creating highest revenue would be implemented. This was also seen as a negative issue, as public services such as public broadcasters would likely be replaced by more profitable services. Also, device manufacturers and operators were seen as more unlikely to invest in development of new technologies if spectrum availability for them is uncertain. A possible negative effect that respondents named was *spectrum hoarding*, that is, the possibility of acquiring frequencies for speculative purposes or to lock-out competition.

Technology neutrality without service neutrality was seen in a more positive light. It would enable technology upgrade paths for operators using existing spectrum leading to faster time-to-market for new technologies, and one respondent mentioned South Korea as an encouraging example: South Korean operators migrated to 3G technologies in existing frequencies as early as 2000, and today 3G users make account for 75% of subscribers, contributing to a 12 – 18% increase in revenues due to add-on services (CDG 2004). Easier migration paths were also seen to lead to increased competition between technologies.

Negative aspects of both service and technology neutrality were smaller economies of scale for device manufacturers, and loss of international harmonisation, making interworking and roaming difficult if not impossible. These factors were also both seen to contribute to higher end user prices.

5. Summary and discussion

Radio spectrum management and policy issues are complex, and it is difficult to claim one approach to be clearly better than another. Command-and-control, market-based, and unlicensed spectrum approach all have their strengths and weaknesses, and all are better suited for some services and technologies than others.

Transition from the traditional command-and-control approach towards a market-based approach will happen in stages, and care should be taken not to lose the benefits of the current system in the process. Furthermore, the choice between the regimes is not black-and-white; there are many different parameters that can be decided on independently. For different frequency bands, different combinations of decisions can be made in e.g. the following issues:

Table 4: Spectrum policy decision points

Issue	Possible outcomes
Primary assignment mechanism	First-come-first-served Beauty contest Auction
Secondary spectrum trading	Allowed / not
Technology neutrality	Yes / no
Service neutrality	Yes / no
Pricing	One-off Annual license fee

It is especially important to consider spectrum trading and change-of-use independently of each other. Our initial analysis indicates that the risks involved in the latter one are substantially higher. Therefore, secondary spectrum trading without the possibility to change the use of the spectrum service- or technology-wise could be a safe first step in developing the policy.

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