EC Request for Opinion from RSPG on the Common Use of Spectrum
Contribution to the Debate

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Abstract

This report is intended to provide input to the debate surrounding the request of the European Commission (EC) to the Radio Spectrum Policy Group (RSPG) to develop and adopt an Opinion on Aspects of a European Approach to 'Collective Use of Spectrum'.

The report draws upon research into the genesis and development of Wi-Fi, the most successful 'common use' application to date. Based on theoretical considerations and empirical findings the 'lessons learned' relevant to the formulation of the Opinion are highlighted.

From this discussion the following four relevant insights emerge:

1. Common Use Spectrum (CUS) is in fact highly regulated,
2. Cooperation between the market and the regulators is crucial in crafting the rules,
3. The lead time for the development and deployment of CUS applications is likely to be long,
4. Continuous monitoring of the use of CUS is needed,

Acknowledgement

This report draws upon the ongoing research program on the Governance of Radio Frequency Spectrum in the Section Economics of Infrastructures of the Department Technology, Policy & Management at the TUDelft, the Netherlands.

This program considers politics, economics and technical elements as related to spectrum management. It does so by considering the role markets can play in the management of spectrum as well as the technical conditions necessary for managing spectrum as a common pool resource.

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1 The CUS Concept

The RSPG has defined Collective Use of Spectrum in the following way:

> "Collective Use of Spectrum allows an undetermined number of independent users and/or devices to access spectrum in the same range of frequencies at the same time and in a particular geographic area under *a well-defined set of conditions*." (emphasis added).

The central concern with the concept is there is little indication of what constitutes a 'well defined set of conditions' at an operational level. The RSPG suggests that the CUS concept complements previous Opinions on spectrum flexibility (the Opinion on WAPECS) and on secondary trading, but it is hard to see how this is so.

The WAPECS opinion is similarly broad. Technologies in the context of the more flexible spectrum management approach were said to operate on both a licenced and unlicensed basis using any frequency 'subject to technical coexistence rules within the band of operation'.

How CUS differs from WAPECS is unclear. In view of the fact that WAPECS in 2005 was considered a key initiative of the i2010 Information Society initiative and part of a renewed commitment to the Lisbon Agenda to make the European Union 'the most dynamic and competitive knowledge-based economy in the world' by 2010, it would appear that the RSPG has advanced very little to achieving this objective in the last three years. See also Akalu (2006).

The approach taken in CUS and WAPECS is moreover difficult to reconcile with the market based approach to spectrum management delivered in the RSPG Opinion on secondary trading. Trading, by definition requires property rights that can be determined as legitimate objects of exchange. How the RSPG proposes to draw the line between private and collective use of spectrum is not provided.

This submission provides guidance to the RSPG by detailing the historical evolution of Wi-Fi, the most successful CUS application to date.

2 Historical development of RF spectrum governance

The radio frequency spectrum is a natural resource with the characteristics of a common pool. An important characteristic of RF waves is that the use of the same frequency at the same place and time will lead to interference, and hence, to the distortion of the communication between the sender and receiver. Interestingly, the RF resource is non-depleting, after its use the resource is immediately available for re-use.

For entrepreneurs in the wireless industry the RF spectrum is an input to the production process. Depending on the frequency band (which determines the propagation characteristics) and the conditions associated with the RF spectrum assignment (e.g., period of licensing, the bandwidth, the number of licensees) the RF spectrum is valued differently.

In their role of governing the RF spectrum, governments also assign RF spectrum to 'internal users', such as the military, the emergency services, and air traffic control. A

third category of allocations and assignments is concerned with the category of license-exempt use of RF spectrum.

3 The license-exempt use of RF spectrum

The licensing regime of RF spectrum involves considerable transaction costs and long transaction intervals, which may be disproportional in certain application cases, such as the use of RF spectrum for industrial, scientific, and medical (ISM) applications. Hence, in a number of frequency bands RF spectrum has been set aside for these applications, see Table 1 (ITU, 1998).

Band	Bandwidth	Centre Frequency	Exceptions
6 765-6 795 kHz	30 kHz	6 780 kHz	
13 553-13 567 kHz	14 kHz	13 560 kHz	
26 957-27 283 kHz	326 kHz	27 120 kHz	
40.66-40.70 MHz	40 kHz	40.68 MHz	
433.05-434.79 MHz	1.74 MHz	433.92 MHz	Only in Region 1, except in the countries mentioned in Footnote No. S5.280.[1]
902-928 MHz	26 MHz	915 MHz	Only in Region 2.[2]
2 400-2 500 MHz	100 MHz	2 450 MHz	
5 725-5 875 MHz	150 MHz	5 800 MHz	
24-24.25 GHz	250 MHz	24.125 GHz	
61-61.5 GHz	500 MHz	61.25 GHz	
122-123 GHz	1000 MHz	122.5 GHz	
244-246 GHz	2000 MHz	245 GHz	

[1] Region 1: Europe and Africa, including Armenia, Azerbaijan, Russian Federation, Georgia, Kazakhstan, Mongolia, Uzbekistan, Kyrgyzstan, Tajikistan, Turkmenistan, Turkey, Ukraine (ITU-R Division of the World for Radio Regulations).

[2] Region 2: North, Central and South America.

Table 1. Bands designated for industrial, scientific and medical (ISM) applications

Although no license is required to use the RF equipment in these designated bands, strict rules have been set for the use in these bands, and manufacturers of equipment have to assure compliance with these rules. In the ISM bands the access to the 'common use' of RF spectrum is unrestricted.

The limitations set by governments to the emitted power is the primary means of limiting interference and avoiding a 'tragedy of the commons'.

Other bands under a license-exempt regime includes the band designated for radio amateurs (ham radio). In this case the power levels permitted are much higher and hence in the early days the radio amateurs had to obtain an operator license and learn the Morse code. Moreover, the equipment used had to be compliant with the rules set by the spectrum regulator.

Here again the RF spectrum can be considered as a productive input for entrepreneurs, albeit, primarily for equipment manufacturers. Albeit, there is no exclusivity and hence no certainty on the number of actors now or in the future that may wish to use the 'RF spectrum commons'.

Therefore, the risk associated with investment decision to be made by entrepreneurs is much akin to investment decisions in product development in open competitive markets. These issues can be framed theoretically under the headings of strategic

management (see, e.g., De Wit and Meyer, 2004; Mahoney, 2005; Porter, 1980) and innovation management (see, e.g., Fagerberg et al., 2005; Lundvall, 1992; Nelson and Winter, 1977; Tidd et al., 2001; Von Hippel, 1988).

4 Empirical findings: the Case of Wi-Fi[1]

For many Wi-Fi has become the preferred means for connecting to the Internet – without wires: at home, in the office, in hotels, at airports, at the university campus. The current day success of Wi-Fi can be traced back to a change in government policy intended to simplify the rules for the use of RF spectrum and the idea to allow public use of spread spectrum technology in 1980.

The 1985 decision of the US Federal Communications Commission (FCC) to allow spread spectrum based radio communication in the ISM bands (900 MHz, 2.4 GHz, and 5 GHz) triggered communication firms to innovate and develop new short range data communication products. In the process, NCR recognized the value of an open standard and became the driving force in the development and adoption of a Wireless-LAN standard – IEEE 802.11, as were its corporate successors AT&T, Lucent Technologies, and Agere Systems.

In contracting with Apple and subsequently cooperating with Microsoft the product reached the mass market. In the process the product moved from its intended use as WLAN in the corporate environment to application in the home. Subsequently the home and business use was extended through Internet access services being provided at 'hotspots', 'hotzones', and more recently through city-wide Wi-Fi networking. The low-threshold technology resulted also in networks being created by communities of volunteers in developed as well as developing countries to provide alternative network access and in filling a void left by the incumbent operators. The case story of Wi-Fi is an illustration of how innovation can be triggered by policy, developed by the industry and shaped by the users.

4.1 Reflecting on the role of policy

The development of Wi-Fi was triggered by a major shift in government policy: the assignment by the FCC of radio frequency spectrum for unlicensed communication purposes. The technology to be applied had been developed in the military domain and was now prescribed for use in the private domain. This can be characterised as a change in the institutional selection environment. Although the FCC ruling prescribed a certain type of technology, firms generated a broad variety of initial products using proprietary protocols. From a theoretical perspective, the FCC opened the possibility for novelty generation.

[1] For a more extensive account on the genesis and development of Wi-Fi see Lemstra and Hayes (2008). NCR and its corporate successors AT&T, Lucent Technologies, and Agere Systems have played a central role in the development of Wi-Fi.

4.2 Reflecting on the role of standardisation

The incompatibility between products from different vendors resulted in a fragmented product market, increasing the risk for the users with respect to future developments, and resulting in a low adoption rate. Through NCR taking a leadership role in establishing a coalition of industry players, the novelty generation in the product market moved to the selection mechanism of the standardization process. The standardization process has been a process of retention and learning of the various firms involved in the development of Wi-Fi.

A strong contribution to the development of the content of the standard, a high degree of participation, as well as skillful negotiation and maneuvering have been the major ingredients determining the outcome of this process. A process being facilitated through well established formal procedures within the IEEE.[2]

4.3 Reflecting on the role of the entrepreneur

The case story of Wi-Fi is a good example of how the innovation process works in practice. The extensive period required for the standardization illustrates the commitment, the tenacity and the resources required from an emerging industry leader involved in 'rule breaking' (De Wit and Meyer, 2004).

While Wi-Fi started as a technological innovation, its development became characterized by subsequent releases of enhancements to the IEEE 802.11 standard. These standards were translated into chipsets which became incorporated in products, which in turn became part of communications systems.

4.4 Reflecting on the role of regulation

For entrepreneurs economies of scale are important to create successful products. This has been possible through the harmonization of spectrum use through regulation. The 1985 ruling by the FCC was followed by the EU in 1991 through an allocation in the 2.4 GHz band, as the 900 MHz band was already in use for GSM.

Most countries have followed these two leading examples. Given the success of 'common use' of spectrum an additional 450 MHz of spectrum has been allocated on a co-primary level by the World Radio Conference 2003 for unlicensed use. This allocation was preceded by an extensive study on the feasibility of co-existence of WLANs and the existing use of the band by military and weather radar. This investigation effort was executed by representatives of the industry and coordinated through the Wi-Fi Alliance, involving both technology experts and lawyers. The co-existence is made feasible through the implementation of WLAN protocols that 'listen-before-talk'.

4.5 Reflecting on the product life cycle

The product life cycle of Wi-Fi, to the extent is has been unfolded, reflects a long gestation period of almost 15 years, followed by a rapid take off in the last 5-6 years, see Figure 1.

[2] The IEEE for instance use the Robert's Rules of Order (Roberts, 2000).

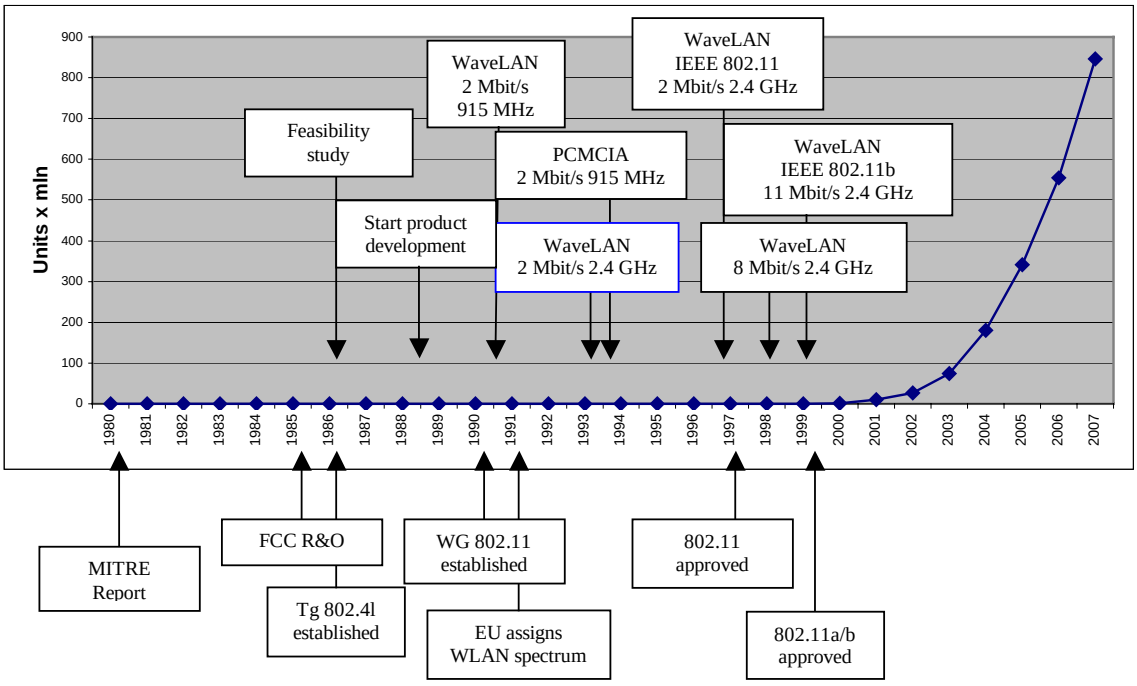

Figure 1. Wi-Fi standards and NCR products

The business plans associated with the development in NCR typically reflected a horizon of 5 years. A detailed business case of 1991 suggested a break-even in 1996, this actually happened in 2000.

4.6 Reflecting on the role of users

The massive adoption by the users shaped the emerging market. This triggered another set of entrepreneurs, including telecom operators, to use Wi-Fi to provide (semi-)public access to the Internet at “hotspots”. Wireless Internet Service Providers (WISPs) typically exploit Wi-Fi technology to provide Internet access services for-a-profit, or in the case the location owner exploits the ‘hotspot’, the objective may be to stimulate the revenues of the core business.

Next to these commercially oriented organisations, groups of volunteers have emerged that are providing Internet access for free or at very low cost. The shared Internet Access and often also direct communications among community members in the form of an Intranet is provided based on Wi-Fi Access Points being interconnected forming a Wireless Neighbourhood Area Network (WNAN).

5 Lessons learned

The Wi-Fi case is important as it reflects the first large scale deployment of radio communication on a ‘common use’ basis. The worldwide adoption of Wi-Fi demonstrates that RF spectrum can be used effectively using a license-exempt regime. As the initial RF assignment has been based on the use of the existing bands designated for the use of Industrial, Scientific and Medical applications, the use can be considered to be highly efficient as no new spectrum had to be allocated.

The relative low power levels do represent a limitation to the deployment of Wi-Fi in the case of community Wi-Fi networks or municipal Wi-Fi, as the signal does not penetrate deeply enough, without antenna boosters, into homes and offices to provide an acceptable quality of service.

The case illustrates that innovation can be triggered by a change in policy, by lowering the barriers to the use of radio frequency spectrum as an input to the production function. The Wi-Fi case illustrates the innovation potential of a license-exempt RF spectrum regime.

Wi-Fi has shown that policy makers not necessarily have to wait until representatives of the industry request the allocation and assignment of radio spectrum for a particular use. Pro-active allocation can provide opportunities for innovation, and an unlicensed regime can result in highly successful products and services.

The case does illustrate the need for the industry to provide leadership in the development of standards, the harmonization of spectrum use, and the compatibility of products to facilitate the creation of a mass market.

Close cooperation between regulators and the industry facilitates the ‘common use’ of a wide range of equipments in the same band, improving the efficient use of spectrum.

The case also shows the constancy of purpose required by the governments and the firms involved to ultimately reap the economic and social benefits: the original idea dates back to 1980 while the large scale deployment of Wi-Fi starts in the year 2000.

The potential of an unrevealed “tragedy of the commons” should motivate Regulatory Agencies to closely monitor the use of Wi-Fi to assist the industry in making timely decisions regarding an accelerated migration towards the 5 GHz band, where spectrum is set aside for unlicensed use.

Ultimately the end-users extended the deployment of the product in unforeseen directions, in this case in providing voice and data services to areas that hitherto have remained unserved.

6 Insights for RSPG and the CUS concept

From this discussion the following four relevant insights emerge:

5. Common Use Spectrum (CUS) is in fact highly regulated,
6. Cooperation between the market and the regulators is crucial in crafting the rules,
7. The lead time for the development and deployment of CUS applications is likely to be long,
8. Continuous monitoring of the use of CUS is needed,

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