

NEW APPROACHES TO PRIVATE SECTOR SHARING OF FEDERAL GOVERNMENT SPECTRUM

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Abstract -- In the United States today, some spectrum is shared between Federal Government users and users regulated by the Federal Communications Commission. But using traditional spectrum sharing techniques the potential for such sharing is limited giving the requirement of high confidence protection of the Federal usage. However, more sharing that could enable new private sector systems and economic growth is possible if certain types of future Federal systems were designed to facilitate sharing by letting the private sector users have real time information about spectrum use. This presentation describes scenarios using radar systems and mobile radio systems.

1. INTRODUCTION

As the U.S. economy and society becomes more and more information-centric and mobile, wireless systems are becoming a major factor in the efficient functioning of our society. Radio spectrum is a key economic input into practical wireless systems. Yet until only relatively recently all spectrum was distributed to possible users by administrative means. Spectrum access has generally been seen as a “zero sum game” in which spectrum was available either to one party or another mutually exclusive party. However, “green field” spectrum is almost nonexistent in the populated areas of the US so growth in wireless technology use must come from more efficient use of existing spectrum. This efficiency could come from traditional efficiency improvements like modulation and coding advances and more intensive spatial reuse of spectrum (as in cellular

communications). Efficiency can also come from new types of spectrum sharing that allows underutilized spectrum to be used by more than one user subject to interference and availability constraints that preserve access for the first user.

In the following discussion we will review the special case of Federal Government spectrum in the US and possible new sharing mechanisms that would allow other users to share it. The focus here is *not* sharing with existing federal systems, but rather how new generations of systems could be designed with the goal of simultaneously implementing federal agency wireless use and facilitating interference-free private sector sharing of the same spectrum.

2. FEDERAL GOVERNMENT SPECTRUM USE

The Federal Government is a large user of wireless systems for both military and civil systems. Some of these uses are uniquely governmental in nature, *e.g.* law enforcement and air traffic control, while others parallel private sector spectrum users, *e.g.* the electric power systems of the Tennessee Valley Authority and Bonneville Power Authority and the medical system operated by the Department of Veterans Affairs.

Unusual, if not unique, among the variety of arrangements various countries use for spectrum management is the US spectrum management bifurcation mandated by Sections 301 and 305 of the Communications Act of 1934, as amended.¹ Under Section 301 the Federal Communications

Commission is responsible for all spectrum use in the US by private parties and state and local governments. Under Section 305, though, the President is responsible for all use by Federal Government users. The President has historically delegated this function to subordinates and at present it is executed by the National Telecommunications and Information Administration (NTIA), an agency of the Department of Commerce.² NTIA is “advised” by the Interdepartmental Radio Advisory Committee (IRAC) which is composed of representatives of the federal agencies that have significant spectrum use.³ In practice, the independence of NTIA and IRAC and their relative dominance in spectrum policy making varies from year to year.

In the US spectrum is divided into three basic categories for management purposes: Federal Government, non-Federal Government, and shared.⁴ Determining the relative size of the three categories is complicated by assumptions that have to be made about what spectrum is under consideration. Also a given band size, say 1 kHz, is more significant at low frequencies than at high frequencies so just adding band sizes from 0 Hz to 100 GHz yields numbers that are not meaningful. Generally the three categories are approximately equal throughout the spectrum. A more precise accounting by John Williams of FCC in 2002 of the spectrum usually of most interest⁵, 300-3000 MHz, determined the distribution shown in Table 1 below. (Since the spectrum considered in this accounting covers only a decade of frequencies the direct addition of bandwidths is more meaningful than when larger blocks are considered.)

Federal Government spectrum is exclusively managed by NTIA and Non-Federal Government spectrum is managed exclusively by FCC. The shared spectrum is managed jointly under an interagency agreement.⁶ Federal government spectrum use generally differs from private sector use in spatial distribution, in peak-to-average ratio, and in the large scale use of radar systems with rotating narrow beam antennas and large occupied

bandwidths. A significant fraction of federal spectrum use is military and military bases tend not to be in the large urban areas where private sector spectrum use is high. San Diego is a notable exception to this spatial distribution in that it has a large naval base adjacent to the central city area. Of course, emergencies can result in large increases in military use in urban areas and any change in spectrum sharing must allow for this contingency.

Category	Fraction (In 300-3000 MHz)
Federal Government	22.4%
Non-Federal Government	34.7%
Shared	34.7%
In transition from Federal to Non-Federal	2.5%
Unlicensed and managed by FCC	5.6%

Table 1. Spectrum Categories in US

3. CONTEMPORARY CHANGES IN SPECTRUM USAGE

Traditional, most spectrum use was either broadcasting, a simplex service, or full duplex real time communications often involving voice. However, in contemporary spectrum usage packetized information is the area undergoing the most growth and full duplex voice usage is relatively stable. Thus there is need for spectrum that can be used for new packetized applications and less need for the traditional paired spectrum for full duplex systems.

The record in the FCC’s AWS-3 proceeding⁷ dealing with an unpaired band 2155-2175 MHz shows interest in using such spectrum that was of little interest only a decade ago. Major cellular companies have proposed to use the band for either

asymmetrical supplements to existing paired bands or for time division duplex (TDD) usage. Potential users have stated that the band can be used for asymmetrical traffic associated with Internet usage, music and video downloads, and real time or near real time video distribution to mobile terminals.

Traditionally only spectrum that was paired and available “1000 ms/s” was of interest since most usage was analog 2-way voice. But with packetized information and frequency agile radios it is possible to produce practical wireless systems that use spectrum with intermittent availability. Indeed, much of the anticipated wireless usage growth in the near future will be in applications with asymmetric spectrum use that can be implemented with packetized technology. So while the commercial wireless industry has traditionally searched for paired full time availability spectrum as the foundation of their systems, unpaired spectrum with intermittent availability can readily be used for many applications with growing demand.

4. PREVIOUS SPECTRUM SHARING WITH FEDERAL GOVERNMENT USERS

As the information in Table 1 showed, sharing federal government spectrum is not a new idea. Actually there have been two generations of sharing approaches to date.⁸ The first generation of government spectrum sharing systems was based on worst-case scenarios that severely limited options for sharing. Thus there has been low power sharing of government bands, a well-known example being Wi-Fi and Bluetooth in the 2450-2490 MHz band⁹, and site-based licensing of private stations in government bands based on case-by-case agreement on the availability of a specific frequency at a specific location by both the government and private users¹⁰.

The second generation of government spectrum sharing started in 2004 with cognitive radio-based sharing of the 5.25-5.35 and 5.47-5.725 GHz radar bands by unlicensed Wi-Fi-like systems. This sharing is called Dynamic Frequency Selection

(DFS) in regulatory and standards publications. Although DFS enabled sharing, the technical criteria were very conservative due to the fact that the military radar systems were not designed for sharing and the fact that interference to these radar systems had to be kept to a negligible likelihood. This resulted in the permitted powers being very low and the required detection sensitivity being very high. (For example for a 200 mW to 1 W e.i.r.p. unlicensed transmitter, the DFS system must avoid a frequency for 30 minutes if it detects -64 dBm average power even for 1 μ s.)¹¹

With this type of rigorous DFS precedent, there will be few other opportunities for negligible interference likelihood access to government spectrum based on purely passive sensing of channel use. The technical tradeoff between false alarm rate and probability of detection will probably result in government users demanding a very high probability of detection for worst case scenarios that will then result in a high false alarm rate. Furthermore, spectrum that is used for intermittent mobile communications raises different DFS issues about how quickly a new government user can be identified so the spectrum can be vacated for that user based on DFS passive sensing. However, a third generation of sharing may be based on new technologies for government radio systems that are designed with sharing in mind and that can actually *facilitate* sharing. The Commerce Spectrum Management Advisory Committee, an advisory committee to the NTIA, has been deliberating on the feasibility of designing federal government systems to facilitate sharing with the private sector. Its report is expected in early 2009. The remainder of this paper will deal with two options for designing such systems to facilitate sharing.

5. “RECYCLING” RADAR SPECTRUM

A significant use of Federal Government spectrum is radar for air traffic surveillance and weather monitoring. Almost all of these systems are the traditional monostatic design (collocated transmitter and receiver) and use rotating antennas

(vice phased arrays) with constant rotation rates.

Today Global Positioning System (GPS) technology is widely available at costs affordable to consumers. While GPS is widely known for its ability to determine location quickly and accurately, it is less well known that the underlying technology can also be used to establish precise time and precise frequency at a location.¹² This precise distribution of timing and frequency references can be used to synchronize radar systems rotations.

Radar systems designated for spectrum sharing could have published rotation rates and rotation phasing that is synchronized with precise timing, for example, a 5s rotation with the antenna pointed due North at all times where the second count is of the form $I \times 5$, where I is an integer. Low power shared spectrum users could then use the radar spectrum when they determine that through knowing their location, the radars location, and the radars rotation phasing that the beam is at least X degrees away from them, where X might be in the order of 30° . Knowing the location and precise rotation phasing of surveillance radars would allow intermittent sharing of the spectrum during part of the rotation cycle. (Due to national security constraints it is unlikely that all surveillance radars will have publicly available location and rotation phasing information. But even sharing parts of the band would be productive.)

6. "RECYLING" MOBILE RADIO SPECTRUM

The author first proposed private sector sharing of public safety land mobile spectrum several years ago during the deliberations of the FCC's Spectrum Policy Task Force.¹³ At the time the concepts were generally criticized by public safety users. However, with passing time this concept has become more acceptable and the FCC's 700 MHz D proposals are similar type of sharing between private sector and public safety users in adjacent blocks with a movable boundary. However, there has never been a parallel proposal

to allow private sector users to share with Federal users. . As in the case of D block new land mobile systems with be need for all participants for such a system to work.

The limitations of second generation passive sharing could be avoided in new government mobile systems that use base stations for control of spectrum access, similar to land mobile trunking systems or the ubiquitous cellular systems. It is interesting to note that sharing based on spectrum use knowledge from a base station can result in an "unrealizable system" in that the resulting DFS system *can predict the future*. This is because the government base station knows 1) exactly what frequencies are being used at a given moment, 2) whether channel demand is growing or decreasing at that moment, and 3) precisely in what sequence new channels will be used when additional channels are needed for use. Thus in a third generation sharing system with cooperative sharing of spectrum use information, there is no question of making errors in deciding whether a channel is being used for government communications, and one could maintain a buffer of unused channels between the primary government users and the private sector users.

The resulting private sector channel use could have large fluctuations in available capacity as government use peaks from time to time, but this could be moderated statistically by using such shared spectrum in conjunction with spectrum permanently assigned to the private sector. The growing trend towards packetized mobile communications with asymmetric traffic flows is consistent with such spectrum use as they do not require continuous use of one radio frequency. Packetized systems can move information among frequencies based on their real time availability.

7. CONCLUSIONS

There are real limitations to first and second generation spectrum sharing with respect to how much spectrum can be shared with a negligible risk

of interference to critical Federal Government systems. However, if future Federal systems are designed to enable and facilitate sharing more effective sharing is possible.

FOOTNOTES

¹ 47 U.S.C. 301,305

² Reorganization Plan Number 1 of 1977; Executive Order 12046; 47 U.S.C. 101,105

³ See <http://www.ntia.doc.gov/osmhome/irac.html>

⁴ In some documents, these categories are called: government, nongovernment, and shared,

⁵ FCC, U.S. Spectrum Allocations 300 - 3000 MHz, November 2002,
http://www.fcc.gov/Bureaus/OPP/working_papers/opp_wp38chart.pdf

⁶http://hraunfoss.fcc.gov/edocs_public/attachmatch/DO_C-230835A2.pdf

⁷ FCC Docket 07-195

⁸ M.J. Marcus, Sharing Government Spectrum with Private Users: Opportunities and Challenges, *IEEE Wireless Communications*, April 2009

⁹ 47 C.F.R. 15.247 (Text of Code of Federal Regulations/C.F.R. citations can be found at <http://ecfr.gpoaccess.gov/>)

¹⁰ 47 C.F.R. 101.1523(b) is an example of such coordination

¹¹ 47 C.F.R. 15.407(h)(2)

¹² <http://www.gps.gov/applications/timing/index.html>

¹³ Mark M. Bykowsky and Michael J. Marcus, Facilitating Spectrum Management Reform via Callable/Interruptible Spectrum, 2002 Telecom. Policy Res. Conf.,
<http://intel.si.umich.edu/tprc/papers/2002/147/SpectrumMgmtReform.pdf>