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Conference Paper

Wide area commons: Current regulation and possibilities for the future

19th Biennial Conference of the International Telecommunications Society (ITS): "Moving Forward with Future Technologies: Opening a Platform for All", Bangkok, Thailand, 18th-21th November 2012

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Elsner, Jens; Weber, Arnd (2012) : Wide area commons: Current regulation and possibilities for the future, 19th Biennial Conference of the International Telecommunications Society (ITS): "Moving Forward with Future Technologies: Opening a Platform for All", Bangkok, Thailand, 18th-21th November 2012, International Telecommunications Society (ITS), Calgary

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**WIDE AREA COMMONS
CURRENT REGULATION AND POSSIBILITIES FOR THE FUTURE**

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Abstract

An internationally harmonized regulation permitting unlicensed transmission in the lower UHF bands is proposed. Such a regulation is expected to create a new market for high range WLAN and digital PMSE devices, closing one of the last gaps of unlicensed wireless communication.

INTRODUCTION

Innovative ways to use the spectrum have historically resulted from technological competition. Prime examples are competition between PDC and PHS or between cdmaOne and W-CDMA in Japan, which contributed to the introduction of the mobile internet, of mobile video and music services, and of flat rates (Weber, Wingert 2006). This way, services were invented that were later popularized and established globally by the success of Apple's iPhone (Weber et al. 2011). Also, competition between licensed and unlicensed communication, such as between W-CDMA and WLAN, was helpful to develop markets and to determine which approach is economic under which circumstances.

Technical rules for wireless communication are set by regulatory agencies and coordinated on a global scale. Spectrum regulation should assure smooth operation of systems sharing the electromagnetic spectrum and enable innovation by providing new opportunities for technological change. These objectives, of course, are in conflict and make a constant monitoring of technological progress necessary to strike a proper balance. In this paper, we point out a last "white spot" of the telecommunication regulation landscape that will foster further innovation: Communication up to the radio horizon with high data rates and without the need for licensed operation. We are convinced that such a regulation will contribute to the discovery of new markets and to lower communication costs. It will also promote freedom by empowering the population to set up their own interconnected networks.

In order to limit the potential interference impact on future wireless devices operating in the same spectrum, we also propose to set quality guidelines for receivers.

The authors did desk research, conducted expert interviews, and organized a workshop for discussing the issues (Weber, Scuka 2011).

CURRENT SPECTRUM SHARING REGULATION

Common knowledge, following scholars such as Coase and Cave, suggests that spectrum commons should be used where congestion is unlikely to occur, i.e., in bands above 2 GHz, with a strong restraint on EIRP (Coase 1959; Cave, Webb 2004; Cave, Doyle, Webb 2007). Market-oriented approaches should be used to achieve optimum usage of the spectrum below those frequencies. With such a justification, WLAN has been crippled in terms of power. Figure 1 shows the current WLAN spectrum regulation for 2.4 and 5 GHz WLAN in Germany; similar frequency ranges and constraints can be found all over the world.

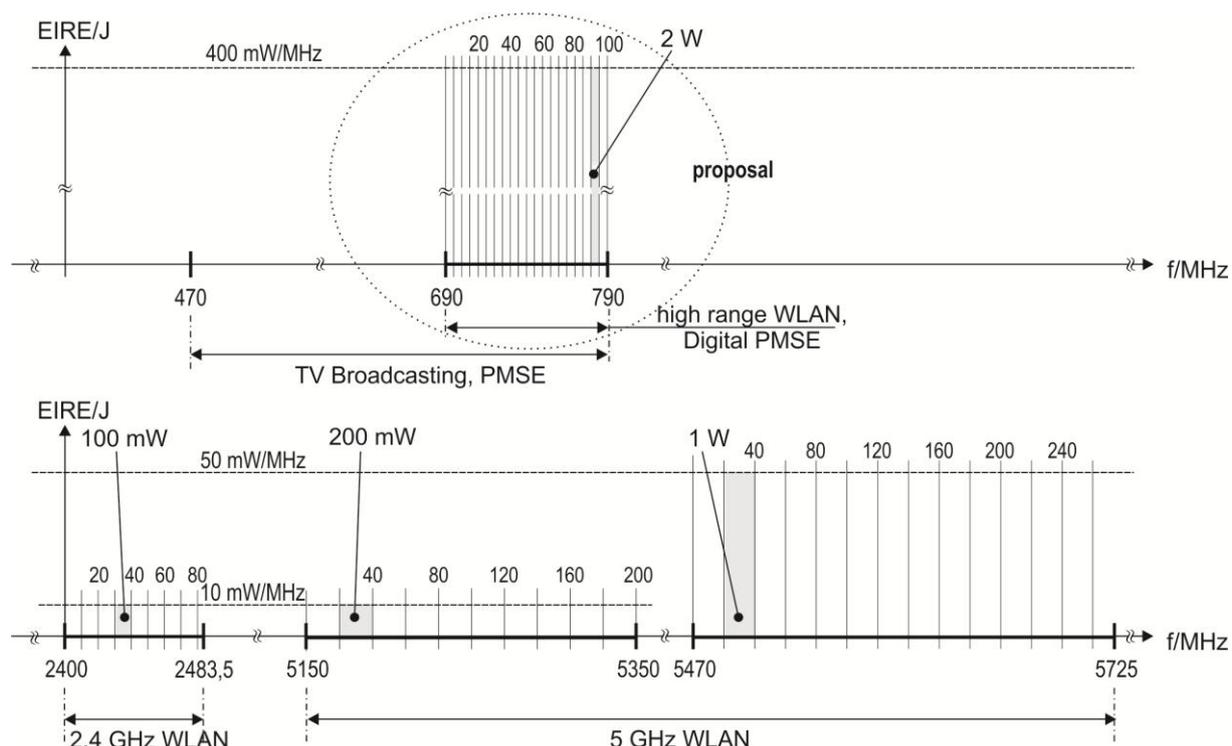


Figure 1: Current and proposed regulation for wireless local area networks (WLANs). German frequency ranges (Bundesnetzagentur 2011) are shown. The 690 MHz to 790 MHz range is an example based on German spectrum regulation, the exact location of high range WLAN and digital PMSE in the lower UHF band would be subject to international harmonization.

SUGGESTION FOR FUTURE REGULATION

By making use of simple technological rules implementable in today's wireless devices to limit congestion, commons can also be used below, e.g., 1 GHz with higher equivalent isotropically radiated power (EIRP). A prime candidate is the UHF band currently assigned to terrestrial television broadcasting and program making and special events (PMSE) equipment. This would allow a slice of the spectrum to be used for free wide-area communications. If a user does not find enough spectrum of sufficient quality in that free band, a user could resort to paid high-range services or higher frequency WLAN instead.

New tools against congestion could be based on mandatory stochastic channel back-off, or adaptive power and bandwidth control if multiple users are present. In cities, this might mean that a user only transmits at low power over a large bandwidth inside his building. In remote areas, users might use a share of that band over larger distances at higher power. This approach would help remove elements now crippling WLAN standards.

PROPOSAL FOR REGULATION

We propose to open at least a 100 MHz fraction of the current TV and PMSE bands to transmission powers of up to 2 W higher transmission powers (see Figure 1). In light of the current 2G/3G standards and transmission properties, a channel bandwidth of 5 MHz is found to be appropriate, with optional channel aggregation with same radiated power and hence lower spectral density.

This approach will become particularly powerful if legislation allows the network to be open for third parties; thus meshing would be permitted. Obvious candidates for such spectrum are the former analog TV bands between 300 and 800 MHz, because terrestrial TV usage is declining. Similar (but very restricted) endeavors have been undertaken by the FCC in the U.S. as part of the white-space regulation. These bands have very good propagation characteristics, i.e., electromagnetic waves pass through walls with low attenuation, but do not travel beyond the radio horizon.

Currently, wireless microphones (PMSE equipment) are allowed to use this TV spectrum, albeit with a narrow spectrum mask. The novel approach would allow digitizing such services. If about 100 MHz were allocated, enough spectrum for a few hundred PMSE devices operating at one single event could be provided. These could get higher priority (or possibly even higher power) than other unlicensed devices operating in that band. 100 MHz would allow significant amounts of such communication.

For all kinds of overlay systems, but especially for wide area WLANs, an important regulatory measure is to define minimum requirements for all receivers operating in shared spectrum channels. These requirements should be given in terms of filter responses, selectivity and total noise figure. This technical information will allow to accurately estimate the effects later changes in spectrum regulation will have, a playing field that today is largely left to contradicting studies of lobbyist of various interest groups, whenever spectrum regulation is changed.

CO-EXISTENCE WITH TERRESTRIAL TV BROADCASTING

Due to the large cell sizes of terrestrial TV broadcasting, “white spaces” exist in the spectrum that can be exploited on a listen-before-talk-basis. The approach currently employed by the FCC allows high powers only if the device accesses a geolocation database, creating the necessity of a backhaul link. A temporary approach that allows only part of the TV spectrum to be used and leaves other TV spectrum untouched leaves far more possibilities for new products and allows evaluating the potential of interference. Furthermore, we believe that in the long run bidirectional services and internet access will be much more valuable than traditional terrestrial TV broadcasting services.

DIGITIZATION OF PMSE EQUIPMENT

High range WLAN also offers a solution to the spectrum needs of the next generation of digital PMSE equipment that, due to delay constraints, cannot make use of the features of digital transmission with the current spectral masks.

The current PMSE spectrum masks allow for 200 kHz transmission channels (Bundesnetzagentur 2011). Due to the high quality and low delay requirements, high rate channel coding with long interleavers is not acceptable. A digital PMSE system operating in the spectrum mask designed for analog frequency modulated systems needs to carry a 48 kHz, 16 bit signal. Assuming a coding rate of $R=2/3$, one needs to support a data rate of 1024 kbit/s in a 200 kHz channel, or a spectral efficiency of 5.12 bit/s/Hz. This corresponds to, e.g., a 64 QAM which is technologically difficult to realize and requires high SINR, thus leading to short transmission ranges. Supporting the same data rate in a 5 MHz bandwidth leads to a spectral efficiency of 0.20 bit/s/Hz, an information density that can be easily realized with robust constant envelope modulation at high ranges. Furthermore, by digitization and making use of time division multiple access (TDMA) or code division multiple access (CDMA), the overall system capacity can be significantly increased. Assuming that an FM signal needs a guard band of 100 kHz and that 25 audio signals are multiplexed in 5 MHz, this increase amounts to 33%. Using short frame lengths, the additionally introduced TDMA delay can be lower than 1 ms, while CDMA would not even introduce an additional delay at the cost of higher technological complexity. Finally, while today's analog PMSE devices are very susceptible to interference as every kind of interference is directly converted to an audible audio signal, digital PMSE devices will be able to mitigate interference through channel coding and minimize audible artifacts.

CONCLUSIONS

In summary, we propose to open parts of the lower UHF bands that are currently used for terrestrial television and PMSE equipment for high power WLAN access. This regulation will close the last remaining white patch in radio services for the common consumer and enable high range WLAN. Furthermore, higher power and 5 MHz bandwidth channels will allow for easy digitalization of the current legacy analog PMSE equipment leading to more efficient use of spectrum.

Another step toward more efficient spectrum sharing on a minimum interference basis will be regulation of receiver characteristics – only if a receiver shows the necessary selectivity, a certain quality of service can be guaranteed to a secondary (and primary) user.

We propose for both suggestions to be taken up in the WRC process, so that the technical details can be discussed with all stakeholders. Operating digital high power systems as secondary users in the TV bands will likely be the first step and is already being implemented in the USA as part of the “white space” regulation. We believe that the suggested geolocation database approach is cumbersome and only results in little additional customer value. A bold approach is necessary, especially in light of the progressing digitization of PMSE equipment.

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