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Using the lower UHF bands for commons & events

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Using the lower UHF bands for Commons & Events

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Abstract

An internationally harmonized regulation permitting unlicensed transmission in the lower UHF bands is proposed, e.g. in the 515–605 MHz range. Transmission power levels up to 2 W EIRP are envisioned. This would give citizens a share of the best spectrum for free use. Tools against congestion could be based on mandatory stochastic channel back-off or, if multiple users are present, on adaptive power and bandwidth control. Compared to the FCC TV white space regulation, no back link would be needed as the spectrum would be used exclusively by wireless devices. In an environment of shrinking interest in terrestrial TV broadcasting, such a regulation is expected to create a new market for high-range consumer devices, competing with licensed communication, while being also suitable for offloading traffic from licensed operations. Furthermore, the approach will allow for efficient digitization of equipment for programme making and special events (PMSE). To enable accurate interference prediction, we propose that, instead of only providing transmitter regulation, receivers should also be required to adhere to a certain minimum selectivity.

INTRODUCTION

This paper addresses four areas of use of the radio spectrum which would benefit from action:

1) What to do with 200-300 MHz of UHF spectrum used so far for television? There is a clear trend towards the use of cable and satellite broadcasting and towards Internet-based TV. The use of terrestrial broadcasting is declining in industrialized countries. In Germany, for example, there are discussions about replacing DVB-T with a tower overlay of 16 MHz via LTE, such as for sports broadcasting (Kürner et al. 2013). Private TV stations have lost interest in terrestrial TV transmission (Mediengruppe RTL Deutschland 2013). Consequently, at least 200 MHz of spectrum could be used for something else. These bands have very good propagation characteristics, that is their electromagnetic waves pass through walls with low attenuation but do not travel beyond the radio horizon.

2) There have been efforts to use the white space of the TV spectrum, in particular in the U.S. (cf. Digital Trends 2012, TV Technology 2012, PCAST 2012, Forge et al. 2012). Due to the large cell sizes of terrestrial TV broadcasting, there are white spaces in the spectrum that can be exploited on a listen-before-talk basis. The approach used by the FCC allows a high power

device to be employed only if it accesses a geo-location database, creating the necessity of a link. The regulation has not, however, created many new products, mainly due to its technological complexity. Because of the fear of interference, many bands cannot be used in many areas, but only in some of the "holes of a Swiss Cheese" (Forde, Doyle 2013). There is also the risk that the operator of the database will remain in control of the white space, if, for instance, an incumbent uses it for providing Internet access (as proposed by Fitch et al. 2011). Also, providing licenses to users might lock that spectrum for many years to come, even if those TV stations stopped operating.

3) Programme making and special events equipment (PMSE) such as wireless microphones would benefit from digitization. Currently, PMSE equipment uses the terrestrial TV spectrum as a secondary user, so if that TV spectrum is to be used for something else, PMSE devices need to adapt. The current PMSE spectrum masks allow for 200 kHz transmission channels (Bundesnetzagentur 2011). Since efficient digitization can only be achieved with broader channels, a change to the spectrum mask is necessary. It has been proposed that a 46 MHz band around 600 MHz be made available exclusively to PMSE operators (Kürner et al. 2013, cf. Figure 1). This, however, would leave that band sitting idle for most of the time in most areas.

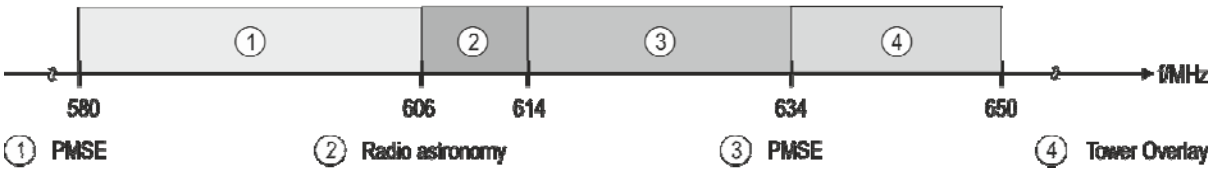

Figure 1: Exclusive PMSE spectrum according to Kürner et al. 2013. The gap of 8 MHz is for use by radioastronomy.

4) Mobile operators may wish to use all of the TV spectrum being freed for licensed communication for transmitting (e.g. video on demand) and for reducing the costs of base stations (cf. Chen 2012, Benkler 2012). However, history shows us that innovation has originated in technological competition, e.g. the discovery of multifunctional handsets using the mobile Internet. Is it possible to set up any competition between technologies?

The last item may need to be explained in more detail. Prime examples of technological competition are the competition between PDC and PHS or between cdmaOne and W-CDMA in Japan. These examples of competition between operators using different technologies led to uncertainty among competitors, each of whom felt they needed to introduce new services in order to address a possible loss of revenue, which might come about because they based their service innovations on the strengths of their respective technology. For example, PHS operators were able to undercut prices and reduce the weight and size of handsets, while PDC operators were able to offer handover (which PHS initially was not capable of), browsers and video cameras (a surprise on 2G). Furthermore, it was relatively cheap to provide music downloads by updating cdmaOne, while this was a challenge for W-CDMA. This way, technological competition led to the discovery of the mobile Internet with multifunctional handsets and flat rates. Later, Apple "only" needed to polish the user interface and distribute these innovations world-wide, with its iPhone. Details of these causalities have been presented in Weber and Wingert (2006) and Weber et al. (2011). Furthermore, competition between licensed and unlicensed

communication, such as between W-CDMA and WLAN, was helpful in developing markets and in determining which approach is economic under which circumstances. Wi-Fi has contributed to a reduction in average revenue per user although operators of the *Universal* Mobile Telecommunications System originally hoped that it would be used almost exclusively by for example businessmen, who, however, in many cases preferred to search for a hotspot instead. The competition from Wi-Fi led to a large upturn in the number of Wi-Fi-enabled devices, and unlicensed communication even overtook licensed communication in terms of the bits transmitted (Rethink Wireless 2013). Hence the challenge: Are more disruptions possible in the future which would contribute to a reduction in communication costs or to the development of new devices and markets?

In this paper, a field in the telecommunications regulatory landscape is described that could foster further innovation, namely communication up to the radio horizon with high data rates and without the need for licensed operation. This approach would at the same time also provide spectrum for new digital PMSE equipment. In order to limit the potential impact of interference on future wireless devices operating in the same spectrum, it is also proposed that quality guidelines be set for receivers.

In the remainder of this paper first the current regulation of commons is presented. Subsequently, a proposal is made for a commons band in the lower UHF frequencies with PMSE as a primary user.

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

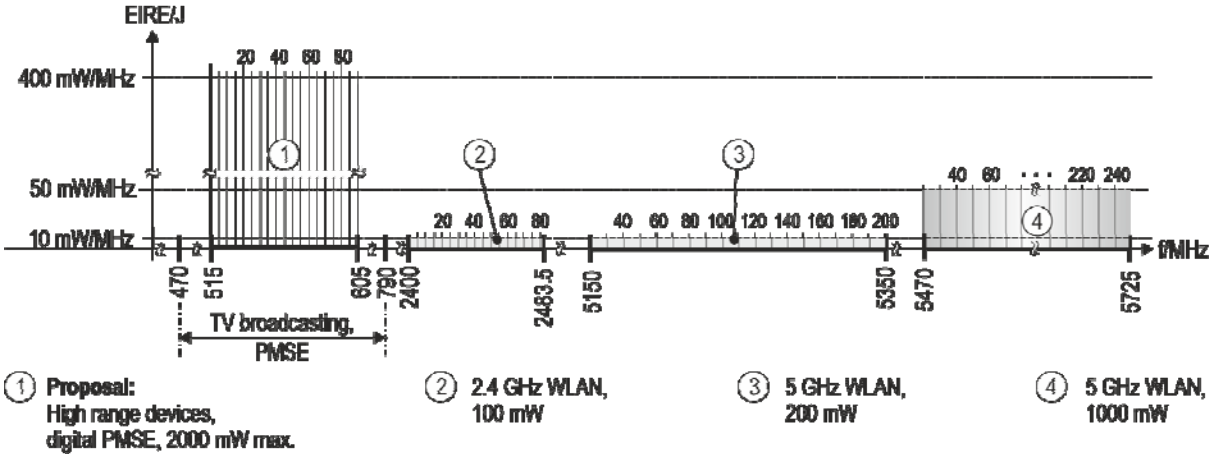

Figure 2: Current and proposed regulation of unlicensed wireless networks, German frequency ranges. The 515–605 MHz range is an example based on German and U.S. spectrum regulation (Bundesnetzagentur 2011).

CURRENT COMMONS REGULATION

Common knowledge, following scholars such as Cave et al. (2007), suggests that spectrum commons can be used where congestion is unlikely to occur, as in short range communications (p. 211). These authors also argue that the regulator can regulate power and politeness protocols in order to reduce congestion (pp. 207, 211). In line with this, commons is typically used in bands above 2 GHz, with a strong limit on the equivalent isotropically radiated power (EIRP). With such a justification, WLAN

has been crippled in terms of power, in the EU much more so than in the U.S. Figures 2 and 3 show the current WLAN spectrum regulation for TV white space as well as for 2.4, 3.7 and 5 GHz WLAN in Germany and in the U.S. Similar frequency ranges and constraints can be found all over the world.

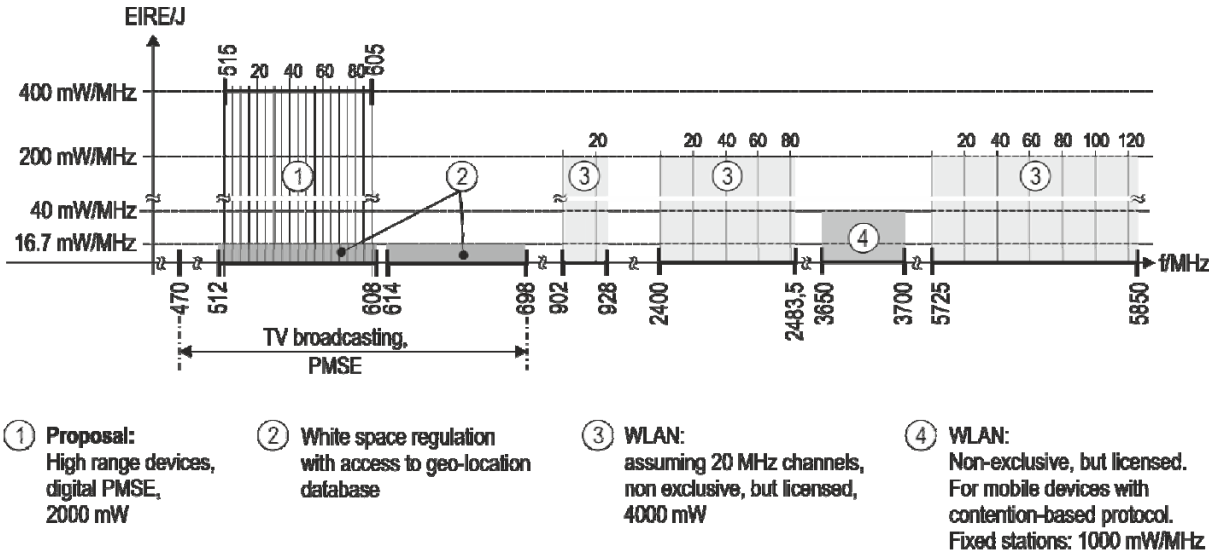

Figure 3: Current and proposed regulations for unlicensed networks, U.S. frequency ranges (FCC 2010, GPO 2013).

THE PROPOSAL

The question arises whether spectrum below 2 GHz should be licensed or unlicensed. Taking Cave et al. literally, at first sight, any band could be used with commons using politeness protocols. The usual answer, however, is that such spectrum can be used for licensed services, thus creating a market and contributing to GDP (following Coase 1959).

However, is it really the best approach to license services below 2 GHz, instead of using the commons approach? Traditional thinking, again following Cave et al., suggests that the economic value of a band should be maximised (pp. 3, 227), which can be judged based on the willingness of users to pay. However, society might be interested in maximising the effect on GDP. This means that a regulatory regime which leads to lower communications costs or higher revenues through the sales of related equipment or services can be better for GDP growth. Having some commons on UHF bands may have various effects:

- Communication costs may be lower, thus making it possible for a country to produce cheaper and therefore become more competitive internationally, just like with classic Wi-Fi. If a user does not find enough spectrum of sufficient quality in that free band, a user could still resort to paid high-range services or higher frequency WLAN instead. Devices could automatically select what is best.
- All things being equal, operators would, however, have fewer bands to use and hence would have higher costs for setting up transmitters, which might have an adverse effect on communications costs.
- On the other hand, operators could use surplus capacity on the new band for offloading traffic from mobile devices, much like with Wi-Fi, but over longer distances, and thus save costs.

- New services might emerge, which following Schumpeter would not be known a priori, but could lead to revenues or at least user satisfaction. For instance, if nodes are open and if meshing is easy, relatively large free mesh networks could emerge.
- The production of related components for commons communication could contribute to GDP growth, at least in the countries where the components are produced.

It appears it will not be possible to reliably estimate the net effect of such a reform a priori on GDP. However, based on widely regarded positive effects of Wi-Fi, a positive effect of high-range commons can be anticipated.

But one can also argue on a different level. One could say that the public should determine what it prefers. GDP maximisation needs not be the only guidance for the population to follow. Coase wrote (1959, p. 14):

"It is true that some mechanism has to be employed to decide who … should be allowed to use the scarce resource. But the way this is usually done in the American economic system is to employ the price mechanism."

This reminds us that applying economic maximisation is not a natural law. Citizens could rather argue: "Free communication with Wi-Fi is very useful and provided good competition to 3G. Let us do the same with greater reach. Give us at least a small share."

In this paper it is proposed that at least a 90 MHz fraction of the current TV and PMSE bands should be opened to transmission of up to 2 W EIRP (see Figures 2 and 3).

Tools against congestion could be based on mandatory stochastic channel back-off or, if multiple users are present, on adaptive power and bandwidth control.

In light of the current 2G/3G/4G standards and transmission properties, a channel bandwidth of 5 MHz is appropriate, with optional channel aggregation at the same radiated power and hence lower spectral density. 90 MHz would amount to 18 orthogonal channels, allowing six cellular-like networks with a frequency re-use factor of 3 to be operated. The exact location of a high-range network and of digital PMSE in the lower UHF band would be subject to international harmonization.

This approach would allow digitizing PMSE efficiently. Allocation of about 90 MHz would provide enough spectrum for a few hundred PMSE devices operating at one single event. PMSE devices need to be given higher priority than commons, e.g. according to a listen-before-talk protocol and possibly higher power allowances than other devices operating in that band. A bandwidth of 90 MHz would allow significant amounts of such communication, and a larger channel bandwidth of 5 MHz would allow for digitization, increasing the robustness of wireless links compared to analogue PMSE equipment as analogue PMSE equipment is too fragile to make efficient use of this spectrum in the presence of interference.

An important regulatory measure for all kinds of overlay systems, but especially for wide area networks, is the definition of the minimum requirements for all receivers operating in shared spectrum channels. A minimum quality of service can only be guaranteed to a secondary (and primary) user if a receiver exhibits the necessary selectivity. These requirements should be defined in terms of filter responses, selectivity and total noise figure. This technical information will make it possible to accurately estimate the effects that subsequent changes in spectrum regulation will have on incumbent users. Today such forecasts are largely left to the contradicting studies of lobbyists for various interest

groups. The approach presented would result in a more accurate estimate of an effect. This approach is a major change in traditional transmitter-only regulation, but provides a scientific basis for interference prediction in heterogeneous spectrum environments. High-range devices also offer a solution to the needs of the next generation of digital PMSE equipment for spectrum that, due to delay constraints, cannot utilize the features of digital transmission with the current spectral masks. Furthermore, the use of higher frequencies is undesirable due to higher body and material attenuation. A change in technology and spectrum mask regulation is necessary to achieve efficient digitization.

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 in digital PMSE systems. A digital PMSE system operating in the spectrum mask designed for analogue 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 64 QAM, for example, which is technologically difficult to realize and requires a high SINR, thus leading to short transmission ranges. Efficient digitization can hence only be achieved by broader channels, for which a change of the spectrum mask is necessary.

Supporting the same data rate of 1024 kbit/s, as discussed above, 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, the overall system capacity can be significantly increased by digitization and making use of time division multiple access (TDMA) or code division multiple access (CDMA). This amounts to a 50% increase, assuming that an FM signal needs a guard band of 100 kHz and that 25 audio signals are multiplexed in 5 MHz. Using short frame lengths, the additional 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 analogue 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 source and channel coding and thus minimize audible artefacts.

CONCLUSIONS

In summary, it is proposed opening parts of the lower UHF bands that are currently used for terrestrial television and PMSE equipment to high power unlicensed access. It has been shown that such "beachfront" spectrum can be regulated in a way to avoid congestion. Using the same band, PMSE equipment could be digitised. Such a combination will be more efficient than a band used exclusively for PMSE. At the same time, it would create competition to licensed communication and scope for innovative ways of backhauling and meshing. Surplus capacity could be used of offloading mobile traffic, as with current Wi-Fi. It is therefore proposed that these suggestions should be taken up in the World Radio Conferences process, so that the technical details can be discussed with all stakeholders.

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