RTT TECHNOLOGY TOPIC
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Neighbour friendly networks

The FCC was established in 1934 partly to sort out the US TV broadcasters who had been busy increasing broadcast power to the point where interference levels were becoming problematic. Nearly 80 years on the problems are similar but different.

The purpose of a regulator is to ensure that radio spectrum is used efficiently and fairly and delivers social and economic (and sometimes political) gain. Amongst other things this involves ensuring that spectrally and or physically proximate entities can co-exist.

In this month's technology topic we discuss the design and performance parameters that need to be specified and how these specification requirements will change in the future in order to ensure that spectrally and physically proximate devices and physically and spectrally proximate networks can happily live together.

Spectral interference – adjacent channel and in band

Spectral proximity is relatively easy to police. Transmit powers and spectral masks can be specified, expressed in standards and enforced through conformance procedures and/or carrier acceptance testing.

Adjacent channel leakage ratios are determined to ensure that devices within a system can co-exist and not cause interference to other devices and or other systems.

Spectral proximity can however be challenging when victim receivers need to receive weak signals. The problem that Light Squared had with GPS is a recent high profile example. Second order products from direct conversion transceivers and third and fifth order products from superhet radio front ends can also prove embarrassing. As the interference is in channel and in band it cannot be filtered out.

Spectral interference and front end compression

Receiver performance can also be compromised in other ways, some of which are equally hard to mitigate.

The Digital Television Group in the UK has been testing a range of TV receivers in the presence of possible interferers including TV White Space Devices and LTE handsets. http://www.dtg.org.uk/

As might be expected there are large differences between different TV receivers. Inconveniently the more expensive receivers tend to be more vulnerable to interference than lower cost receivers possibly due to better sensitivity and possibly due to better dynamic range.

This would seem odd as dynamic range provides protection against front end compression but the problem is in the automatic gain control circuits which are upset not by the strength of the interfering signal but by the short term periodicity of the signal. The result is that the AGC circuit turns down the front end gain and the picture disappears. Not what you want from your £10,000 big screen TV.

LTE handsets are unlikely to suffer this particular problem. Apart from other factors they are working over a much narrower band typically a few tens of MHz (30 MHz for example) whereas a TV front end will be covering the whole UHF band (over 300 MHz). In any case the front end receiver dynamic range has

to be able to cope with the locally transmitted uplink which will often be the strongest received signal even after duplex filtering.

It does however illustrate that receivers can behave in unexpected ways in the presence of signals which they were never previously expected to see.

This is a painful but useful experience given that White Space devices are also propositioned for use in other parts of the radio spectrum with adjacency to a wide variety of other networks. Academic research papers for example highlight the potential for radios that can opportunistically acquire radio channels anywhere between low band VHF and 3 GHz. That is not 30 MHz or 300 MHz but 3000 MHz of operational bandwidth.

That sort of bandwidth is available in military radios but not in small form factor low power budget consumer or low cost industrial devices.

You can of course buy smart phones today that will go from 700 MHz to 2.4 GHz but these are multiple radios in a box supporting discrete bands and discrete technologies. A quad band GSM, HSPA and 3 G and LTE 700 MHz iPad or iPhone for the US market is a contemporary example.

Getting a device to run **anywhere** across this bandwidth is significantly harder. Most RF designers would initially puzzle over how to design the antennas and matching circuits but actually it is equally hard to realize the receive only functions which will need to have sufficient dynamic range to manage any signal , wanted or unwanted, anywhere within the 3000 MHz

It is relatively easy to increase receiver dynamic range but the amount of current drawn by the low noise amplifier will increase as will the noise floor.

This is inconvenient because radios that opportunistically acquire spectrum have to be able to search and sense for available radio bandwidth and at some point devices end up measuring their own front end noise rather than the signals they are supposed to be sensing.

Increasing the amount of current drawn will also increase the power drain overhead of the search and sense algorithms. Smart phone users who leave Wi Fi enabled know how quickly this can flatten a battery. Power drain is obviously important for mobile and portable devices (including portable TV's) but also for battery driven fixed devices such as meter readers where duty cycles have to be measured in months or years. Duty cycle constraints can invalidate the most ambitious of business plans.

Finally a channel of interest has to be mixed out of the 3000 MHz This could be anything from a few KHz to tens of MHz wide and has to be presented to an A to D with sufficient bit width to handle the received signal. The A to D can therefore be an additional compression point. The answer is to increase the bit width but this increases the power drain and increases cost (memory and processing overheads).

Changing the performance of new devices does not of course resolve the issue of legacy device vulnerability. The present proposal is that interference into TV receivers from White Space devices and other devices such as LTE smart phones is managed by a commercial agency presently described as MITCO (Mitigation Company) with a budget of £180 million to be recovered from entities bidding for or using the spectrum.

The estimate of the number of homes affected is 2.3 million with a budget of up to £10,000 per house. This would be a worst case where a house could no longer receive (free) terrestrial broadcast and would need equipment replaced and compensation for having to use some other (not necessarily) free service (broadband or cable rather than Freesat). Even a few of these would blow the £180 million budget.

It is however premature to be negative about TV White Space and it is quite possible that a well implemented network with well-behaved devices could happily co-exist with the UHF terrestrial broadcast community. (See our April technology topic on machine to machine connectivity)

http://www.rttonline.com/tt/TT2012_004.pdf

But whether the approach would scale to a wider bandwidth must be open to question. This would imply that these devices could happily co-exist with present and future cellular networks in all present and future bands. The assumption is that mobile broadband OFDM will be more robust and resilient to interference which may or may not be true. The higher order modulation options on the downlink will be inherently sensitive to noise in the front end of an LTE smart phone. The dynamic range of the base stations on the uplink may or may not be adequate and will depend on what they have been specified to handle. This will not necessarily include high power and or close in White Space devices.

In last month's technology topic we argued that autonomous White Space devices could be awkward neighbours if required to co-exist with cellular and mobile broadband networks. To an extent this will be proven or disproven if and when White Space devices are deployed in the 700 MHz band but the mobile broadband industry already has many of its own co-existence issues to resolve. In refarmed spectrum new technologies need to co-exist with legacy technologies and wide band channels need to co-exist with narrow band channels. LTE Advanced with inter band channel aggregation introduces additional complexity.

Managing new sources of interference is therefore the last thing that most mobile operators need. The notion of White Space device coexistence with all networks in all bands is therefore significantly ambitious. It also includes the need to be a good neighbour to devices receiving signals from non-cellular networks such as geostationary and low earth orbit satellites and public safety radio networks. None of these network operators are going to be happy to accept even a modest risk of interference from White Space devices and or White Space networks.

The social and economic (and possible political) gain that could potentially be realized from White Space devices therefore has to be set against the increased risk of interference. Interference implies mitigation cost and if mitigation fails then litigation cost.

This suggests a need for a closer coupling of regulatory and competition policy with a brief to foster collaborative/cooperative rather than competitive business models that encourage TV broadcasters, cellular and mobile broadband operators and other stakeholders to work with rather than against White Space deployment – a new world of neighbour friendly networks. This would imply that White Space can be shown to deliver clear economic gain to these communities. How this would be achieved is not obvious but is a subject to which we will return in future technology topics.

Neighbour friendly networks are one of many topics addressed in RTT's latest book '**Making Telecoms Work- from technical innovation to commercial success'** published In January 2012 and available from the **RTT book shop.**

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RTT, the Jane Zweig Group and **The Mobile World** are presently working on a number of research and forecasting projects in the mobile broadband, two way radio, satellite and broadcasting industry. If you would like more information on this work then please contact **geoff@rttonline.com**

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