Assessing the 6 GHz RLAN studies

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Introduction

A number of studies that consider the potential for sharing between RLAN and other services in the 6 GHz frequency band have been completed in the recent period. Many of these studies have been submitted to CEPT SE45 which has discussed the study work and delivered two reports [1, 2]. Based on this study work, further discussion has taken place within CEPT FM57 which has also produced a report which recognises that sharing is possible but proposes severe constraints on RLAN operations [3].

What is the next step for administrations aiming to provide spectrum for RLAN services? A careful interpretation of the reports is required; this is especially the case for administrations looking to develop practical and forward-looking spectrum management policy.

This paper sets out some high-level discussion of the study methodologies used and the relative importance of these contributions to decisions made within spectrum management.

Inequalities

Approaches to numerical modelling of sharing inevitably involve simplifications and generalisations. It is also the case that the vast majority of spectrum sharing studies involve future systems with parameters that are not well defined; this has been the case with the 6 GHz RLAN studies.

In this uncertain environment it is sensible to exercise caution when modelling these problems; on the other hand, the modelling can quickly become over-conservative. At the extreme end are the worst case static analyses. With these studies, the assumptions are that all system parameter values and all other aspects of the problem (geometric, propagation, traffic levels, antenna alignments etc) take the least favourable values with respect to sharing potential.

The other end of the modelling scale is to assign a probability distribution to each variable aspect of the problem, and to account in some way for correlations between variables.

Both methods are legitimate and often both methods are required in a well-organised and extensive programme of studies.

To allow for an equal consideration of contributions from different sources, discussions within CEPT do not usually focus on the relative utility of these two approaches and this is apparent when reading the 6 GHz reports.

We argue that these two methods should not be assigned equal weights in any decision-making process on sharing and especially in discussions on practical implementation. This is because, in practice, we see enormous inequalities in the scope of these two study methods and in the potential for deep understanding of sharing potential. A reliance on worst-case modelling can unnecessarily hamper efforts to facilitate emerging radio services.

Worst case studies

Sharing studies are regularly performed using the Minimum Coupling Loss (MCL) methodology. Although MCL studies can be non-worst-case, these static analyses often model the worst possible interference scenario between a victim receiver and an interferer, based on for example:

- Line-of-sight interference
- Maximum transmitter power at the interferer
- Maximum antenna coupling

Calculations can be made for single-entry interference and the I/N ratio, say, which are then compared with a predetermined threshold. Violations of the threshold will suggest that additional losses are required on the interference path and may lead to the calculation of a minimum separation distance or minimum frequency separation between victim and interferer.

With a static analysis, these inputs can sometimes be combined arbitrarily leading to unreasonable focus on the unlikeliest of interference problems and, because probabilities are neglected, a weak link to the agreed inputs.

An example from the 6 GHz studies, see [1], is an MCL analysis of interference between RLAN and fixed links which includes a scenario where the RLAN interferer is located outdoors, radiating at maximum power with the antenna at a height of 1.5 m. According to the agreed distributions, the probability of the interferer's outdoor deployment is 0.02, the probability that an outdoor interferer radiates at maximum power is 0.0324 and the probability of the outdoor interferer's antenna being positioned at a height of 1.5 m is 0.95. Even with this large probability for antenna height, the involvement of an RLAN with these characteristics in the interference scenario has a joint probability of 0.000616 (0.02 x 0.0324 x 0.95). An earlier iteration of this analysis assumed an RLAN antenna height of 28.5 m which has a probability of 0.005 leading to a joint probability of 0.00000324. These low probabilities are obtained before we consider other inputs including the likelihood of potent interference geometries between the RLAN and fixed link receivers.

While it makes sense to explore worst-case events, it is very well understood that MCL can be conservative with respect to successful real-world spectrum sharing scenarios. CEPT ERC Report 101 [4] made the following observation in relation to adjacent band studies around twenty years ago:

'In the past, WG SE adjacent band compatibility studies utilised the Minimum Coupling Loss (MCL) method, based upon minimum receiver sensitivity, to determine both minimum frequency separation and, by the application of an appropriate propagation model, interference distances. However, concerns were raised regarding the pessimistic results given by this method, particularly since real systems operating on an uncoordinated basis, operate apparently quite satisfactorily with much reduced minimum separation distances.'

The results of the MCL analyses discussed above are used as a basis for arguments that sharing is only possible with severe constraints imposed on the interfering service such as low power indoor operations and very low power outdoor (unless further constraints are involved). There is no proper evaluation of the risks involved.

Statistical analyses

Statistical modelling can deliver a more balanced approach and, potentially, a deeper understanding of the risks associated with excess interference. A good Monte Carlo simulation will capture worst-case events *including* the probability of their occurrence and so an assessment of risk.

A whole range of inputs can be exercised and post-simulation calculations can be used to investigate various assumptions. Using Monte Carlo in the deployment domain, configurations of the interfering network can be exposed to an extensive investigation. Parameters such as location, antenna height, transmit power and antenna pointing can all be randomised according to agreed distributions. Fixed value parameters such as Duty Cycle and Polarisation Mismatch Loss may also be considered with the aim of bringing the model closer to the real-world radio interference environment.

With a statistical analysis, the results for a victim receiver can be presented in the form of an Interference Graph. This gives the probabilities that values on the x-axis, such as aggregate I/N ratios, are exceeded.

A statistical study is sometimes thought of as rather abstract, especially by those involved in practical frequency coordination work, but it can be used in a very practical way to seek out and expose worst-case scenarios. Because this method is able to deliver an extensive search of the simulation space, it can, while respecting agreed distributions, deliver improbable or even impossible events and investigation of the most potent interference events may be required.

This is particularly the case if real data is involved. For example, real fixed links data has been used in the recent 6 GHz simulations with randomly deployed RLAN interferers in the neighbourhood of the fixed link receivers. Monte Carlo might randomly assign antenna height to an RLAN interferer that violates the first Fresnel Zone on a fixed link's Line-of-Sight wanted path. Clearly such an assignment would imply that the fixed link planner has not respected Line-of-Sight planning conventions, leading to a potent but unlikely interference scenario. Such cases were investigated and then removed during the 6 GHz studies, highlighting one of the strengths of statistical modelling combined with careful analysis of the results.

Statistical analyses can be run in the deployment domain, where a large number of possible network deployments are investigated, or in the time domain, where time varying features of a network are exercised. In practice, models often combine some deployment domain and time domain features. Results can be difficult to interpret, especially when protection criteria associated with the time domain is considered. This features in the recent studies and is reported on in [2] where results for short-term interference are based on simulations in the “time-space” domain.

One very obvious pitfall with a statistical analysis, no matter how elaborate or extensive the study, is to assume that answers to all questions can somehow be derived from the results. In general, the results are more widely accepted when presented in a straightforward manner and with precise descriptions of inputs, simulations and outputs.

In general, a statistical study should lead to a good understanding of the interference problem including the probabilities associated with excess interference events. On this basis, such studies must carry more weight in the decision-making process than a simple worst-case analysis that sets out to highlight potent interference events that may actually have a low probability of occurrence.

Practical considerations

In general, CEPT studies neglect practical planning features that are everyday work for spectrum managers and engineers. This can lead to results and, later, decisions that are unnecessarily conservative.

One obvious example is the protection criteria used in sharing studies which are usually one step removed from practical planning. It is common practice to assess interference with respect to a threshold I/N ratio at the victim receiver. This allows for a specified degradation of noise. An I/N = -10 dB threshold, for example, allows for a 0.41 dB degradation. However, in the studies, there is usually no consideration given as to whether such an interference margin can easily be accommodated at the victim receiver or even if a larger interference margin is possible.

There has been much focus in the 6 GHz studies on interference into fixed links using Ofcom data but little attention paid to the large minimum fade margins of 35 dB assigned to these links in the UK. When links are planned such that the assigned EIRP is the minimum required to resolve the link’s availability requirement, there may well be scope to designate some excess fade margin as interference margin.

These and other considerations are important when spectrum management sets out to find a sharing solution, taking account of CEPT studies and results but also practical planning issues including best practice in day-to-day spectrum engineering work.

Conclusions

We have discussed, briefly, some aspects of the modelling in the 6 GHz studies. In general, these swing in favour of well-established incumbents, producing unnecessarily conservative results and recommendations.

The results and conclusions given in these reports should be read with a critical and sceptical eye. However, there are progressive arguments and modelling available. It is likely that many of the results showing excess interference could be resolved through more reasonable modelling and practical spectrum management.

References

[1] ECC Report 302 (2019), Sharing and compatibility studies related to Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) in the frequency band 5925-6425 MHz.

[2] ECC Report 316 (subject to approval May 2020), Sharing studies assessing short-term interference from Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) into Fixed Service in the frequency band 5925-6425 MHz.

[3] CEPT Report 73 (2020), Report from CEPT to the European Commission in response to the Mandate “to study feasibility and identify harmonised technical conditions for Wireless Access Systems including Radio Local Area Networks in the 5925-6425 MHz band for the provision of wireless broadband services”, Report A: Assessment and study of compatibility and coexistence scenarios for WAS/RLANs in the band 5925-6425 MHz.

[4] CEPT ERC (1999), ERC Report 101, A Comparison of the Minimum Coupling Loss Method, Enhanced Minimum Coupling Loss Method, and the Monte-Carlo Simulation.

How we can help

We can help spectrum managers and service providers analyse the CEPT Reports including the provision of:

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