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Title	**Impact of buildings on Mesh to PMP Co-channel Interference**
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Re:	Coexistence task group activities in session # 15
Abstract	This paper shows the effects of buildings on the required geographical spacing between co-channel FBWA systems, where one system is a mesh (or possibly a collection of point to point links) and the other system is a conventional 802.16 or similar PMP system.
Purpose	For consideration in the TG2 meeting at session # 15
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Impact of buildings on Mesh/PP to PMP Co-channel Interference

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1. Introduction

This paper is provided for general interest and as a source for possible additional content for the existing part 1 of the Coexistence Recommended Practice. It shows the effects of buildings on the required geographical spacing between co-channel FBWA systems, where one system is a mesh (or possibly a collection of point to point links) and the other system is a conventional 802.16 or similar PMP system.

Mesh systems make use of terrain and buildings, combined with use of low transmit power and relatively short links, to reduce interference. The reduction in interference serves two functions:

- it reduces internal interference, thus allowing increased frequency reuse and significantly improved spectral efficiency.
- It reduces external interference, so that geographical spacing and guard bands can be reduced.

In this paper, the impact of buildings on coexistence of a mesh system is calculated, using a simulation tool. The simulator computes the cumulative interference from a mesh system into a victim receiver, which may be a PMP base station, PMP terminal station or a mesh node station. For the purposes of this document, only the most severe case (the PMP base station) is examined.

Since a mesh system is designed specifically to make use of buildings for reduction of interference, the model includes additional path losses due to buildings, using a methodology adapted from that used in the RAL CRABS report [4].

The impact of buildings is varied in the model by means of a parameter describing the distribution of building heights (Rayleigh parameter).

2. Simulation Methodology

The simulator computes the power received from a complete MP- MP system (mesh) at a PMP base station receiver, a PMP subscriber station receiver or other victim receiver, in a cell adjacent to the mesh. The simulation is performed using a purpose-written program, which repeatedly constructs random (but adequately legitimate) MP-MP (mesh) systems and integrates the total power received at a given range and elevation, based on system, beam and terrain geometries.

A description of the simulation tool is provided in 802.16 contribution C802.16.2a-01/02 [10] and will therefore not be repeated here.

The main analysis and all the results presented are based on systems operating in the 24- 28GHz band, but can be applied to any frequency up to at least 43.5GHz.

2.1 Interfering Power Calculation

From each mesh transmitter and in line with the line of sight probability, the power received by the victim base station is computed. All these powers are summed, and the result rounded to the nearest dBm and assigned to a histogram bin, so that the relative probability of each power level can be estimated.

3. Simulation Results

In order to assess the impact of different building heights, the parameters in the simulation tool were set as follows:

- Frequency = 28 GHz
- victim receiver = bases station with 90 degree sector antenna and 19dBi gain
- distance from mesh edge to base station = 12km (any value can be set)
- mesh link lengths from 50m to 1000m
- mesh nodes placed 1m above roof height in all cases
- mesh antenna gain = 25dBi
- Rayleigh parameter (building height distribution) varying from zero to 20m

The only parameter varied between simulation runs was the Rayleigh parameter. This characterises the building height distribution curve, so that a value of zero would mean that there are no buildings, whilst a value of 20m would be a reasonable figure for a city. An example taken from real data, for the large city of Leeds in the UK, indicates a best –fit value of R=40.

Each simulation run was based on 10,000 trials, in which each trial represented a separate random mesh with 100 nodes per sq km. A cumulative distribution curve was produced for each run, showing the probability that the total interference received at the victim station was less than a particular value (x axis of the graph). The results are shown in figure [1] .

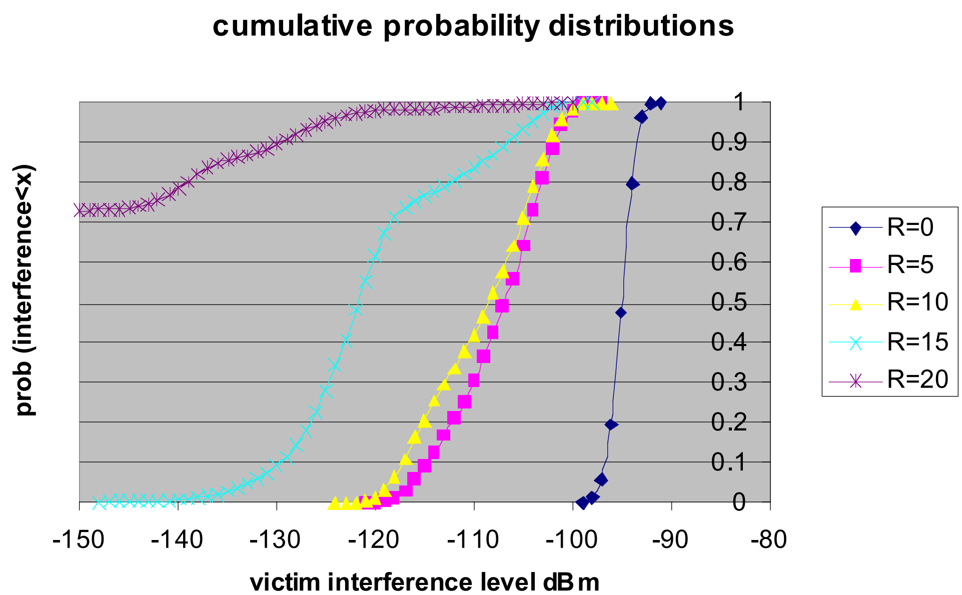

Figure 1: Interference plotted as cumulative probability curves as function of R

It can be seen that for all significant (non – zero) values of the Rayleigh parameter R, buildings have a significant impact on the level of interference. The target maximum level for interference is nominally –100dBm (-114.5dBm/MHz).

For values of R in the range 5<R<20 the proportion of the random meshes that exceed the threshold is very small, so the 12 km spacing is likely to be a reasonable value in the great majority of deployments.

For the case where there are no buildings, the highest value is 7-8 dB above the threshold, so that a wider spacing would then be required. However, a mesh would not be deployed when there are no buildings on which to mount nodes. This scenario is therefore highly pessimistic and an unrealistic representation of real deployments.

4. Conclusions

Buildings have a significant and extremely useful effect on interference from a mesh system, reducing the required co- channel system spacing by a factor of approximately 2. This effect does not rely on the use of any additional mitigation technique and is derived from a simple assumption that all mesh layouts are random. Even relatively low buildings are effective in reducing interference, because mesh nodes are placed at or near building height rather than on tall masts.

Even with no buildings, the co-channel spacing is similar to or less than that recommended for PMP systems in SE19 report [3].

5. Further work

It is proposed to carry out further simulation work for the same area, adjacent channel scenario. A modified version of the simulation tool described above has been used to indicate that a single guard channel is sufficient to reduce the number of instances of interference above the –114.5 Bm/ MHz threshold to a negligible level. This tool can be adapted to handle a range of building distribution values (R).

5. References

[1] ETSI TM4 Technical Report DEN TR 4120;
[2] IEEE; Recommended Practice for Coexistence of Fixed Broadband Wireless Systems
[3] ERC Report; "SE19 Report on the analysis of the coexistence of two FWA cells in the 24.5-29.5GHz bands".
[4] ACTS Project 215, Deliverable Report D3P1B; Cellular Radio Access for Broadband Services (CRABS)
[5] ITU-R P.838; "Specific attenuation model for rain for use in prediction methods"
[6] ITU-R P.452-8; "Prediction procedure for ... microwave interference ..."
[7] ITU-R P.676-3; Atmospheric attenuation
[8] ITU-R P.840-2; Rain attenuation
[9] ETSI EN 301 215-2,V1.1.1; Antennas for use in PMP systems (24GHz to 30GHz)
[10] C802.16.2a-01/02: Coexistence between point to point links and PMP systems by Philip Whitehead, August 2001

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