

Overlapping BSS Analysis of Channel Requirements

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Authors:

Name	Affiliations	Address	Phone	email
Graham Smith	DSP Group	2491 Sunrise Blvd, #100, Rancho Cordova, CA 95742	916 851 9191 X209	Graham.smith@dspg.com

Abstract

The objective is to carry out an analysis of OBSS with the intention of determining the criteria and features that will be used in a OBSS solution

Using empirical propagation formula, the number of overlapping networks is estimated for various residential scenarios.

A Channel Selection search simulation program is then used to estimate the overlapping probabilities for each scenario.

The results are then analyzed.

Propagation Formula

Indoor propagation loss formula (11n) *,

F in MHz, d in feet

For $d < 16.5ft$

$$L_p = -38 + 20 \log F + 20 \log d + \text{Wall/Floor loss}$$

(Free Space formula)

For $d > 16.5ft$

$$L_p = -38 + 20 \log F + 20 \log 16.5 + 35 \log (d/16.5) + \text{Wall/Floor Loss}$$

Std. Dev 3-4dB (Shadow Loss)

*Erceg et al (2004) as per 11n, Channel Model B – Residential

- 10dB Outer Wall loss has been used in calculations
- No internal wall or floor losses used in calculations

NOTE: “Indoor Propagation Empirical Formula with Testing in a typical Californian Home”, Graham Smith 2004

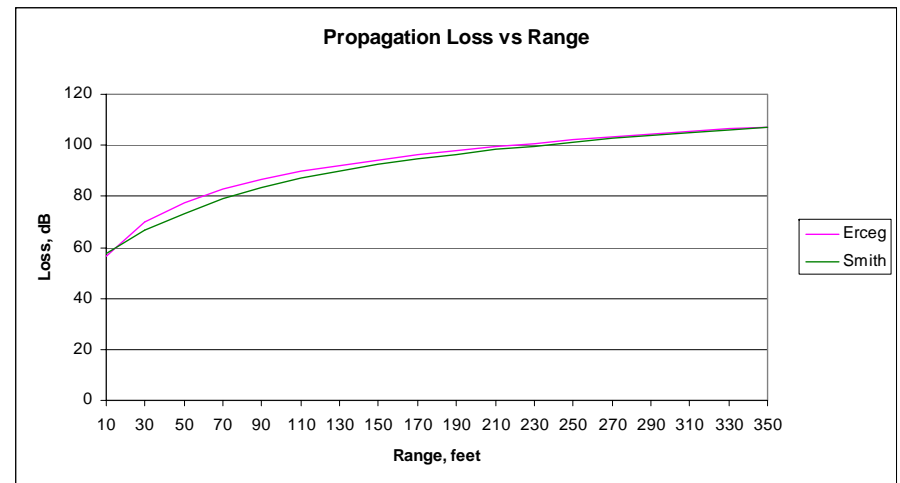
For $d < 35ft$

$$L_p = -38 + 20 \log F + 20 \log d + \text{Wall/Floor loss}$$

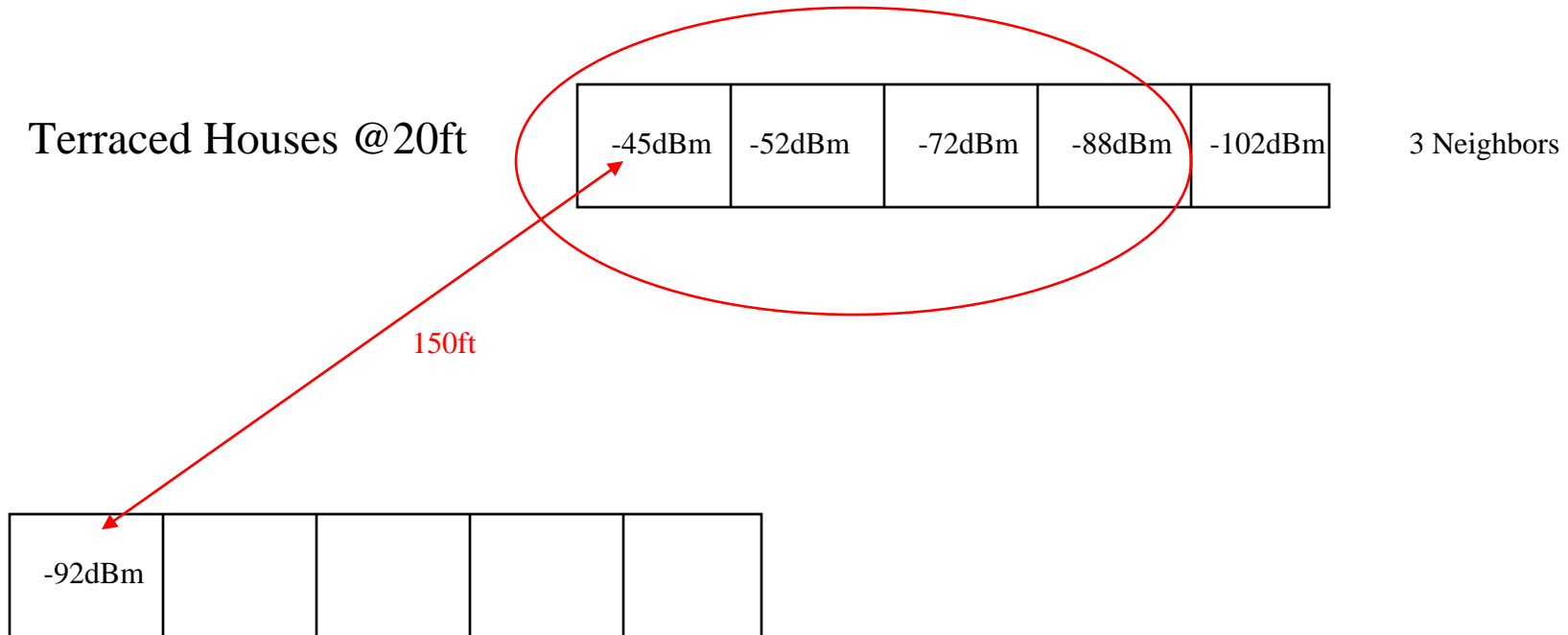
For $d > 35ft$

$$L_p = -69 + 20 \log F + 40 \log d + \text{Wall/Floor Loss}$$

Measured std dev of error = 4.5dB



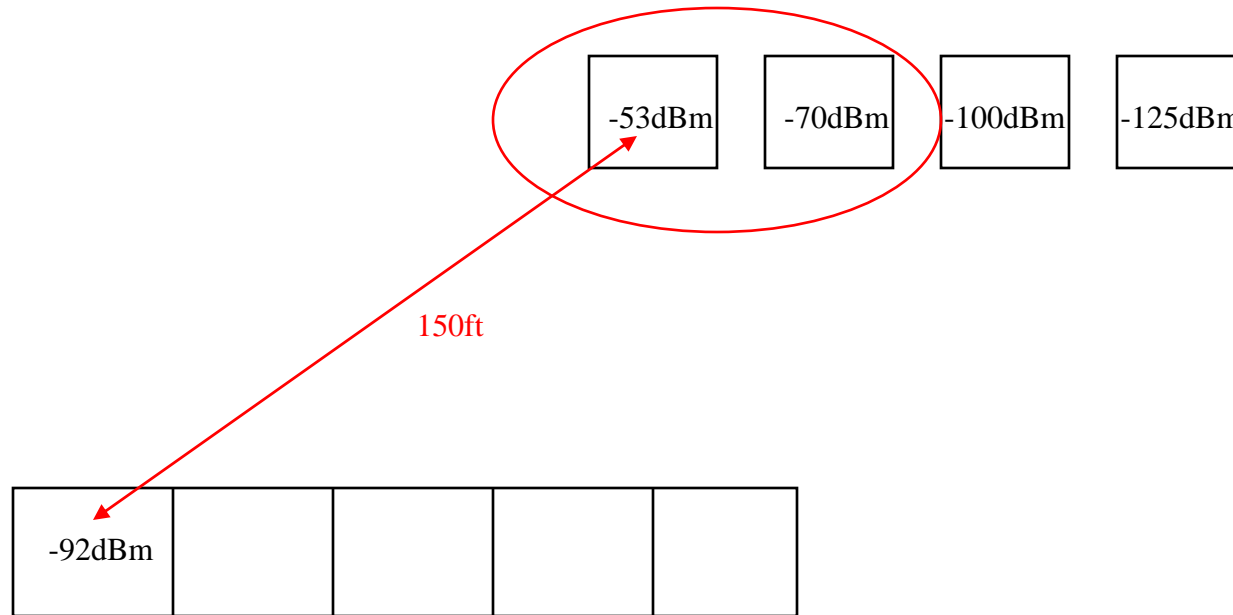
Terraced/Town Houses



Neighbors 3 houses down, and opposite houses within 150 feet have potential to overlap

Note: No internal wall losses, external wall loss only.

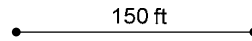
Detached Houses



Neighbors 1 house down, and opposite houses within 150 feet have potential to overlap

Detached Houses

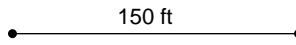
Woking, England



12 Potential APs in range

Town Houses - Dense

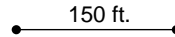
Bleiswijk, The Netherlands



25 Potential APs in range

Terraced Houses

Leigh Park, Havant, England



16 Potential APs in range

Summary

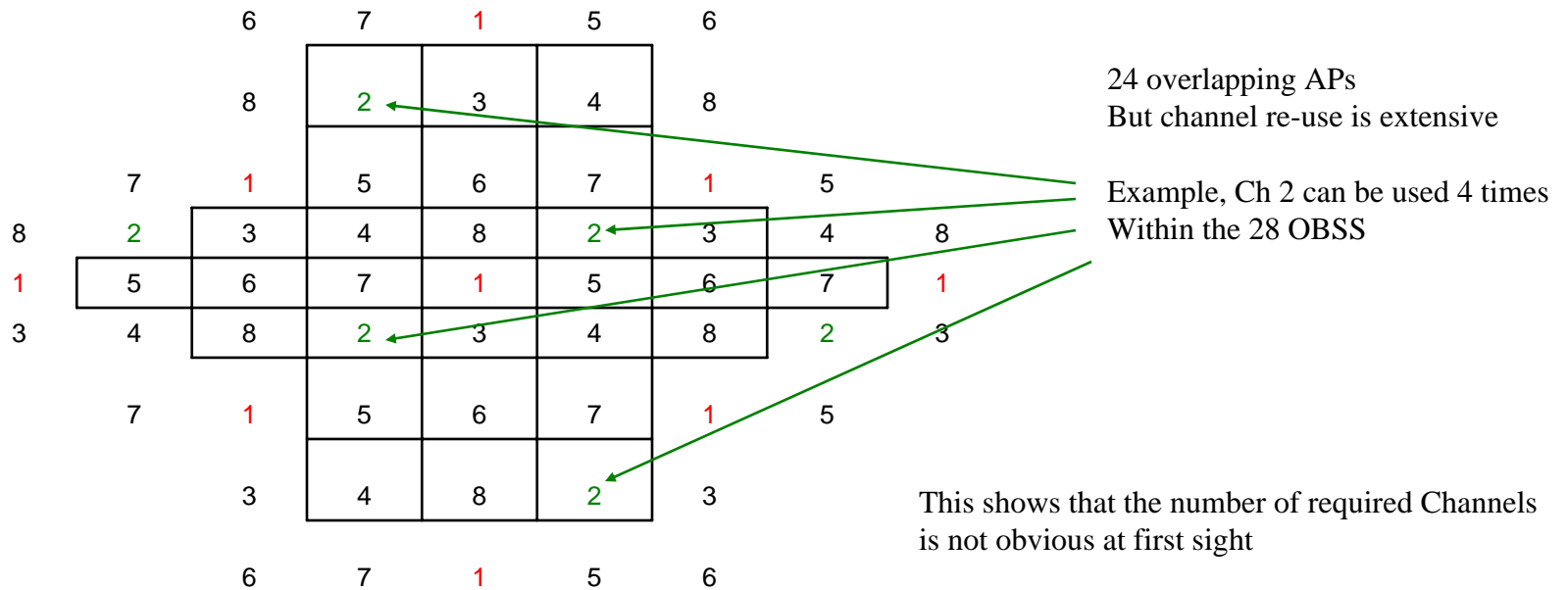
- **Examples used show maximum potential number of APs within range**
 - Detached Houses 12
 - Terraced Houses 16
 - Townhouses 25
 - Single Layout Apartments 28
 - Double Layer Apartments 53

- **Number of Channels**
 - 2.4GHz 20MHz 3
 - 5GHz 20 MHz 24 USA, 19 Europe
 - 40MHz 11 USA, 9 Europe

Minimum number of Channels

Apartments single layout

In fact, if one applied standard channel re-use to the Apartment single layout, 28 overlapping APs, only 8 channels are actually required.



Channel Selection Analysis Program

- **A program has been written in order to analyze what happens when each AP uses a Channel Selection scheme.**
- **The objectives are:**
 - Determine how many channels are required to ‘guarantee’ zero or one overlaps
 - Investigate the overlap situation and “AP chains”
 - Use results to determine requirements for the OBSS solution

AP Channel Selection Analysis Program

Set-Up

- **Set up an Apartment block or block of houses, e.g.:**
 - Number of Apartments per floor
 - Number of floors
- **Select number of Channels (24 max)**
- **Select percentage of Apartments/Houses to be assigned**
- **Select number of times to run through the program**
 - So as to obtain a reasonable variation (e.g. run 100 times and gather the results)

Program outline

- **Randomly select an Apartment/House**
- **Scan the surrounding apartments/houses in range**
 - First select channel(s) with least other APs
 - If more than one, then select channel with least total overlaps
 - E.g. Channel 1: 2 other APs, 1 overlap (one AP already sharing)
 - Channel 2: 2 other APs, 0 overlaps.
 - Selection will pick Channel 2
- **Update each apartment/house with the number of other APs with which it is sharing**

Program Inputs used for Reported Results

- **Number of Channels**
 - 24, 22, 19, 17, 11, 9
 - Representing maximum 20MHz for USA and Europe: 24 and 19
 - Say 2 channels lost to radar: 22 and 17
 - 40MHz channels: 11 and 9
- **Scenarios**
 - Detached House 12 others in range
 - Terraced Houses 16 others in range
 - Town Houses 24 others in range
 - Apartment single block 28 others in range
 - Apartment Double Block 53 others in range
- **Number of apartments/houses**
 - Apartment blocks 10 x 10 (x 2) 100 for single, 200 for double
 - Houses Block of 100 Houses
- **Percentage Apartments/houses assigned 10% to 100%**

Program Outputs

Over the total number of times the program is run (usually 100)

- **The Total number of apartments/houses assigned channels**
 - **Optional print out of Assigned Channel and Overlapping Matrices**
 - **The number of apartments/houses that are sharing, as a fraction,**
 - Zero others
 - Zero or just one other
 - Two others
 - Three or more others
- Possibility of a ‘hidden’ AP
- Definite AP Chain situation

Detached Houses – 12 overlaps

Possibility Zero overlap

Channels	% Houses Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Channel Selection finds a clear channel – same result if Channel Only or Channel plus Overlaps selection

3 Channels does not work

Percentage of Houses to be assigned:100

Probability of no overlaps: 0.1415

Probability of zero or one overlap: 0.5253

Probability of two overlap: 0.3551

Probability of three plus overlaps: 0.1195

Terraced Houses – 16 overlaps

Possibility Zero overlap

Channels	% Houses Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9998	0.9986
9	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9974	0.9880	0.9653	0.9144

Possibility Zero or 1 overlap

Channels	% Houses Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Town Houses – 24 overlaps

Possibility Zero overlap

Channels	% Apartments Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9986	0.9850	0.9624	0.9146
9	1.0000	1.0000	1.0000	1.0000	0.9988	0.9823	0.9437	0.8731	0.7917	0.6981

Possibility Zero or 1 overlap

Channels	% Houses Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9992	0.9967

With 11 Channels
100% chance that zero
Or single overlap

Possibility 2 overlap

Channels	% Houses Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0008	0.0033

0.3% chance of a
Hidden AP situation

Possibility 3+ overlaps (AP Chain)

Channels	% Houses Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Single Apartment Block – 28 overlaps

Possibility Zero overlap

Channels	% Apartments Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9709	0.9161	0.8400	0.7574
9	1.0000	1.0000	1.0000	0.9985	0.9796	0.9227	0.8227	0.7163	0.5912	0.4723

Possibility Zero or 1 overlap

Channels	% Apartments Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9998	0.9980
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9990	0.9948	0.9833	0.9579

With 17 Channels
100% chance that zero
Or single overlap

Possibility 2 overlap

Channels	% Apartments Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0020
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0053	0.1656	0.0386

0.2% chance of hidden AP
With 11 channels

Possibility 3+ overlaps (AP Chain)

Channels	% Apartments Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002

0.02% chance of AP chain
With 9 channels

Double Apartment Block – 53 overlaps

Possibility Zero overlap

		% Apartments Assigned Channels									
Channels		10	20	30	40	50	60	70	80	90	100
24		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9952	0.9649
22		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9930	0.8497	0.8997
19		1.0000	1.0000	1.0000	1.0000	1.0000	0.9987	0.9854	0.9308	0.9200	0.7402
17		1.0000	1.0000	1.0000	1.0000	0.9990	0.9885	0.9239	0.8338	0.7164	0.6019
11		1.0000	1.0000	0.9887	0.9198	0.7556	0.5788	0.4101	0.2809	0.1803	0.1017
9		1.0000	0.9960	0.9233	0.7364	0.5067	0.3130	0.1801	0.0996	0.0600	0.0350

Possibility Zero or 1 overlap

		% Apartments Assigned Channels									
Channels		10	20	30	40	50	60	70	80	90	100
24		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
22		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9992
17		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9986	0.9927
11		1.0000	1.0000	1.0000	1.0000	0.9968	0.9858	0.9460	0.8635	0.7342	0.5928
9		1.0000	1.0000	0.9997	0.9984	0.9854	0.8748	0.7484	0.5682	0.4134	0.2850

99.27% chance of zero or one overlap
With 17 channels

Possibility 2 overlap

		% Apartments Assigned Channels									
Channels		10	20	30	40	50	60	70	80	90	100
24		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0008
17		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0014	0.0073
11		0.0000	0.0000	0.0000	0.0000	0.0032	0.0144	0.0536	0.1312	0.2411	0.3444
9		0.0000	0.0000	0.0003	0.0036	0.0343	0.1208	0.2276	0.3535	0.4140	0.4157

0.73% chance of 2 overlaps with 17 channels

Possibility 3+ overlaps

		% Apartments Assigned Channels									
Channels		10	20	30	40	50	60	70	80	90	100
24		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0053	0.0247	0.0830
9		0.0000	0.0000	0.0000	0.0000	0.0003	0.0044	0.0240	0.0783	0.1727	0.2993

With 17 Channels no cases of 3 overlaps

Double Apartment Block – 53 overlaps –Not using overlap selection

Possibility Zero overlap

Channels	% Apartments Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9959	0.9650
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9956	0.9625	0.8929
19	1.0000	1.0000	1.0000	1.0000	1.0000	0.9992	0.9834	0.9247	0.8406	0.7364
17	1.0000	1.0000	1.0000	1.0000	0.9998	0.9821	0.9305	0.8199	0.7038	0.5862
11	1.0000	1.0000	0.9957	0.9116	0.7570	0.5763	0.4222	0.2953	0.2073	0.1390
9	1.0000	0.9995	0.9273	0.7253	0.5255	0.3508	0.2249	0.1373	0.0866	0.0510

Possibility Zero or 1 overlap

Channels	% Apartments Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9997	0.9976
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9990	0.9959	0.9915
17	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9991	0.9956	0.9858	0.9687
11	1.0000	1.0000	1.0000	0.9976	0.9862	0.9514	0.8943	0.7980	0.6847	0.5720
9	1.0000	1.0000	0.9983	0.9810	0.9310	0.8304	0.6949	0.5523	0.4211	0.3200

Compare to previous slide

Channel Selection using the number of overlaps is better

Possibility 2 overlap

Channels	% Apartments Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0023
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0041	0.0084
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0009	0.0044	0.0138	0.0307
11	0.0000	0.0000	0.0000	0.0024	0.0132	0.0470	0.0997	0.1821	0.2654	0.3259
9	0.0000	0.0000	0.0017	0.0186	0.0657	0.1516	0.2574	0.3307	0.3662	0.3582

Possibility 3+ overlaps

Channels	% Apartments Assigned Channels									
	10	20	30	40	50	60	70	80	90	100
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0006
11	0.0000	0.0000	0.0000	0.0000	0.0006	0.0016	0.0060	0.0200	0.0498	0.1020
9	0.0000	0.0000	0.0000	0.0004	0.0033	0.0180	0.0477	0.1170	0.2127	0.3218

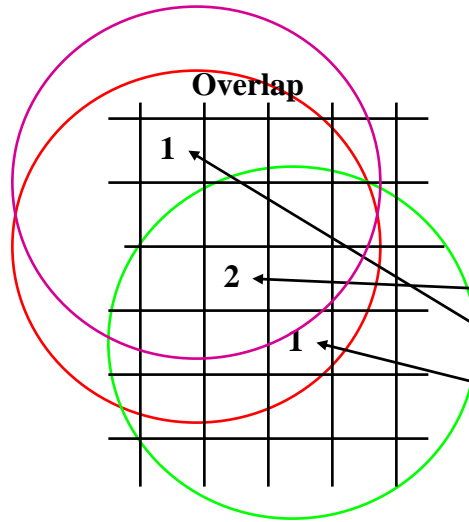
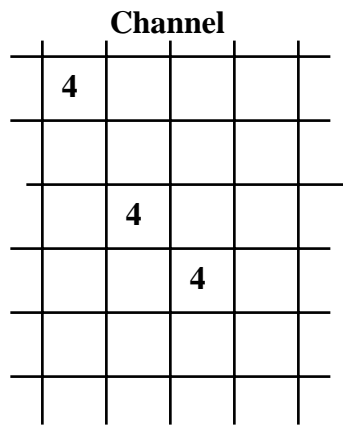
**Before we analyze these results,
I want to divert to look at what
2 or 3+ overlaps indicates**

**1 overlap is clearly the basic OBSS.
Two APs hear each other and can communicate**

**Next slides are examples of outputs
where deliberately low number of channels
chosen to force 2 and 3 overlaps**

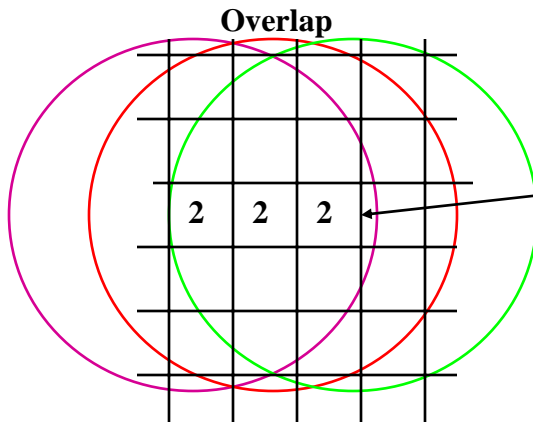
HIDDEN AP

Assume APs advertise their overlaps



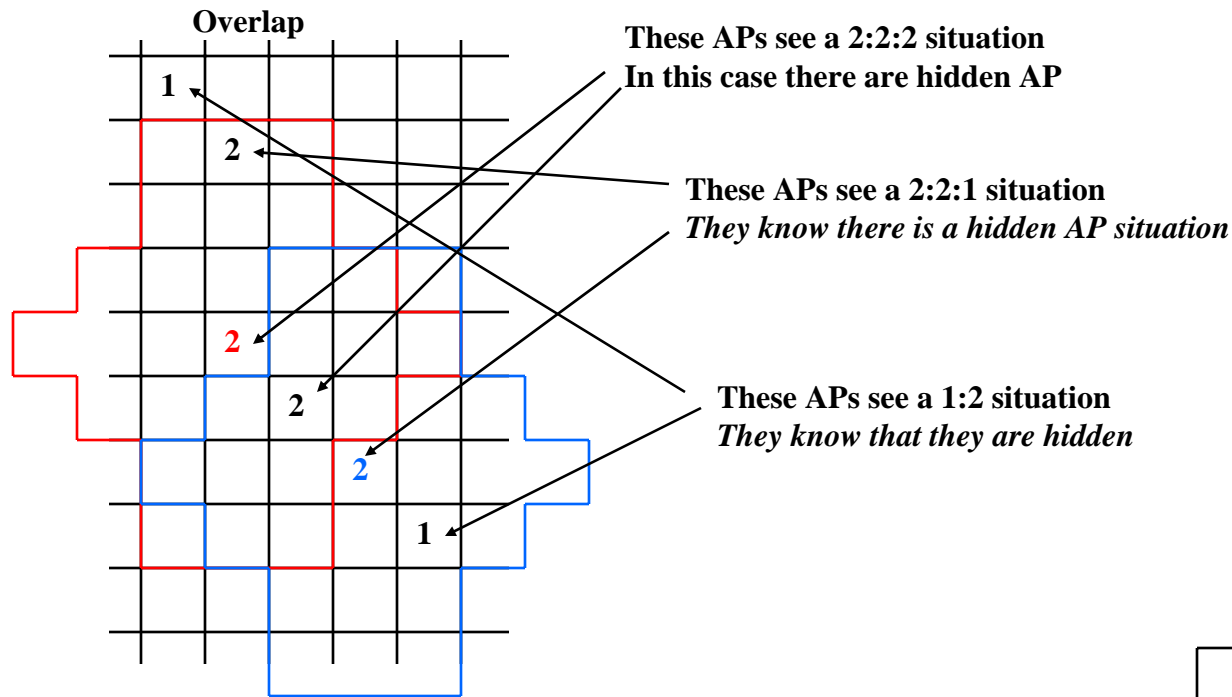
This AP sees 2:1:1
Knows that it is sharing with APs
That are not sharing with any other AP

These both see 1:2
Know that they are sharing with
an AP that is sharing with one other, that is hidden

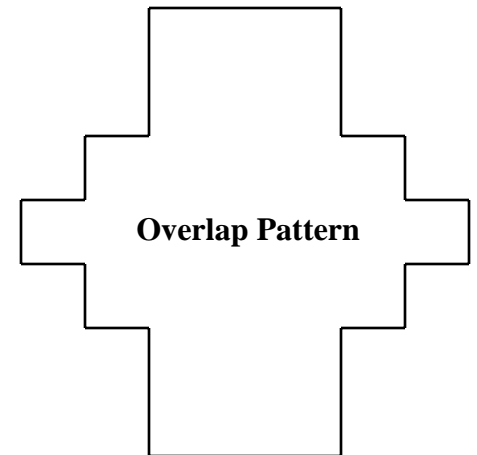


Each AP sees 2:2:2
Knows they are sharing with two others, who also share with 2 others
In this particular case, all APs see each other and no hidden APs
BUT ...See Next Slide

2:2:2 Situations – Hidden APs?



An unknown case is 2:2:2



3 Overlaps

Single Apartment Block, 28 overlap
10 x 10

Max number of channels: 7 to force bad overlap

1 1 0 1 0 0 1 1 1 0
 1 1 2 1 3 0 1 1 1 1
 1 2 1 2 1 2 2 1 1 0
 1 1 2 1 1 0 3 2 2 2
 1 1 2 2 3 2 2 1 2 1
 0 2 1 2 2 2 1 1 1 1
 1 1 1 1 1 1 3 2 2 1
 0 1 2 1 1 1 1 1 2 0
 0 1 1 1 2 1 2 1 1 1
 0 0 0 1 1 1 1 1 0 0

2 2 1 3 6 7 1 1 4 2
 5 5 4 3 4 2 5 3 7 3
 1 4 7 7 1 4 6 6 7 1
 1 3 6 2 1 3 5 2 5 4
 4 2 6 5 5 4 7 1 2 4
 0 6 3 5 7 6 1 3 5 2
 7 7 1 4 6 2 2 7 7 6
 3 5 1 4 3 3 5 4 6 1
 4 5 2 2 1 5 4 6 3 7
 1 6 3 7 7 4 1 2 5 4

Look at Channel 4 chain

This AP sees 3:2:2:2

These APs see 2:3:2

This AP sees 2:2:1

This AP sees 2:2:3

This AP sees 1:2

*In each of above
the AP knows there
is a hidden AP*

Identifying Hidden APs

Assuming QAPs advertise their overlaps

- We see following overlap situations; QAP A:QAP B: QAP C
- 0 No sharing
- 1:1 QAP A sees QAP B who sees only QAP A
- 1:2 QAP A knows that QAP B sees an AP that is hidden from QAP A
- 2:1:1 QAP A sees two APs who do not see each other
- 2:2:1 QAP A knows that QAP B sees an AP that is hidden from QAP A
- 2:2:2 Could be that all three QAPs see each other *but not sure*
- 3:1:1:1 QAP A sees three other QAPs, but knows that they do not see each other
- *3* Any other combination with a 3 implies hidden APs

Can we use this in any meaningful way?

Results for Channel Search

- **Number of available channels is really important**
 - Double apartment block with 53 APs in range
 - 17 Channels, 99.3% possibility of zero or 1 overlap - GOOD
 - 11 Channels, 59.3% possibility of zero or 1 overlap – NOT GOOD
 - Single Apartment Block, 28 APs in range
 - 11 Channels, 98.6% possibility of zero or 1 overlap – OK?
 - 9 Channels, 91.5% possibility of zero or 1 overlap – NOT TOO BAD?
 - Town Houses, 24 APs in range
 - 11 Channels, 99.4% possibility of zero or 1 overlap - GOOD
 - 9 Channels, 99.1% possibility of zero or 1 overlap - GOOD
 - Terrace Houses, 16 APs in range
 - 9 Channels, 99.8% possibility of zero or 1 overlap - GOOD
 - Detached Houses, 12 APs in range
 - 9 Channels, 100% possibility of zero or 1 overlap - GOOD

Channels Conclusions – 40/20MHz Channels

Use of 11 and 9 Channels

- **For “House” scenarios, 40MHz channels should be able to operate OK.**
- **For “Apartment” Scenarios, 40MHz channels can cause concern**

CONCLUSION

- **40MHZ channels should drop back to 20MHz when the overlapping situation becomes excessive.**
- **We need a workable method for 11n APs to decide when keeping to 40MHz channel is not the right thing to do (for their own sake as well as others)**

20/40MHz Operation

20/40 BSS Operation*

Co-Existence with neighboring BSSs is managed through a number of mechanisms, including:

- Overlapping BSS scanning and careful channel selection on initial BSS setup to avoid channels already in use by other BSSs.
- Changing channels or operating width after BSS setup if a new BSS is detected operating on the secondary channel

Also

- 40MHz Intolerance bit can be set by any STA, (7.3.2.61) but only for 2.4GHz
- 20/40 Intolerant Channel Report Element (7.3.2.59)
- Overlapping BSS Scan Parameters element (7.3.2.60)

**In high OBSS conditions, networks should fall back to 20MHz operation
NEED TO MAKE SOME RULES??**

* Reference: “Next Generation Wireless LANS: Throughput, Robustness and Reliability in 802.11n”, Eldad Perahia and Robert Stacey, Cambridge University Press 2008.

Channel Search Conclusions – Overlap Indication

- Channel Search algorithm is slightly better if the overlaps are used
- QAPs could indicate their overlap situation
- QAPs know if “hidden” QAPs are on same channel, if they know the overlap figures

Conclusion: Worthwhile that a QAP indicates its overlap situation

Summary

- **5GHz operation is necessary**
- **Channel Selection is required**
- **With Channel Selection, overlap with zero or just one other is a very common occurrence**
- **QAPs should indicate their overlap information:**
 - The Channel Selection is better
 - QAPs ‘know’ if there is a hidden QAP
- **40MHz channels is fine for many scenarios**
- **Need to ensure 40MHz channels drop back to 20MHz when the overlap is excessive**

These Points are now to be used in the OBSS Proposal “OSQAP”