TGaa OBSS Background

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Abstract

- **TGaa has been working on a proposal for OBSS. This work has included much background investigation that is considered to be of interest to TGac.**
  - What is the OBSS problem?
  - Sizing OBSS
  - Channel Selection
  - TGaa proposed solution “QLoad”
  - Sharing

What is the problem?

Effects of OBSS - 1

#	Network A	OBSS Network B	Effect	Result
1	**Legacy**	**Legacy**	**Traffic simply competes**	• **Reduced bandwidth in each network** • **No lost packets** • **Not recommended for streaming**
2	**EDCA**	**Legacy**	**Higher priority traffic in Network A will drive down traffic in Network B**	• **AC_VO and AC_VI traffic dominates. Could be OK for streaming traffic but no admission policy** • **Network A "wins"**
3	**EDCA**	**EDCA**	**Traffic competes on a priority basis. Networks compete on an 'equal' basis**	• **Reduced bandwidth in each network** • **No real protection for streaming traffic in either network**

Effects of OBSS - 2

#	Network A	OBSS Network B	Effect	Result
4	**Admission Control**	**Legacy**	**Higher priority traffic in Network A will drive down traffic in Network B**	• **AC_VO and AC_VI traffic dominates.** Could be OK for streaming traffic • **Network B bandwidth can be drastically reduced**
5	**Admission Control**	**EDCA**	**Traffic competes on a priority basis.** **Admission Control in Network cannot control traffic in Network B**	• **No protection for admitted traffic in Network A**
6	**Admission Control**	**Admission Control**	**Traffic competes on a priority basis.** **Admission Control in either Network cannot control traffic in other Network**	• **No protection for admitted traffic in either Network**

These cases are cause for concern, Admission Control is intended to provide QoS 'protection', and it breaks down in OBSS!

Effects of OBSS - 3

7	HCCA	Legacy	Scheduled TXOPs in Network A also apply CFP to Network B.	• Full protection for scheduled traffic in Network A • Network B bandwidth reduced
8	HCCA	EDCA	Scheduled TXOPs in Network A also apply CFP to Network B.	• Full protection for scheduled traffic in Network A • Network B bandwidth reduced
9	HCCA	Admission Control	Scheduled TXOPs in Network A also apply CFP to Network B Admitted traffic Network B is lower priority than scheduled traffic in Network A	• Full protection for scheduled traffic in Network A • Network B bandwidth reduced • Both Networks using TSPECS
10	HCCA	HCCA	Each HCCA AP will admit streams and allocate time to them BUT each AP and STA will obey the TXOP allocation of the other. No guarantee that each Network can allocate time when it needs to. ,	• Reduced protection for scheduled traffic in either network.

OBSS and QoS

1. For non-QoS (non-real time streaming) applications OBSS is simply a sharing or reduced bandwidth per network – Not a significant problem, if we assume DCF works!
2. OBSS is a significant problem ONLY when QoS is used AND when some ‘guaranteed performance’ is at stake

How big is the problem?

Propagation Formula

Indoor propagation loss formula (11n) *, F in MHz, d in feet

For d<16.5ft

Lp = – 38 + 20 log *F* + 20 log *d* + *Wall/Floor loss* *(Free Space formula)*

For d>16.5ft

Lp = – 38 + 20 log *F* + 20 log *16.5* + *35* log *(d/16.5)* + *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

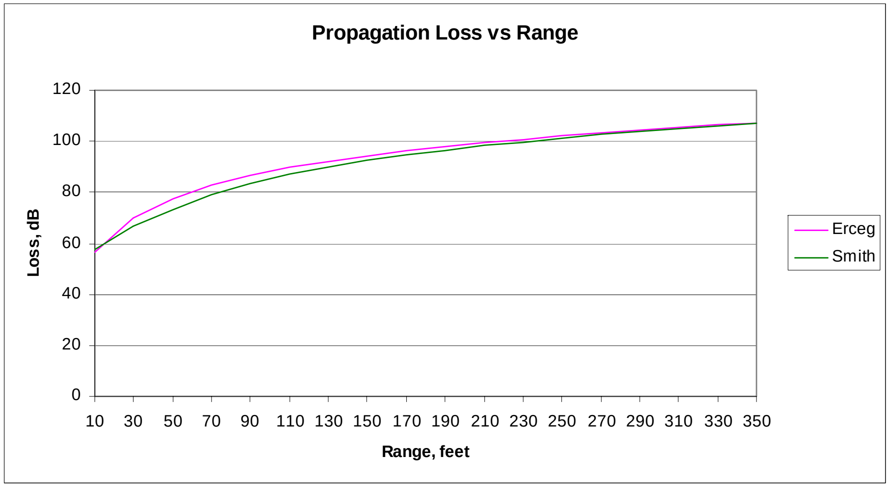
For d<35ft

Lp = – 38 + 20 log *F* + 20 log *d* + *Wall/Floor loss*

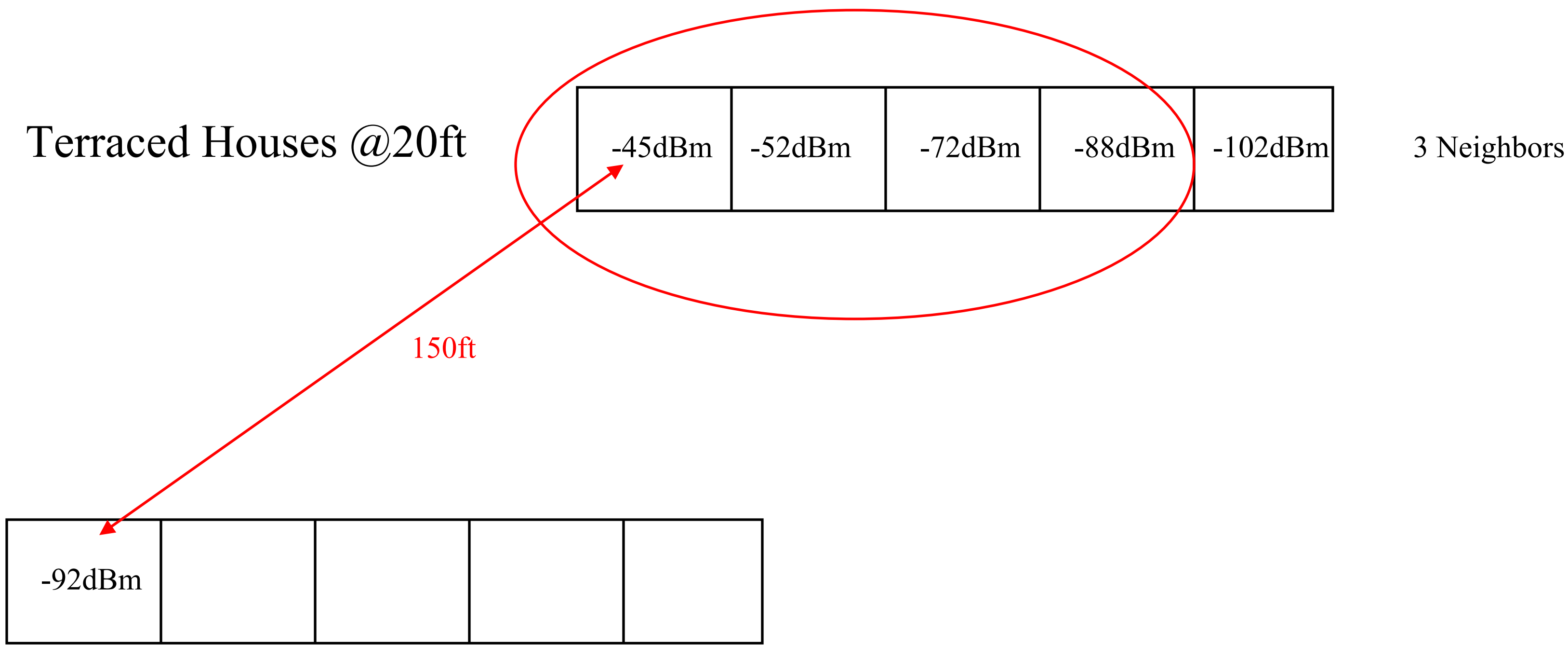
For d>35ft

Lp = – 69 + 20 log *F* + 40 log *d* + *Wall/Floor Loss*

Measured std dev of error = 4.5dB



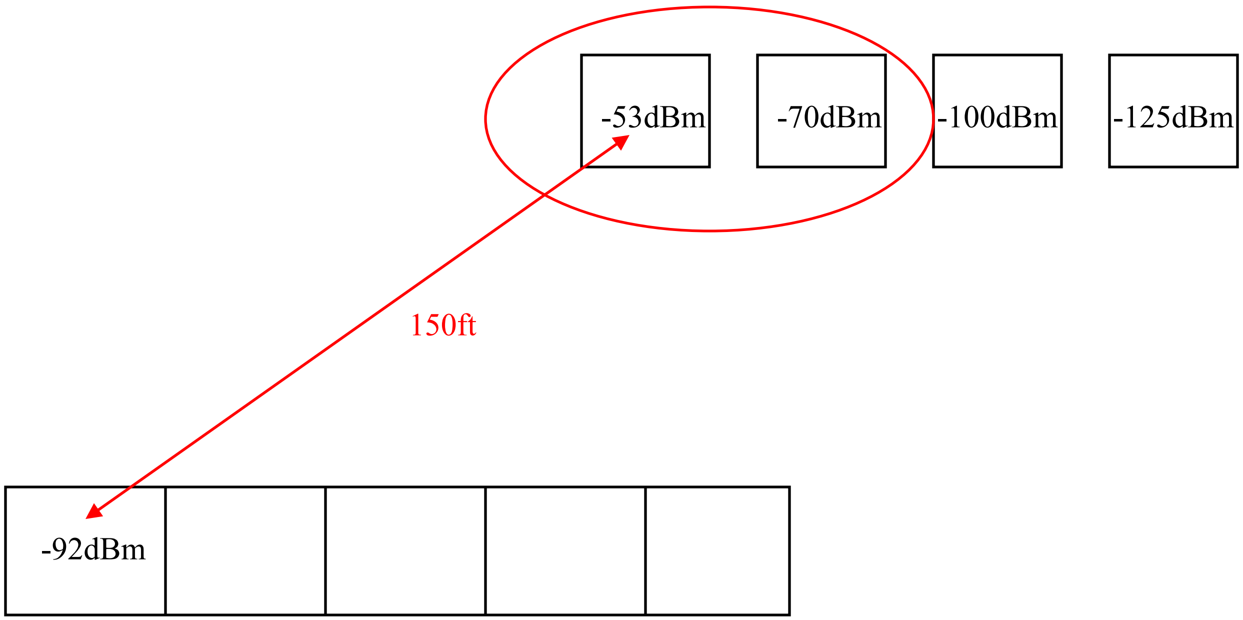
Terraced/Town Houses



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

12 Potential APs in range

Town Houses - Dense

Bleiswijk, The Netherlands

150 ft

25 Potential APs in range

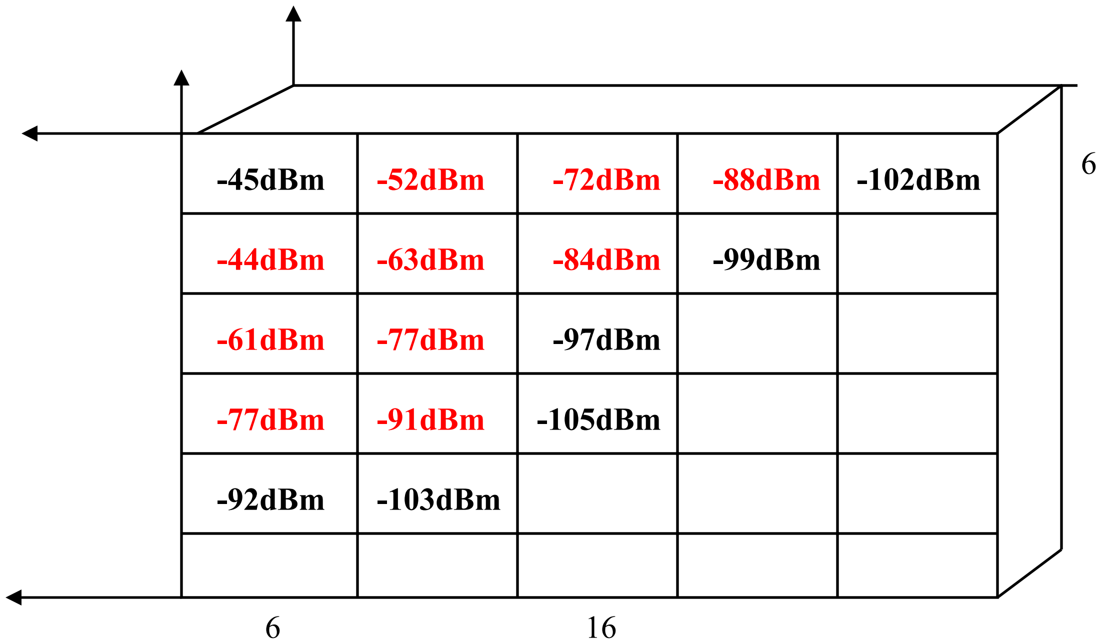
Terraced Houses

Leigh Park, Havant, England

150 ft.

16 Potential APs in range

Apartment Block Single Layout



		-91	-77	-91		
		-77	-61	-77		
	-84	-63	-44	-63	-84	
-88	-72	-52	-45	-52	-72	-88
	-84	-63	-44	-63	-84	
		-77	-61	-77		
		-91	-77	-91		

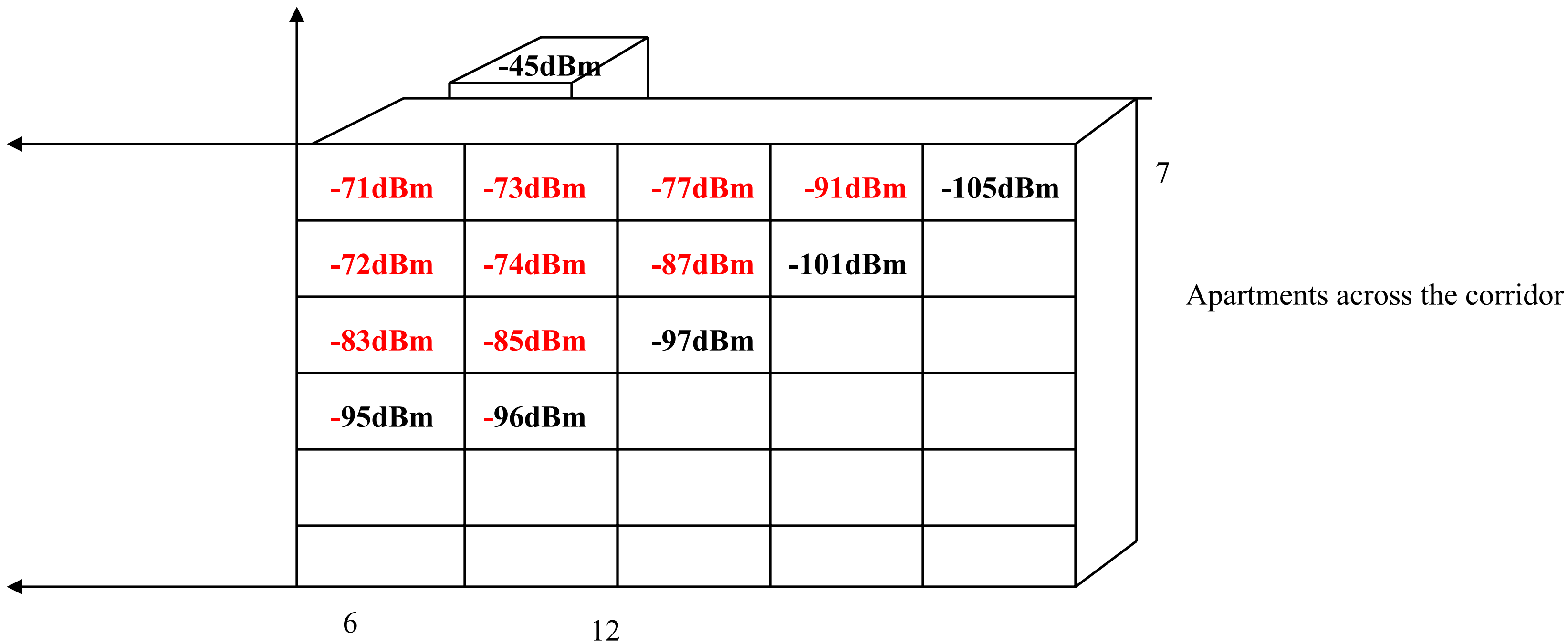
Each Apartment
20 x 35 feet
about 700 square feet

Total within range = 28

			-77			
		-77	-61	-77		
		-63	-44	-63		
	-72	-52	-45	-52	-72	
		-63	-44	-63		
		-77	-61	-77		
			-77			

NOTE: If each AP restricted operation to 54Mbps (11a/g), then overlaps reduce to 18 (or less)

Apartment Block – Double Layout



Total within range = 28 + 25 = 53

NOTE: If each AP restricted operation to
54Mbps (11a/g), then overlaps reduce to 29 (or less)

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

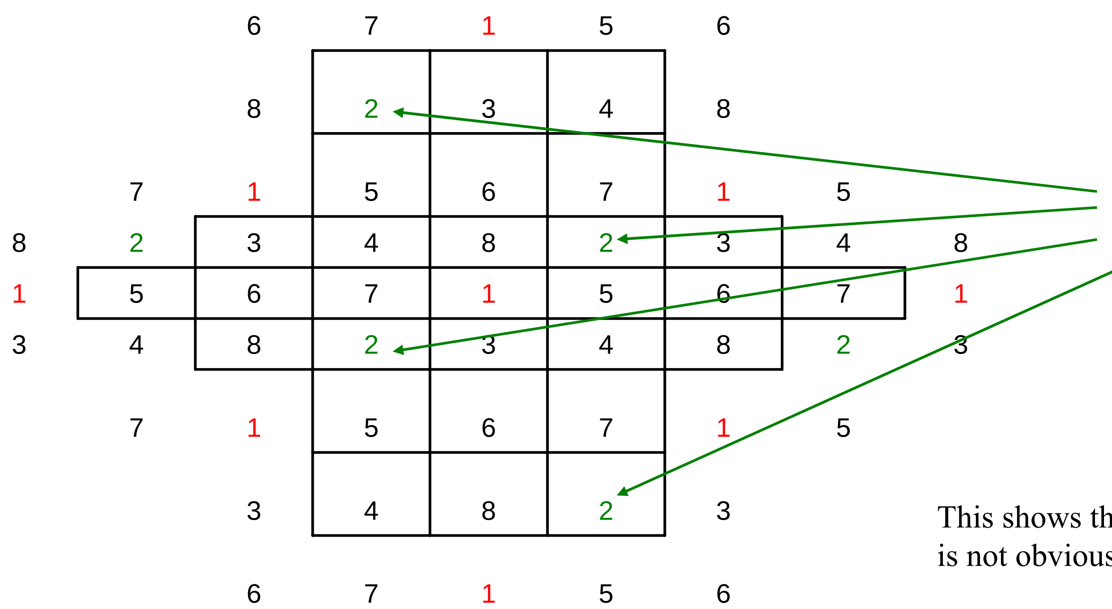
- **Number of Channels**

– 2.4GHz	20MHz	3
– 5GHz	20 MHz	24 USA, 19 Europe
	40MHz	11 USA, 9 Europe

Channel Selection

Aside - Minimum number of Channels Apartments single layout

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



24 overlapping APs
But channel re-use is extensive

Example, Ch 2 can be used 4 times
Within the 28 OBSS

This shows that the number of required Channels is not obvious at first sight

Channel Selection Analysis Program

- **A program was written in order to analyze what happens when each AP uses a Channel Selection scheme.**

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**
- **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

Detached Houses – 12 overlaps

Possibility Zero overlap

	% Houses 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	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

	% Houses 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	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

	% Houses 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	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

	% 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	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

	% 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	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

	% 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	0.0000	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)

	% 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	0.0000	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

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	0.9952	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	0.9865	0.9239	0.8338	0.7164	0.6019
11	1.0000	1.0000	0.9887	0.9198	0.7556	0.5786	0.4101	0.2609	0.1603	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

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	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	0.9856	0.9460	0.8635	0.7342	0.5926
9	1.0000	1.0000	0.9997	0.9964	0.9654	0.8748	0.7484	0.5682	0.4134	0.2850

99.27% chance of zero or one overlap
With 17 channels

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	0.0003	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

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	0.0004	0.0053	0.0247	0.0630
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

	% 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	0.9959	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

	% 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	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

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	0.0003
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

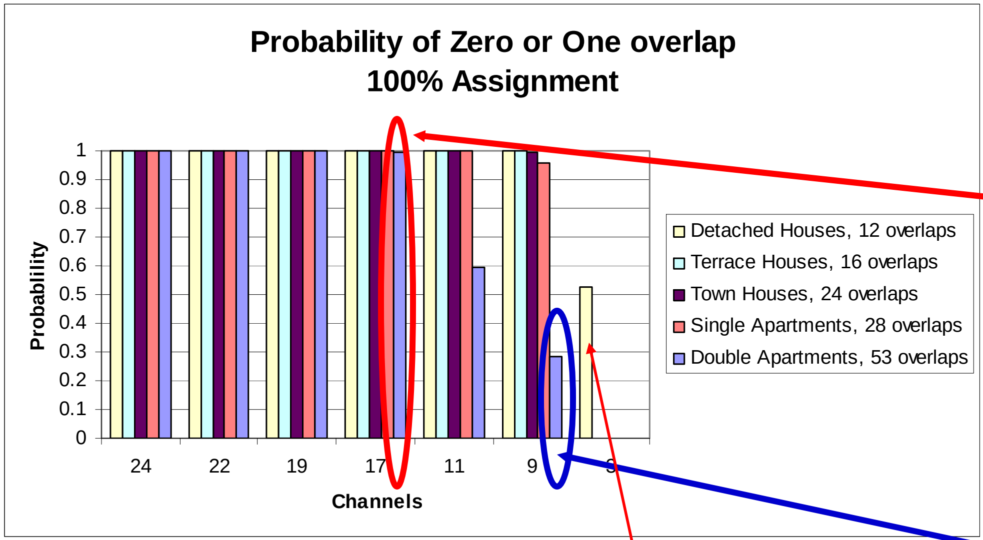
Possibility 3+ overlaps

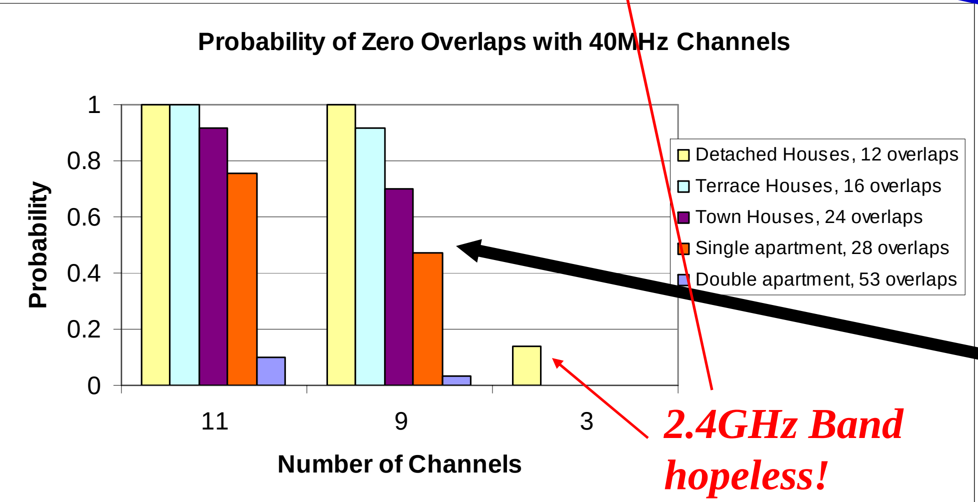
	% Apartments Assigned Channels									
Channels	10	20	30	40	50	60	70	80	90	100
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
17	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
	0.0000	0.0000	0.0000	0.0004	0.0033	0.0180	0.0477	0.1170	0.2127	0.3218

Compare to previous slide

Channel Selection using the number of overlaps is better

Channel Selection Analysis (08/1470r4)





2.4GHz Band hopeless!

Double Apartment

- 100% occupancy
- 53 overlapping apartments

17 CH (20MHz Channels)

99.3% probability of 0 or 1 channel overlap

***Zero chance of length > 2 or size > 3**

(<1 occurrence of 2 overlaps in 100 apartments)

9 CH (40MHz Channels)

***Zero chance of length < 2**
many cases of size > 3

Hence need to drop back to 20MHz and increase number of available channels

BUT

Many APs will use 40MHz channels

Number of Channels? What about 40/20 MHz?

40/20 MHz Example

Run the Channel Selection program

1. **40 MHz scenario**
   - 100 Apartments (10 floors of 10)
   - 28 potential apartments within range
   - 9 Channels, (40MHz channels)
2. **20 MHz Scenario**
   - 100 Apartments (10 floors of 10)
   - 28 potential apartments within range
   - 17 Channels, (20MHz channels)

In each case look at the channel sharing results

OVERLAPS

0	0	1	0	1	0	0	0	0	0
0	0	1	1	0	1	1	0	0	0
0	1	0	1	1	1	0	0	0	0
0	1	1	1	1	1	0	1	1	0
1	0	1	0	1	1	1	2	0	0
0	1	0	1	1	2	1	0	1	0
0	0	1	2	1	1	1	0	1	0
0	0	1	1	0	1	0	0	0	0
0	0	0	0	1	1	0	0	0	0
0	0	0	0	1	1	0	0	0	0

CHANNEL #

7	5	1	2	7	5	4	1	3	5
6	8	1	4	9	7	8	6	2	9
3	2	7	5	4	2	3	5	4	0
4	2	6	3	1	6	9	8	7	1
1	9	3	8	5	1	4	7	3	5
6	1	4	2	9	2	4	6	9	2
8	5	7	7	9	8	7	5	9	8
3	2	6	1	4	6	3	1	4	6
7	9	8	3	1	5	9	2	7	5
6	1	4	2	5	8	4	6	3	1

100 Apartments (10 floors of 10)
28 potential apartments within range
9 Channels, (40MHz channels)

Result:
58 Apartments not sharing
34 Apartments share with one other
3 Apartments share with 2 others
5 Apartments share with 4 others

Double apartment block is worse with 54 potential overlaps

20/40MHz channels

Assume that a sharing 40MHz channel, dropped back to 20MHz

- **The 1 : 1 share can be two independent 20MHz channels**
  - e.g. L : U (Lower 20MHz, Upper 20MHz)
- **The 1 : 2 : 1 chain can be independent 20MHz channels**
  - e.g. 2L : 2U : 2L
- **The 1 : 2 : 1 : 2 : 1 can be also be independent 20 MHz channels**
  - e.g. 7L : 7U : 7L : 7U : 7L

Now:

- **58 Apartments using 40MHz channel, not sharing**
- **42 Apartments using 20MHz channels, not sharing**

  Compare with (40MHz)
    - **34 Apartments share with one other**
    - **3 Apartments share with 2 others**
    - **5 Apartments share with 4 others**

OVERLAPS									
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

CHANNEL #									
6	3	4	1	2	6	3	7	1	4
1	5	9	7	12	11	5	8	10	2
4	2	8	3	4	1	2	6	3	7
7	11	6	5	10	9	12	11	5	8
3	12	4	2	8	7	3	13	4	9
6	1	7	11	6	5	10	1	2	11
4	5	8	3	12	4	8	7	3	6
9	2	10	1	9	2	6	11	10	1
3	11	6	4	7	3	12	4	9	5
1	7	9	2	8	5	0	1	8	2

100 Apartments
17 Channels, 20MHz channels

Result:
100 Apartments not sharing

40MHz Sharing compared to 20MHz

- **Theoretical** (Figs 8.1 and 8.5 "Next Generation Wireless LANS", Perahia and Stacey)

  2 x 2
  - 40MHz channel, max throughput 91Mbps and 210Mbps (RIFS + BAR)
  - 20MHz channel, max throughput 62Mbps and 100Mbps (RIFS + BAR)

  3 x 3
  - 40MHz channel, max throughput 85Mbps and 300Mbps (RIFS + BAR)
  - 20MHz channel, max throughput 69Mbps and 150Mbps (RIFS + BAR)

Assuming perfect sharing, 20 MHz throughput is better or same as shared 40MHz throughput

- **Practical (two overlapping networks, AP and 1 STA)**
  - Individually (out of box)
    - 40MHz Channel BSS A: 77-80Mbps BSS B: 58Mbps
    - 20MHz Channel BSS A: 40-50Mbps BSS B: 60Mbps
  - Sharing
    - 40MHz Channel BSS A: 77-80Mbps BSS B: 2-7Mbps

DCF Sharing is not ideal, it seems!

Observation

If sharing with an overlap of 2, then definitely in everyone's interest to drop back to 20MHz channel

If sharing with an overlap of 1, then could consider sharing IF you consider that sharing 40MHz is better than an independent 20MHz

BUT

If you believe that in practice, devices will share equally on 40MHz, I have a bridge I want to sell you.

Conclusion

Equal sharing using DCF and EDCA is not always true in practice. Smaller number of channels results in OBSS "Chains"

Drop back to 20MHz channels when no clear 40MHz channel is available.

Extend this to higher bandwidths?

OBSS Solution

PROPOSED "QLOAD" ELEMENT

QLOAD ELEMENT

Element ID	Length	Overlap And Prority	Access Fraction	QAP (Self) ID	QAP Priority Streams	Qload (Self)	QAP ID	QAP Priority Streams	Qload	Etc. For all QAPs In OBSS Graph
1	1	1	2	2	1	6	2	1	6	VAR

Overlap and Priority

Overlap (4 bits)	Reserved	CHP bit
b0	b4	b7

NOTE: CHP bit not used if HCCAOP Advertisement is used.

Access Fraction

	Access Fraction	Access Factor Integral	Access Factor Fraction
bits	8	2	6

QAP ID

Random Value	Octet 6 of MAC Address
1	1

QAP Priority Streams

	Number AC3 streams	Number AC2 streams
bits	4	4

Qload

	MEAN	STDEV and Distance	HCCA Peak
octets	2	2	2

STDEV	Distance
b0 … b13	b14 b15

Overlap

- **QAP indicates the number of other QAPs with which it is sharing and indicates the size of the OBSS graph:**
  - Zero indicates QAP has no other QAPs on the same channel within range
  - 1 indicates already sharing with one other QAP
  - 2 indicates already sharing with two other QAPs
  - etc

The QAP is advertising the overlap to other QAPs who may be considering sharing.

This parameter should be included in the Channel Selection procedure in order to select the best channel (08/1470r4)

Distance

- Distance is set to 0 for Self
- If QAP ID Directly visible to the QAP Self, then "Distance" is set to 1
- If not directly visible to the QAP Self, then "Distance" is set to 1 plus the value reported for that QAP ID in the QAP that is directly visible
- Any QAP with Distance" > 2 is not recorded in QLoad Element

QAP ID

- First octet = random number (0 to 255)
- Second octet = octet 6 of MAC Address
- **Once established, QAP ID is not changed**

- **Enables a QAP to indentify its QLoad in other QLoad elements**

QLoad Self

There are three methods for the QAP to build QLoad Self:

1. **QSTAs in the BSS may send a TSPEC (ADDTS) with Inactivity Interval set to 0 (or 1) for instant timeout**
   - By sending in a TSPEC the STA has the QAP commit, in advance, medium time for the STA
2. **QAP notes and adjusts for new TSPECs from QSTAs**
   - If accepted, “QLoad Self”, and also “QLoad Total” are adjusted only when the QSTA submits the ADDTS
   - Chance that ADDTS is denied as QSTA did not reserve medium time in advance
3. **In response to TSPEC Requirements Request**
   - QAP request STAs to indicate or confirm their TSPECs
   - Used by QAP to ‘clear house’ or initially set up Q Load.

The QAP is advertising its own potential QoS load to other QAPs who may be considering sharing

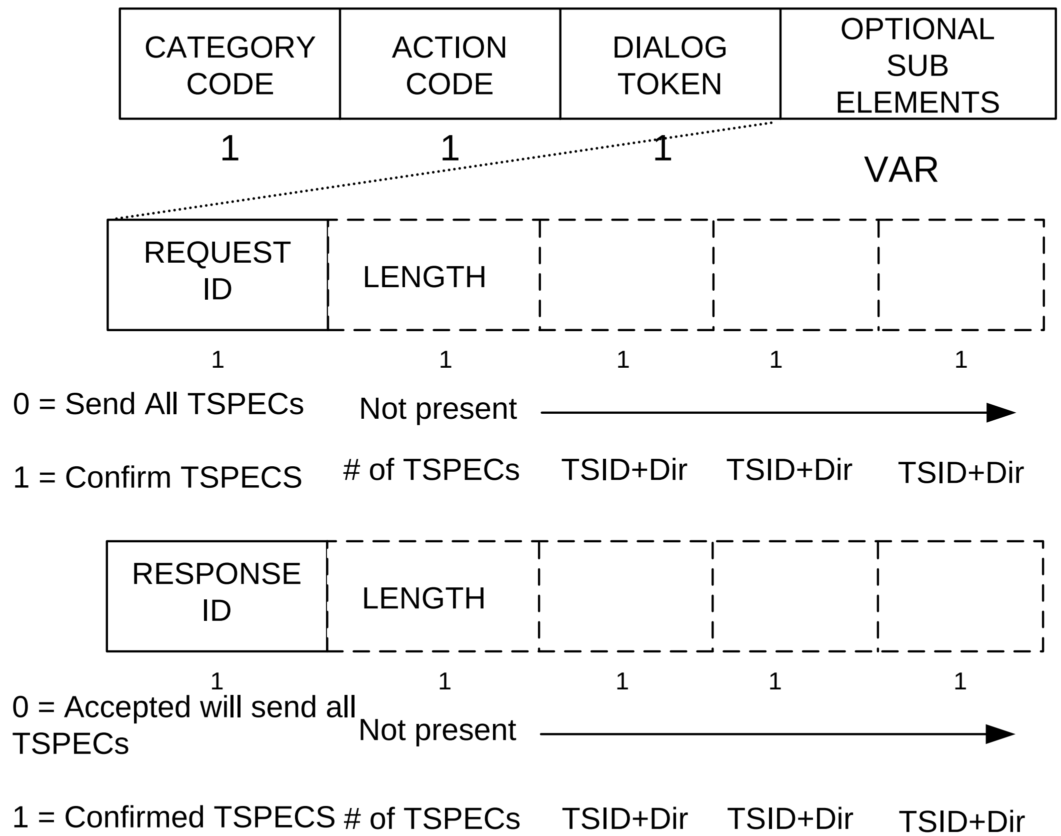
TSPEC Requirement Request Response

Request from QAP to a particular STA

Two types of Request:

1. Send All TSPECs (ID 0)
   – Effectively all previous (if any) TSPECs are deleted, need to set them up again
2. Confirm TSPECs (ID 1)
   – Confirm which TSPECs are still required
   – TSID plus Direction defines TSPEC

TSPEC Requirement Request Response Action Frame



QLoad MEAN and STDEV

For detailed explanation see 09/0496r2

MEAN and STDEV is estimated from the individual TSPECs:

MEAN $\mu = \Sigma MEANi$

STDEV $\sigma = 0.25 \text{ sqrt}\{\Sigma(MAXi - MINi)^2\}$

MEAN $\boldsymbol{\mu_{tot} = \Sigma MEANi}$
STDEV $\boldsymbol{\sigma_{tot} = \text{sqrt}(\Sigma\sigma_i^2)}$

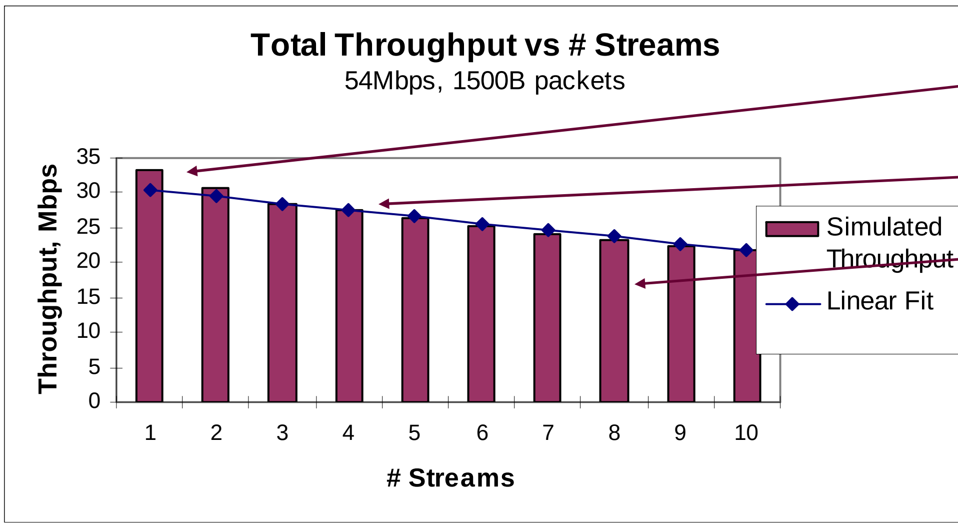
Total Traffic Requirement can be estimated:

1. MAX traffic = $\mu_{tot} + 2\ \sigma_{tot}$
2. 90% Traffic = $\mu_{tot} + 1.3\ \sigma_{tot}$
3. 80% Traffic = $\mu_{tot} + 0.83\sigma_{tot}$

EDCA Overhead – Capacity drops with # streams

As number of video streams increases, the contention also increases.
In order to keep latency low the capacity of the Channel is decreased.

Maximum throughput on (shared) channel decreases as number of video streams increases



Limits to ensure low loss:

1 stream @ 33Mbps

4 Streams, 27.5Mbps total

8 Streams 23.3Mbps total

NOTE: Above graph is simulation for independent streams. Downlink streams from QAP may be better due to queuing at the AP

HENCE:
Total Allocation MUST take account of the number of streams
Note: This is also for Admission Control on each QAP

QAP Priority Streams

- **Number of EDCA Priority Streams, AC_VO and AC_VI**
- **Used to estimate "EDCA Bandwidth Factor"**
- **EDCA Bandwidth Factor = 1 + 0.05 N** (approx; keep it simple, see 09/0497)
  - **Where N = Number of streams**
  - **Example:**
    4 streams Effective Bandwidth Factor = 1.2
    Four 5.5Mbps streams will require 1.2 x 4 x 5.5 = 26.5Mbps

Access Fraction and Access Factor

- **Access Fraction**
  - Total actual admitted time and/or scheduled time expressed as a fraction of 32us/sec rounded down to 1/256
- **Access Factor**
  - Total Traffic Requirement of self plus all other visible QAPs. Expressed as a fraction that may be greater than 1
  - Calculated as follows:
    - Sum the individual QLoads of all QAPs in the QLoad element as a composite stream
    - Calculate the EDCA Bandwidth Factor from the total number of Priority Streams in the visible QAPs (Distance 0 and 1)
    - Multiply the two to obtain the “Access Fraction”

.

Sharing

- **If the Access Factor is >1, then there is a potential over-allocation**
  - Hopefully QAPs should avoid this in the Channel selection process
- **Sharing Scheme**
  - QAPs should examine their QLoad Element in order to determine the maximum “Access Factor” being reported. This maximum value is then used to determine the allocation limit for that QAP in order not to cause over-allocation in other QAPs that are overlapping,
  - Using the Access Fractions (actual “live” traffic), Access Factor and QLoad self, a decision can be made whether to admit a new request.
  - Rules could be recommended in informative text.

HCCA Peak

- **The total HCCA TXOP requirement for the QAP, expressed in 32us/sec.**
  - The sum of all the HCCA Peak values is the "HCCA Access Factor"
  - If HCCA Access Factor > 1sec then potential for TXOP over-allocation
  - HCCA TXOPs can sum to "1" independent of EDCA Medium Time allocations, as TXOPs terminate immediately when no more data

Medium Time Allocations - Sharing

It is important to understand how the AP allocates the actual Medium Times in responses to TSPECs and checks that it has not exceeded its 'limit'

1. **In response to each TSPEC the AP allocates the Medium Time or TXOP (HCCA) that corresponds to the peak traffic**
2. **When allocating an additional Medium Time or TXOP, the AP must calculate what the composite stream would be, and check that this composite medium time does not exceed the limit**
3. **It is this composite time, that is advertised in the Access Fraction**
   - **The actual sum of the Medium Times and TXOPs will be greater than the composite time, but EDCA only uses what it needs, and hence the statistical nature of the streams causes the composite time to be the maximum of what is actually being used. Similarly HCCA TXOPs terminate when no more data.**
   - Allocated HCCA TXOPs cannot exceed "1"

HCCA

- **Two schemes are under consideration for HCCA TXOPs scheduling**

1. **HCCAOP Advertisement element**
   - This is based upon the MCCA Element used in 11s. Each QAP advertises its TXOP and the others then avoid it
   - Suffers from clock drift and ‘gaps’ in the schedules
   - Expandable to any size OBSS and hidden QAPs
2. **Supervisor QAP**
   - Supervisor hands off the schedule to each QAP using Wireless DS to communicate AP to AP
   - Efficient
   - Limited to visible QAPs

Conclusions

CONCLUSIONS

- **OBSS is only a real problem for QoS**
  - If 802.11 wants to provide guaranteed performance for QoS applications, then something has to be done
- **OBSS is a real possibility, even at 5GHz.**
- **The number of available channels is very important**
  - Dropping back to lower channel bandwidth, and increasing the channel pool has distinct advantages
- **Channel selection using inputs such as “Overlap” and “QLoad” is very desirable**
- **The proposed QLoad element provides all the necessary information to enable ‘good’ sharing for QoS networks.**