IEEE P802.11
Wireless LANs

Throughput and Cell Radius Comparison of TGa PHY Submissions

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Abstract

As mentioned in Doc. 98-104 and 98-110 , actual throughput comparison in a presence of interference is one of the most important issues. Although simulations are needed to get accurate results, an easy and possible comparison method is proposed in this document.

A cell radius comparison, that is another important issue, is discussed in the end of this document.

1. Throughput

1-1. Assumptions

1-1-1. Propagation loss

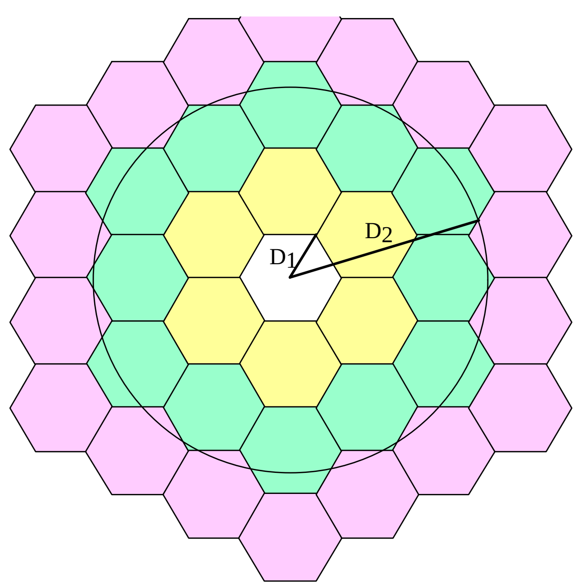
A propagation loss that describes an interference condition is assumed as given by

$$L=A+25\log(d) \quad (1)$$

where *d* is distance between a transmission site and a reception site.

Thus *CIR* at the edge of a cell is given by

$$CIR=25\log(D_2/D_1) \quad (2)$$



where D_1 is the distance between a desired signal transmission site and a reception site, D_2 is the distance between an undesired signal transmission site and the reception site. This *CIR* shall be reserved to secure an appropriate quality even if a station is placed at the edge of the cell.

1-1-2. Traffic Model

Let's assume a flat traffic model and all access points are sending downlink signals in the cells. Hexagonal cells are also assumed as used in the Doc 98-104. A flat user (traffic) distribution is also assumed.

1-1-3. Interference

All undesired signals (interference) come from neighbor access points that are sending downlink packets to stations in their cells. A perfect CSMA/CA scheme is also assumed to make this comparison easy. When an access point detects intolerable interference, which exceeds CCI immunity, the access point shall share the same frequency. Degradation due to backoff algorithm is discussed in Session 5.

1-2. Cluster Size

Although a cluster size is an idea for circuit exchange calls, the same concept can be applied to this comparison. Within the cluster, no access points can send a packet on the same frequency that is being used by an access point that causes interference. The cluster size *C* is given by

C=(interference area by an access point)/(coverage of an access point)

$$= \frac{\pi \cdot D_2^{\ 2}}{\left(\frac{3\sqrt{3}}{2}\right) \cdot D_1^{\ 2}} \qquad (3)$$

1-3. Average shared data rate of the downlink

Assuming *CIR*=*CCI*, the number of cells in a cluster (cluster size) is obtained with equ. (2) and (3). The total throughput of a band is shared by the cells that are in the cluster. This means that the data rate of a channel (carrier) multiplied by the number of carriers in the band is shared by all cells in the cluster. Therefore, the average shared data rate S_r is given by

$$S_r = \frac{R \cdot N_c}{C} \qquad (4)$$

where N_c is the number of carrier in a band, *R* is the data rate.

1-4. Numerical Examples

Though still waiting for important evaluation results, numerical comparison can be provided with data as much as we have. The *CCI*s of 64 bytes packets are used in this numerical comparison attempt because all *CCI*s of the 64 bytes packets are available in the evaluation templates except PPM.

OFDM

R	Nc	CCI	D_2/D_1	Area of Cluster $\pi D_2^2/D_1^2$	C : equ. (3)	Shared rate(S_r) equ. (4)
30	5	14	3.630781	41.41425685	15.94035489	9.410079074
20	5	10.5	2.630268	21.73451095	8.365617166	11.95369069
15	5	8.3	2.14783	14.49271903	5.578250155	13.44507649
10	5	5.5	1.659587	8.652664659	3.33041218	10*
5	5	2.3	1.235947	4.798990306	1.84713223	5*

* *C* is less than N_c. Each cell exclusively occupies one carrier.

Single Carrier

R	Nc	CCI	D_2/D_1	Area of Cluster $\pi D_2^2/D_1^2$	C : equ. (3)	Shared rate(S_r) equ. (4)
50	4	20	6.309573	125.0690562	48.13910218	4.154626716
42	4	17	4.786301	71.96972987	27.70116194	6.06472755
25	4	15	3.981072	49.79088809	19.16452176	5.217975238
21	4	13	3.311311	34.44687845	13.2586097	6.335505902

PPM

R	Nc	CCI	D_2/D_1	Area of Cluster $\pi D_2^2/D_1^2$	C : equ. (3)	Shared rate(S_r) equ. (4)
23.88	3	Not Reported				
20	3	Not Reported				
10	3	Not Reported				

1-5. Considering MAC procedure

Since MAC sub-layer controls packet sending, *aSlotTime*, *SIFS* and some other overhead should be taken into account to predict the actual throughput. When a data stream is divided into fragments and sent on a shared medium, the following sequence is proceeded:

waiting DIFS+backoff - > sending PHY/MPDU - > waiting SIFS - > sending PHY/ACK

The actual throughput (S) is the proportion of a data length in time domain to the packet transmission sequence length in time domain. This is given by

$$S = \frac{(data\,length)}{(\mathrm{DIFS} + \mathrm{backoff} + \mathrm{header\ of\ MPDU} + \mathrm{data\ (MPDU)\ length} + \mathrm{SIFS} + \mathrm{header\ of\ ACK} + \mathrm{ACK})} \quad (5)$$

Assuming an MPDU of 1500 bytes in a fragment of a data stream, predicted throughputs are found in the following Tables. Actual throughput may be less than these results because packet errors are not taken into consideration and *CCI*s of 64 bytes packet is used instead of 1500 bytes.

OFDM

R	Data length (1500B)	training	MPDUheader	SIFS	ACK	slottime	backoff	DIFS	Throughput (S) : equ (5)	Actual data rate : S*shared rate
30	400	20.6	31.533333	13	30.2	6	45	25	0.734304	6.9098610
20	600	20.6	37	13	30.2	6	45	25	0.799786	9.5604031
15	800	20.6	42.466666	13	35	6	45	25	0.832928	11.198786
10	1200	20.6	53.4	13	39.8	6	45	25	0.871966	8.7196628
5	2400	20.6	86.2	13	54.2	6	45	25	0.914843	4.5742166
	µs	µs	34+7 Bytes	µs	21 Bytes+hdr	µs	µs	µs		Mbit/s

Single Carrier

R	Data length (1500B)	training	MPDUheader	SIFS	ACK	slottime	backoff	DIFS	Throughput (S) : equ (5)	Actual data rate : S*shared rate
50	240	16	21.44	13.4	18.24	7.4	55.5	28.2	0.636976	2.6463995
42	285.714285	16	22.476190	13.4	18.666666	7.4	55.5	28.2	0.673922	4.0871567
25	480	16	26.88	13.4	20.48	7.4	55.5	28.2	0.768664	4.0108703
21	571.428571	16	28.952380	13.4	21.333333	7.4	55.5	28.2	0.79496	5.0364734
	µs	µs	34 Bytes	µs	14 Bytes+hdr	µs	µs	µs		Mbit/s

PPM

R	Data length (1500B)	training	MPDUheader	SIFS	ACK	slottime	backoff	DIFS	Throughput (S) : equ (5)	Actual data rate : S*shared rate
23.88	502.512562	20	31.390284	5	24.690117	3	22.5	11	0.841598	
20	600	20	33.6	5	25.6	3	22.5	11	0.859968	
10	1200	20	47.2	5	31.2	3	22.5	11	0.911230	
	µs	µs	34 Bytes	µs	14 Bytes+hdr	µs	µs	µs		Mbit/s

2. Cell Radius

Coverage of an access point is dominated by its propagation loss, sensitivities, antenna gain, transmission power shadowing and so on. For a comparison, the same the propagation loss and antenna gain are assumed. The cell radius of each proposal for all data rates are shown in the Table below.

OFDM

Data Rate	30 Mbit/s	20 Mbit/s	15 Mbit/s	10 Mbit/s	5 Mbit/s
TxPower [mW]	30	30	30	30	30
TxPower [dBm]	14.7712125	14.7712125	14.77121255	14.7712125	14.77121255
Gain of ANT [dB]	12	12	12	12	12
Sensitivity [dBm]	-77	-81	-83.5	-86.3	-89.6
Tolerable Propagation Loss [dB]	103.771212	107.771212	110.2712125	113.071212	116.3712125
Radius (free space:L=47+20log(d)) [m]	715.591471	1134.136051	1512.394732	2087.68588	3052.566655
Radius (L=47+25log(d)) [m]	186.572874	269.679852	339.5068193	439.388313	595.4543906
Fade Margin at 100 m (330 ft.) [dB]	6.77121254	10.7712125	13.27121255	16.0712125	19.37121255

Single Carrier

Data Rate	50 Mbit/s	41.9355 Mbit/s	25 Mbit/s	20.9677 Mbit/s
TxPower [mW]	50	50	50	50
TxPower [dBm]	16.98970004	16.98970004	16.98970004	16.98970004
Gain of ANT [dB]	12	12	12	12
Sensitivity [dBm]	-65	-67	-75	-77
Tolerable Propagation Loss [dB]	93.98970004	95.98970004	103.9897	105.9897
Radius (free space:L=47+20log(d)) [m]	232.0542521	292.1389948	733.8199773	923.824617
Radius (L=47+25log(d)) [m]	75.78582833	91.11460604	190.3653939	228.8695426
Fade Margin at 100 m (330 ft.) [dB]	-3.010299957	-1.010299957	6.989700043	8.989700043

PPM

Data Rate	23.88 Mbit/s	20 Mbit/s	10 Mbit/s
TxPower [mW]	50	50	50
TxPower [dBm]	16.98970004	16.98970004	16.98970004
Gain of ANT [dB]	12	12	12
Sensitivity [dBm]	-70	-72	-75
Tolerable Propagation Loss [dB]	98.98970004	100.9897	103.9897
Radius (free space:L=47+20log(d)) [m]	412.6572985	519.5047594	733.8199773
Radius (L=47+25log(d)) [m]	120.1124434	144.4069189	190.3653939

Fade Margin at 100 m (330 ft.) [dB]	1.989700043	3.989700043	6.989700043

Low transmission power and sufficient fade margin contribute for reducing power consumption.