IEEE P802.11
Wireless LANs

Advantages of Code Channelization (Ver.2)

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Abstract

"Advantages of Code Channelization, doc:IEEE802.11-98/118" was presented at Irvine meeting on March 1998. This document is a continuous effort. Throughput analysis for code channelization, based on the doc:IEEE802.11-98/143 proposed by NTT and Lucent for TGa, is described. Throughput and delay time simulation under the leakage condition are also described.

1. Summary of doc:IEEE802.11-98/118

(1) Aspect of reliable BSA and unreliable BSA.
MIS tries to build WLAN using the reliable BSA. Unreliable BSA is much wider than reliable BSA but insufficient for reliable operation because of propagation loss and multipath delay spread.

(2) Code channelization provides better throughput if BSAs are not overlapped
- In order to obtain floor-to-floor and room-to-room isolation
- For unmanaged BSAs (SOHO market)

2. Throughput analysis, based on the doc:IEEE802.11-98/143 proposed by NTT and Lucent

1. Summary of Throughput Analysis Scheme by doc:IEEE802.11-98/143 by NTT and Lucent

1. Assumptions

Figure 1

A propagation loss is assumed as

(1)

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

The CIR at the edge of a cell is given by

(2)

where D_1 and D_2 are showed in the Figure 1.

A flat traffic model is assumed. All access points are assumed to be sending downlink signals in the cell.

A perfect CSMA/CA scheme is also assumed. When an access point detects intolerable interference, which exceeds CCI immunity, the access point shall share the same frequency.

2. Cluster size

Cluster size C is given by

C = (interference area by access point)/(coverage of an access point) (3)

3. Average shared data rate

Assuming CIR=CCI, average shared data rate is given by

(4)

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

2. Extension of *Sr* applicable to Code Channelization

The equ. (4) can be extended to the equ. (5) applicable to code channelization.

$$Sr = k \frac{R \cdot Ncf \cdot Ncc}{Cc^2 + (Ncc-1) \cdot Ca^2 + (Ncf-1) \cdot Ac^2 + (Ncf-1) \cdot (Ncc-1) \cdot Aa^2} \quad (5)$$

where

$$k = \frac{3\sqrt{3}}{2p}, \quad (6)$$

$$Cc = 10^{\frac{CCIc}{25}}, \quad (7)$$

$$Ca = 10^{\frac{CCIa}{25}}, \quad (8)$$

$$Ac = 10^{\frac{ACIc}{25}}, \quad (9)$$

$$Aa = 10^{\frac{ACIa}{25}} \quad (10)$$

Ncf and *Ncc* are defined as the number of carriers in a band and the number of applicable code channels respectively. *CCIc*, *CCIa*, *ACIc* and *ACIa*, appeared in the equ. (9) through (12), are interference immunities (dB) for conditions of the Table 1. Summation of all states is *Ncf Ncc*.

Table 1

Symbol	Frequency channel	Code channel	Number of states
CCIc	Co-channel	Co-channel	*1*
CCIa	Co-channel	Adjacent channel	*Ncc-1*
ACIc	Adjacent channel	Co-channel	*Ncf-1*
ACIa	Adjacent channel	Adjacent channel	*(Ncf-1) (Ncc-1)*

3. Numerical Examples of *Sr*

1. Parameters

Various parameters in order to obtain *Sr* for Micrilor, Harris (same for Raytheon), Lucent and Alantro proposals for TGb are referenced from the Comparison Matrix of doc:IEEE802.11-98/140 as shown in Table 2.

Table 2

Parameter	Micrilor	Harris/ Raytheon	Lucent
R in USA (Mbps)	**10.0**	**11.0**	**8.0/10.0**
R in Japan (Mbps)	**6.0**(1)	**11.0**	**8.0/10.0**
Ncf in USA	**2**	**3**	**3**
Ncf in Japan	**1**	**1**	**1**
Ncc	**48**	**1**	**1**
CCI (dB)	**6.0**(2)	**6.8**(3)	**6.0**(4)
ACI (dB)	**-35.0**	**-35.0**	**-35.0**
CCIc (dB)	**2.0**	**6.8**(5)	**6.0**(5)
CCIa (dB)	**2.0**	**-**	**-**
ACIc (dB)	**-35.0**(6)	**-**	**-**
ACIa (dB)	**-35.0**(6)	**-**	**-**

(1) 5Mbps products operated by BPSK have been already introduced to Japan. 6Mbps can be easily obtained by applying MSK.
(2) 2dB is found at the comparison matrix, although the same number as Lucent is applied.
(3) In case of applying 11Mbps jammer to 11Mbps signal proposed in the doc:IEEE802.11-98/116 by Harris
(4) It may increase in case of 10Mbps
(5) Applying the same value as *CCI*
(6) Applying the same value as *ACI*.

2. Calculated Result

Table 3 shows calculated result using parameters shown in Table 2. Micrilor's proposal, two frequency channel and 48 code channel scheme, shows more than 20% higher shared data rate than others for use in USA. It also shows about more than 30% higher throughput than others for use in Japan.

Table 3

	***Sr* (Mbps) in USA**	***Sr* (Mbps) in Japan**
Micrilor	**10**	**3.357**
Harris / Raytheon	**7.792**	**2.600**
Lucent	**6.565 / 8.207**	**2.191 / 2.738**

Figure 2 shows *Ncc*. vs. Shared data rate characteristics for both use in USA and Japan.

Figure 2

3. Throughput and Delay Time Simulation under the Leakage Condition

1. Leakage Condition

Figure 3 is a conceptual drawing of the leakage condition proposed by the doc:IEEE802.11-98/118 for TGb. Neighbours' systems are allocated enough closely to sense almost all signals generated by them. However, D/U ratio in my cell is always enough higher than interference immunity of my system.

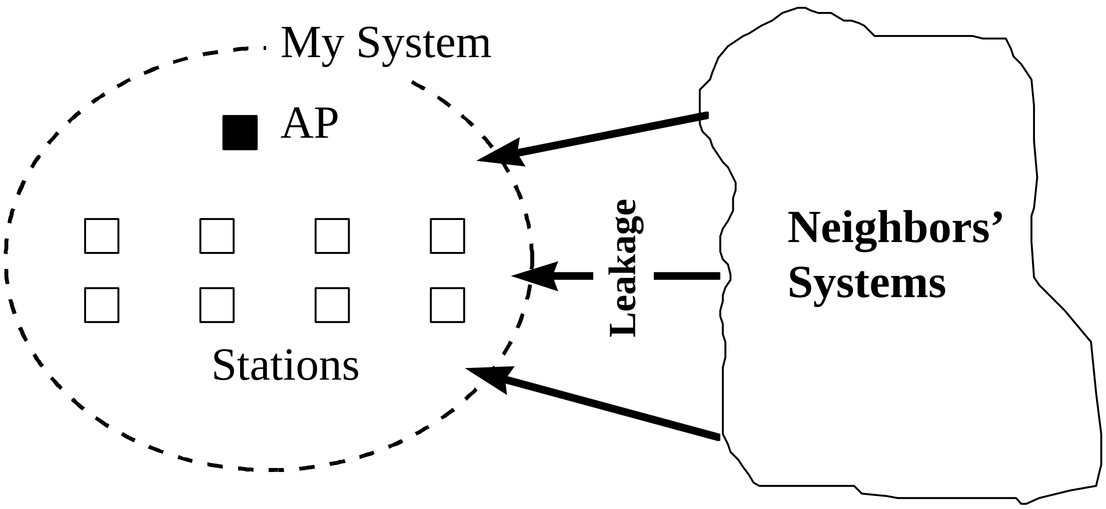

Figure 3

Such case seems to happen very often at SOHO applications. In this case, errors caused by collisions of signals between my system and neighbours' systems can be negligible. Although, CSMA/CA function of my system is disturbed by signals generated by neighbours' systems and may degrade the throughput. Its degradation mechanism is quite different from the one described in previous session.

2. Simulation Conditions

All conditions, except (2), (8) and parameter No. 7 are the same as doc:IEEE802.11-98/118.

(1) The channel access model is based on 802.11 (P802.11D6.1 pp 86-pp 98).
(2) ACK transmission protocol is compliant with 802.11 also.
(3) DATA type is INF_DATA and ACK only.
(4) The INF_DATA packets are generated by Poisson distribution.
(5) The radio propagation characteristic is ideal, namely Frame Error is caused by collisions only.
(6) No hidden node is considered.
(7) INF packets consist of same information with fixed length.
(8) **Header length is considered.**
(9) The positions of STAs are fixed.
(10) Data flow direction : STAs to AP

Table 4

No.	Parameters	Value
1	Propagation Delay (sec)	0.1 (μsec) (Assuming propagation distance = 30m)
2	INF Length (bit)	512 or 12000 (64 or 1500 Byte)
3	ACK Length (bit)	112 (=14 Byte)
4	INF Length of Leakage Traffic	512 (bit) (=64Byte)
5	Data Rate (bps)	10M
6	Cwmin	32
7	**The number of maximum retransmission**	**16**
8	Nodes in my system	Station : 8 AP : 2
9	Rx-Tx delay (ms)	0.015
10	Distance between AP and Interference sources (m)	100
11	Load of Interference	0.1~0.5
12	Mean Inter-Pulse Time (s)	INF Length * Nodes/Transmit Speed/Load
13	Slot Time (s)	Propagation Delay + Rx-Tx Delay
14	SIFS	Rx-Tx Delay
15	DIFS	SIFS + 2*Slot Time
16	Timeout Time	3*Propagation Delay + Rx-Tx Delay + SIFS + (INF Length + ACK Length) / Transmit Speed
17	Simulator	BONeS DESIGNER ver.3.6 by ALTA GROUP of Cedence Design systems, Inc.

Figure 4 and Figure 5 show flow charts of the simulation.

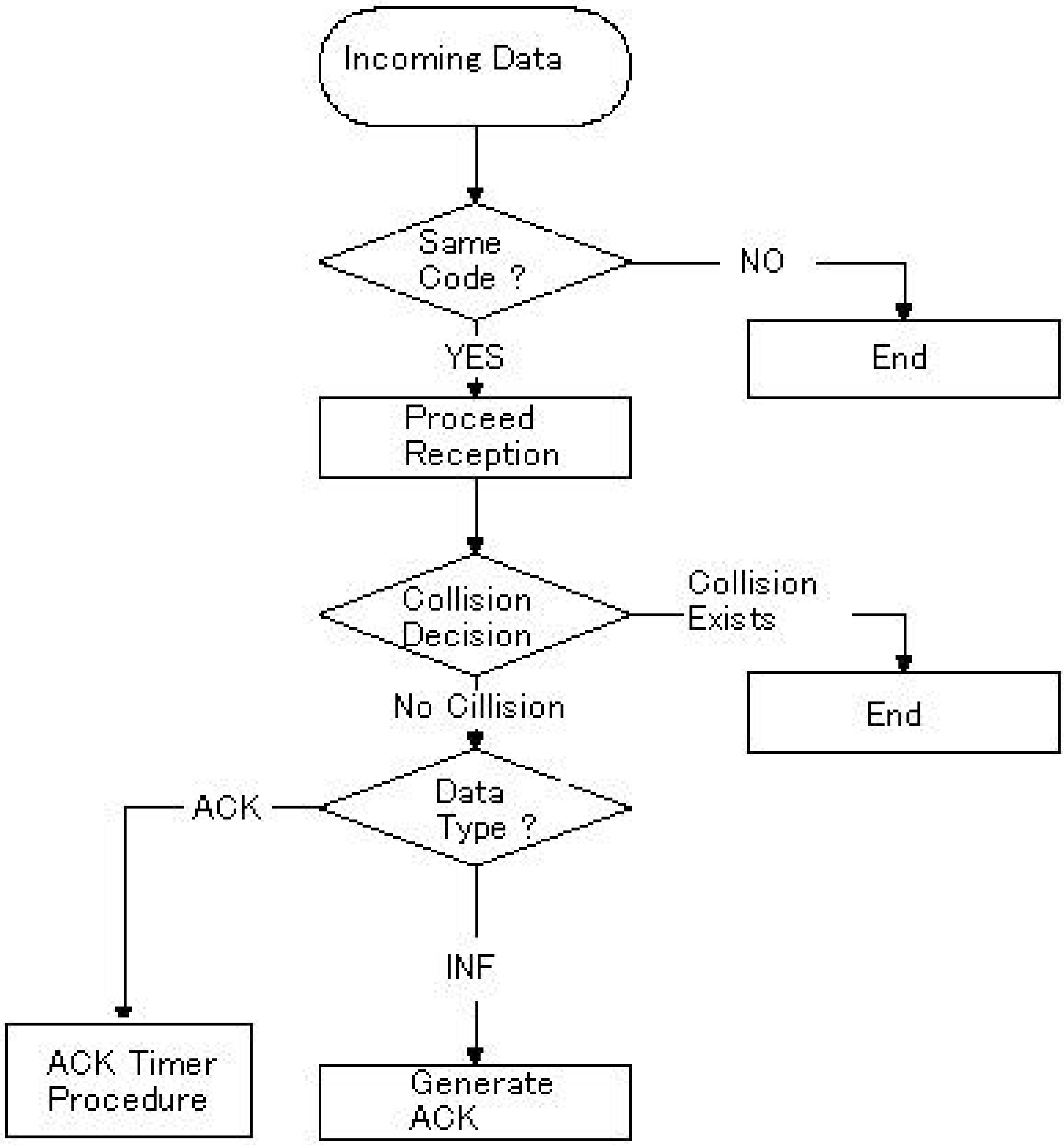

Figure 4

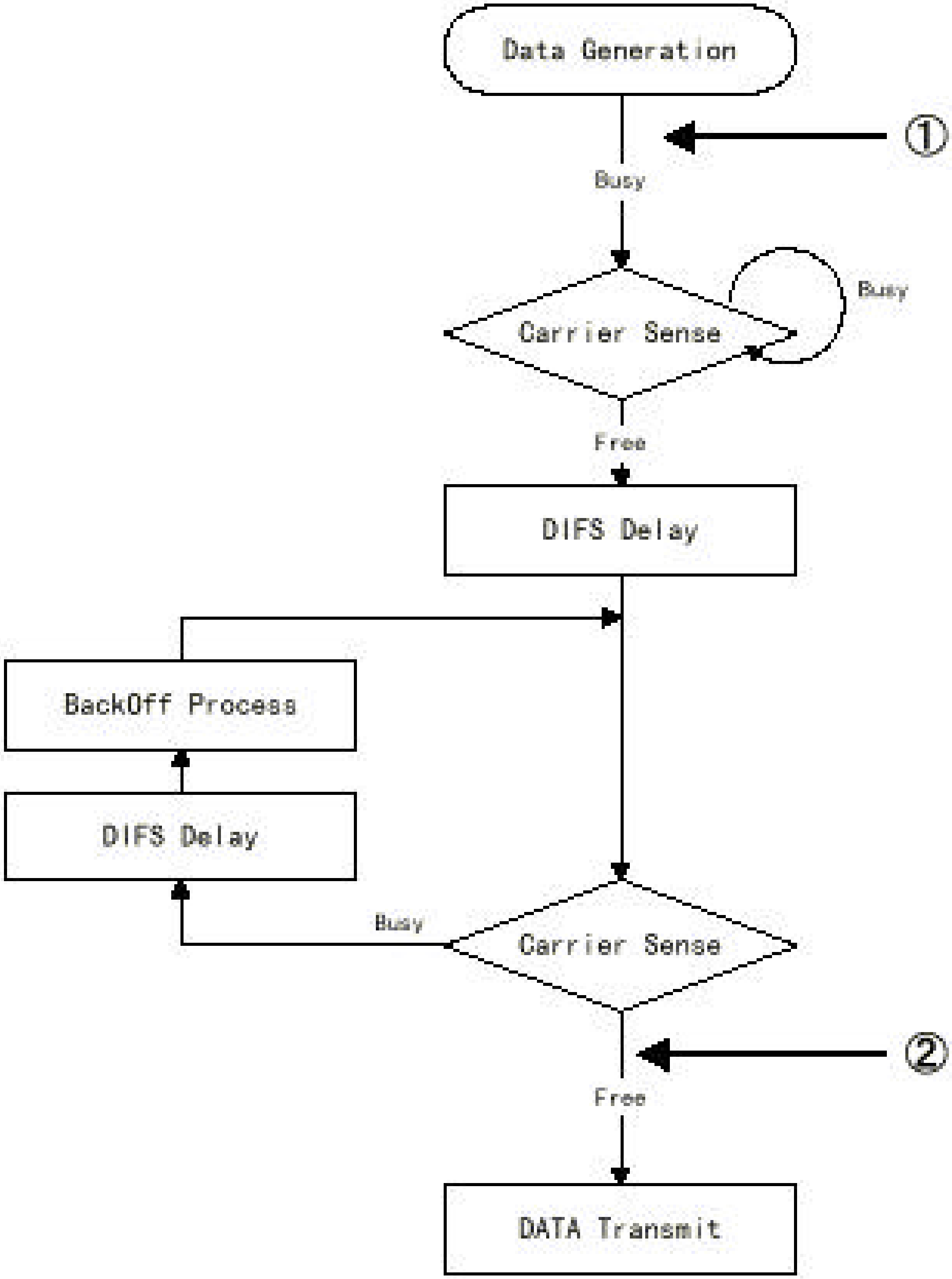
Data Generation
①
Busy
Carrier Sense
Busy
Free
DIFS Delay
BackOff Process
DIFS Delay
Busy
Carrier Sense
②
Free
DATA Transmit

Figure 5

3.

Simulation Result

Figure 6 and Figure 7 show Throughput vs. Leakage Traffic characteristics. CS means carries sense without code channelization and CD means Code Detect with code channelization. In case of 1500 byte packet transmission under 0.3 Leakage Traffic condition, more than 20% degradation occurs by leakage traffic without code channelization.

Figure 6

Figure 7

Figure 8 and Figure 9 shows Traffic vs. Average Delay Time characteristics. In case of 1500 byte packet transmission, Traffic of more than 0.6 causes abrupt increase of the delay time. In case of 64 byte packet, undesired increase of delay occurs at lower traffic than for 1500 byte transmission.

Figure 8

Figure 9

4. Conclusion

Throughput analysis for code channelization proposed by Micrilor, based on the doc:IEEE802.11-98/143 by NTT and Lucent for TGa, is decribed for comparison. Combination of two frequency channels and 48 code channels shows more than 20% shared data rate than Harris's proposals for use in USA. It also shows 18% better than Lucent's and 36% better than Harris's respectively for use in Japan.

Traffic vs. Throughput and Delay Time characteristics, under extended conditions to the doc:IEEE802.11-98/118, is also analysed. It shows that leakage causes degradation of more than 20% in case of 1500 byte packet transmission and undesirable increase of the delay time.