IEEE P802.11
Wireless LANs

A proposal to use a PN sequence for the Synchronisation Preamble

Date: January 11, 1999

Author: **Geoffrey T. Anderson**, Janos Enderlein, Takashi, Usui
Sony Electronics Inc.
1 Sony Drive MD:TA-1, Park Ridge NJ, 07656
(Phone) 201-930-6261
(Fax) 201-930-6397
(E-Mail) geoffrey_anderson@mail.sel.sony.com

Abstract

It is important for HIPERLAN or Wireless Local Area Network to reduce the time for synchronisation at the beginning of a frame or a packet. We have proposed PN preamble for the synchronisation[1].
In multipath fading environment, the acquisition error increases because of the degradation of the correlation peak. We have investigated the distribution of correlation peaks in the multipath fading environment.

It has been revealed that PN wave is better than OFDM preamble for time synchronisation even in the multipath fading environment.

We propose that the use the PN sequence for frame and packet synchronisation at the beginning of each frame and packet. This document is submitted also to BRAN.

1. Definition

1.1 PN Wave (Psudo Noise Wave)

PN Wave in this document is a band limited wave which has sharp correlation characteristic. Filtered m-sequence is one of the PN Waves.

2. Preamble Structure

Although several structures are proposed, we have used a simple structure in order to concentrate on the investigation of the degradation by the multipath fading environment. Fig. 1 shows the preamble structure of both PN and OFDM used in this document.

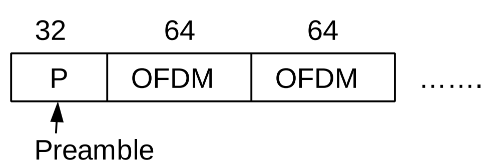

Fig.1 Preamble Structure

2.1 PN

The number of samples of the preamble is 32. This preamble is made by 31bit m-sequence and one additional bit. The specification of the m-sequence is described before[1]. The 32nd additional bit is the first bit of the m-sequence. The OFDM data symbol follows this PN preamble. Fig. 2(a) shows the waveform of the preamble.

2.2 OFDM

The preamble consists of 32bit OFDM symbol. The even number of 24 carriers (2,4,6,8,…22,24,40,42,44,…60,62) are used. Each carrier is modulated by QPSK. OFDM data symbol follows this OFDM preamble. Fig.3(a) shows the waveform of the preamble.

2.3 Data Symbol

The number of samples of the data symbol described above is 64. The number of carriers is 50. Each carrier is modulated by QPSK.

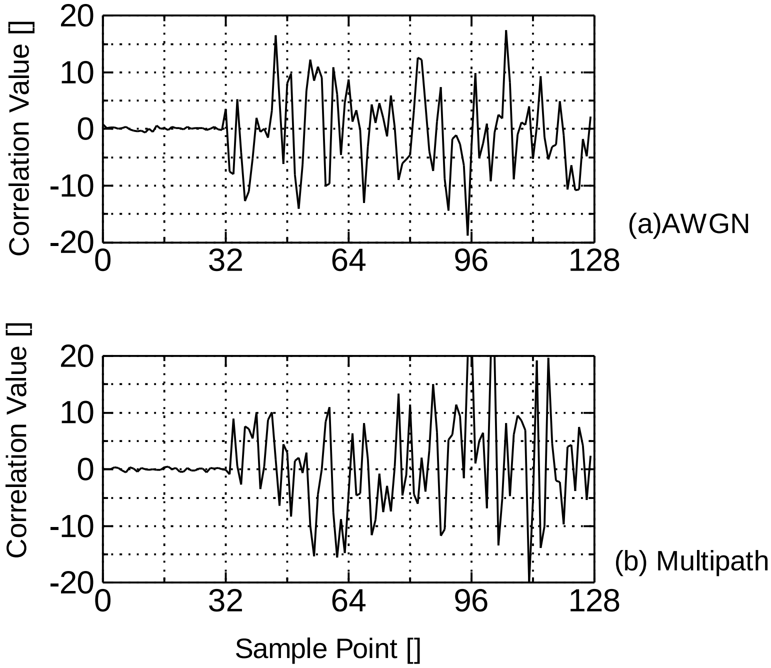

Fig.2 Waveform of [PN preamble + OFDM Data Symbol] (Only real part)

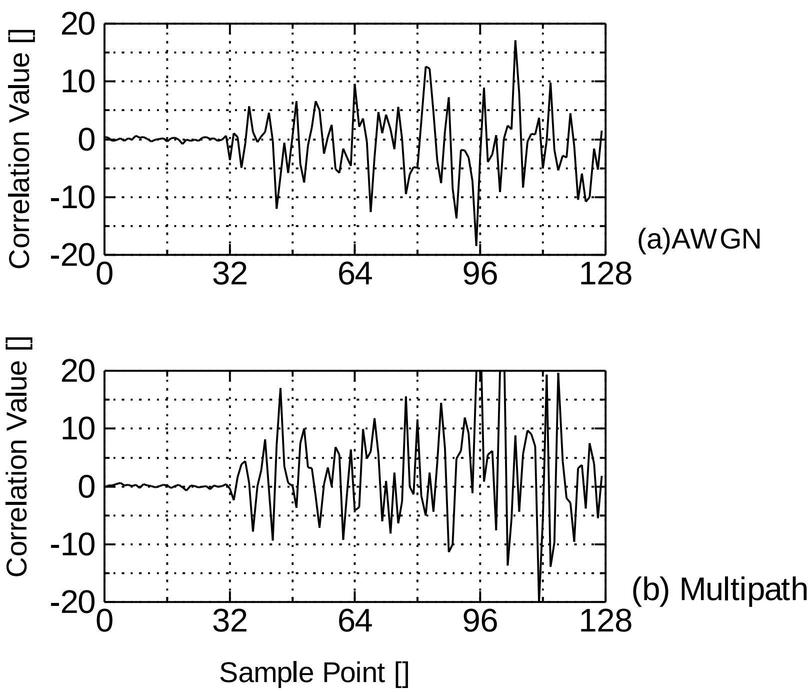

Fig.3 Waveform of [OFDM preamble + OFDM Data Symbol] (Only real part)

3. Detector

There are two types of detection. One is auto-correlation type, the other is cross-correlation type. We have investigated cross-correlation type detection in this document. (In the case of auto-correlation type detection, one more preamble should be added in series.)
Fig. 4 shows the block diagram of the correlator. The 32 samples of a received signal are correlated with 32 samples of the reference waveform. The correlation is taken in complex form.

Here, R(k) is the correlation output, r(n+k) is the received signal, h(n) is the reference waveform, * is the conjugation.

$$R(k) = \sum_{n=0}^{31} r(n+k)h^*(n) \tag{3-1}$$

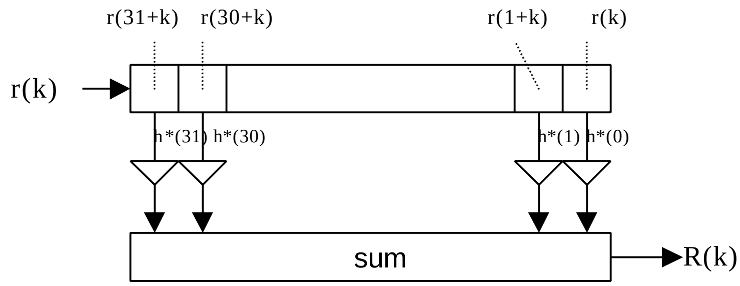

Fig.4 Detector Block Diagram

4. Multipath Fading Environment

The impulse response of the channel is shown in Fig. 5. This channel model is MODEL-E which is described in [2]. The delay spread is 250nsec. 5 models are described in the reference [2]. MODEL-E is the most severe case of all [1].

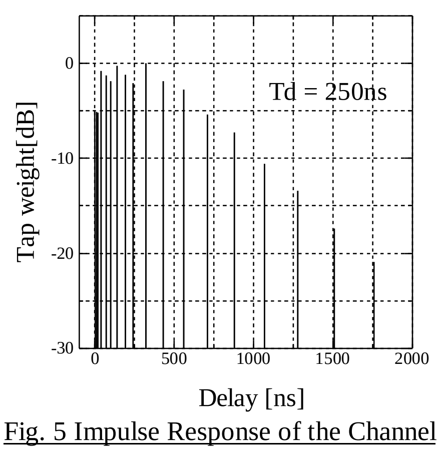

Fig. 5 Impulse Response of the Channel

An example of a received waveform of a PN preamble is shown in Fig.2(b). An example of a received waveform of an OFDM preamble is shown in Fig. 3(b).

5. Simulation Result

5.1 Degradation of Correlation Output Waveform

Fig. 6 shows the waveform of the correlation output for PN preamble. SNR is 25dB. Fig. 6(a) is the waveform with AWGN, (b) is the waveform in the multipath fading environment. Fig. 7 shows the waveform of the correlation output for OFDM preamble. Fig. 7(a) is the waveform with AWGN, (b) is the waveform in the multipath fading environment. Note that Fig.6(b) abd Fig.7(b) waveforms are calculated under the same fading condition.

From these figures, the correlation peak value in AWGN for both PN and OFDM preamble is almost 1. It is understood that both PN and OFDM preamble works well in AWGN environment. However, the peak value in the multipath fading environment is decreased and even multiple peaks appears. From Fig. 6(b) and Fig. 7(b), it is understood that there is the strongest signal at the sixth sample delayed from the first arrival in this case. And that, the sharpness of the correlation output is degraded with wider sample points. It means that the time resolution of the synchronisation becomes worse in the multipath fading environment. In order to compare how much these correlation output waveforms are degraded, the distributed functions of the correlation peak value are calculated.

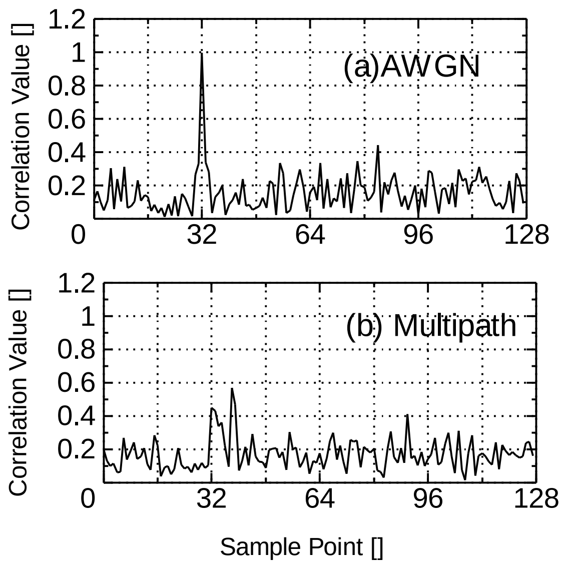

Fig. 6 Waveform of Correlation Output for [PN preamble + OFDM Data Symbol]

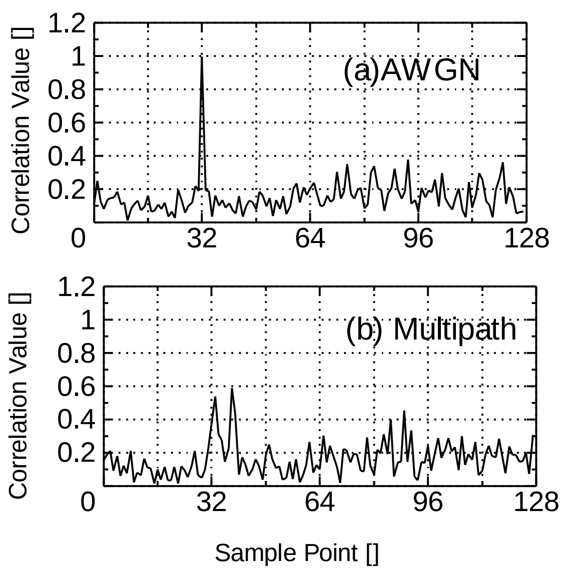

Fig. 7 Waveform of Correlation Output for [OFDM preamble + OFDM Data Symbol]

5.2 Distribution Function of the Peak Value

Fig. 8(a) shows the distribution function for AWGN, while Fig.8(b) shows the distribution for multipath fading environment. In AWGN, most of the peaks are around 1. On the other hand, in the multipath fading environment, the probability that the peak value becomes less than 0.5 is 0.05 for PN preamble, 0.16 for OFDM preamble. It means that the degradation of the PN preamble is not as much as the one of the OFDM preamble.

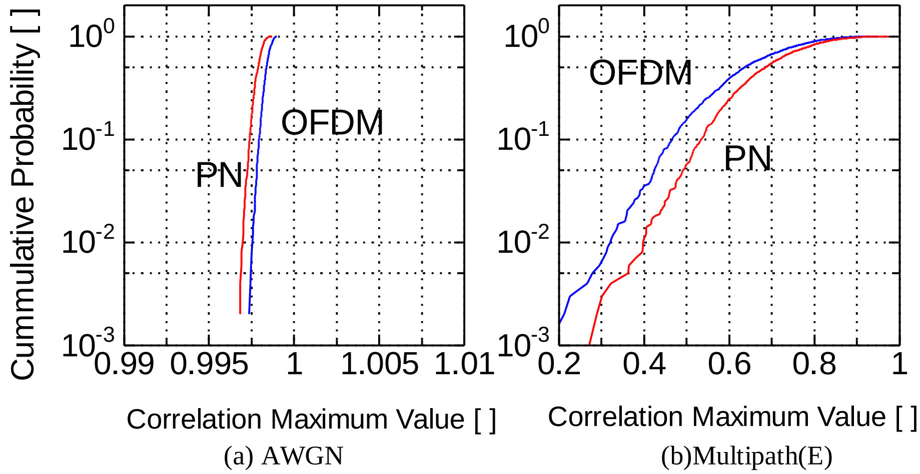

Fig. 8 Distribution of Correlation Peak Value

Table 1 Prob[correlation peak value < 0.5]

PN preamble	OFDM preamble
0.05	0.16

6. Other Comments

6.1 Preamble Generator

PN preamble can be generated by using linear feedback shift register(LFSR) and FIR filters. The hardware needs extra circuits, however, it can be generated in a small number of clocks. PN preamble can also be generated by using IFFT. In this case, it doesn't require extra circuits, even thought requires some tens of clocks.

On the other hand, OFDM cannot be generated by LFSR. Since the preamble is needed in a short period, high speed IFFT is required.

7. Conclusion

We have investigated the degradation of the peaks of correlation output. In AWGN channel, PN and OFDM preamble show almost the same performance, however, in the multipath fading environment, PN preamble has a better performance. In total, we can observe that PN preamble has a better performance.

PN preamble can be considered as the better solution to generate the waveform fast than OFDM preamble.

8. References

[1] "A proposal of Fast Synchronisation Scheme" HL11.5SON1a, ETSI EP BRAN December 1998
[2] "Criteria for Comparison" 30701F ETSI Project BRAN July 1998

Decision/action requested

Use the PN sequence for frame and packet synchronisation at the beginning of each frame and packet.