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Proposal for a common preamble for HIPERLAN/2 and IEEE802.11

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Author: Mika Kasslin
Nokia
P.O. Box 407, FIN-00045

Nokia Group, Helsinki

Finland
Phone: +358-9-4376294
Fax: +358-9-43766856

e-Mail: mika.kasslin@research.nokia.com

Abstract

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Abstract

In this input we propose a common preamble structure to both IEEE802.11 and BRAN.

Introduction

The physical layers of IEEE802.11 and HIPERLAN type 2 are being harmonized to a large extent. One important issue for harmonization is the specification of a common preamble. This preamble is to be used for AGC setting, time synchronization, and frequency-offset and channel estimation. The preamble must be designed in a way to satisfy the requirements of both systems. This document is intended to support the choice of a suitable sequence.

Initial situation

The design of the preamble and the algorithms for signal strength detection, AGC setting, synchronization, and frequency offset and channel estimation has to take into account the following sources of distortion:

- Intersymbol interference introduced by the dispersive channel
- Frequency offsets of up to 200 kHz (±20ppm)
- SNR's as small as 5dB due to path loss and fading
- Clipping due to the limiting characteristics of receiver components

Due to the MAC scheme of HIPERLAN 2 the channel may be occupied continuously by the AP and active MTs. This makes it very difficult to implement an analogue AGC in order to facilitate the AGC setting in the digital part. As a consequence the algorithm in the digital part must work for small SNRs (when the AP is far away) as well as for heavily clipped input signals (when the AP is quite close).

A high detection probability is required to support handover and sleep modes, to reduce the processing overhead, and to save battery power.

For IEEE the situation may be slightly relaxed since due to the different MAC an analogue AGC could support the digital one. (This may reduce the dynamic range of the signal levels the digital part has to cope with.) However, if co-channel interference becomes a limiting factor the analogue AGC will no longer work properly and the dynamic range of signal levels is similar to that for HIPERLAN 2.

Simulation results

Several simulations were performed to investigate the effects of the different sources of distortion on the AGC setting and timing synchronization.

During the first set of simulations a frequency offset of 200 kHz and a fixed dispersive channel were assumed. For the sake of simplicity the channel taps were derived from the power delay profile of the C channel model [1]. This channel model has an exponentially decreasing power delay spectrum with a rms delay spread of 150 ns. The amplitude values were chosen equal to the square roots of the power of the single taps as depicted in Figure 1

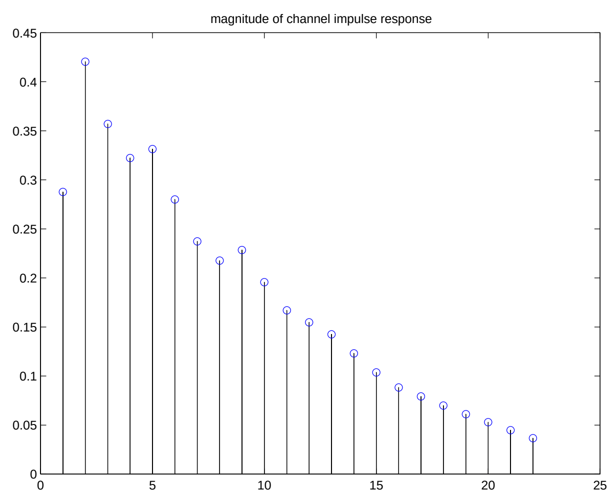


Figure 1: Channel amplitudes derived from C channel model

The spacing between the single taps is 50 ns. The tap phases were chosen to be uniformly distributed between 0 and 2π.

Figure 2 shows the result for a correlation of symbol t6 (16 T-spaced samples) of the IEEE preamble with the whole preamble.

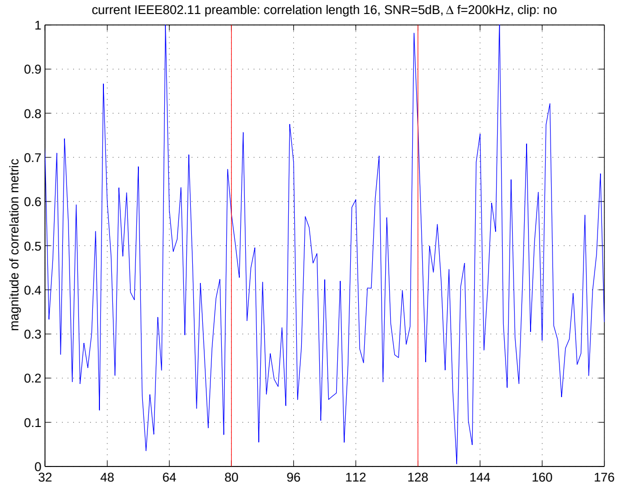
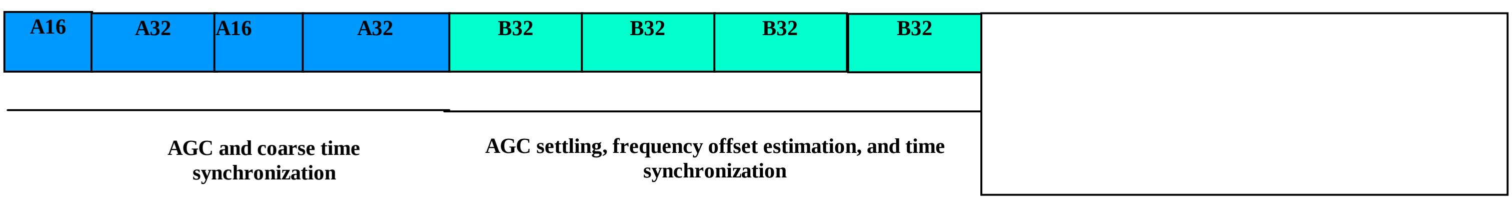


Figure 2: Correlation with a length 16 sequence

Note that the SNR is set to 5dB but no clipping was applied. Due to the repetitive structure of the IEEE preamble, peaks are expected at positions that are multiples from 16. However, it shows that no significant peaks can be detected at the specified location. Hence with the IEEE preamble it seems to be difficult to guarantee a proper AGC setting and time synchronization in the presence of multipath and frequency offsets at low SNR levels.

One way to improve the performance is to consider correlation symbols with greater length, e.g. length 32. For this purpose we constructed a preamble as depicted in the next figure.



Symbol A32 is derived by a 32 point IFFT from the sequence:

S_{A32} = 1/sqrt(2) (0 1+j 1+j 1-j -1+j -1+j -1+j 1-j 1-j 1-j -1+j 1-j 1-j 0 0 0 0 0 0 0

1+j 1-j –1+j 1+j 1-j –1-j 1-j -1+j 1-j 1+j –1+j 1+j)

Symbol A16 is derived as the cyclic extension of the symbol A32.

Symbol B32 is derived by a 32 point IFFT from the sequence:

S_{B32} = 1/sqrt(2) (0 –1-j –1+j –1-j 1+j –1-j –1+j –1+j 1+j –1+j –1+j 1-j –1+j 0 0 0 0 0 0 0

1-j –1-j 1+j –1-j 1-j 1+j –1+j –1+j –1+j –1+j 1-j 1-j)

Symbol C64 is identical to the long training symbol in IEEE802.11a. C32 is derived as a cyclic extension of C64.

The next two figures show the results for the correlation of symbol A32 with the whole sequence. No clipping was applied in the figure on the left. Clipping with a clipping level set to the mean power level was applied in the figure on the right.

Figure 3: correlation results for a length 32 symbol with and without clipping

Peaks are expected at positions 48 and 96. It shows that without clipping the peaks can be easily detected. Even in the case of clipping detection is possible if one takes into account the repetitive structure of the sequence.

To verify these results a second set of simulations was performed. In these simulations the false alarm probability as well as the probability of detection failure was determined for length 16 and length 32 symbols assuming a MAC frame length of 2 ms.

Simulations were done for low SNRs as well as for clipping when the mean signal power level lies 20 dB above the clipping level. Simulations were performed for the IEEE type preamble with symbols of length 16 as well as for the preamble with symbols of length 32 as described above. The simulations are shown for the E channel model [1] as worst case channel with 250 ns rms delay spread. This time the actual channel was varied statistically for each simulation.

The results for the preamble with symbols of length 16 are shown next:

Figure 4: Probabilities for false alarm and detection failure for a sequence with length 16 symbols

As one observes the most crucial case is the one for small signal to noise ratio. If a detection rate for the preamble of 90% shall be guaranteed the threshold has to be set to a value smaller than 0.7. However, for this value the false alarm probability is equal to 1, i.e. in each MAC frame at least one false alarm would occur.

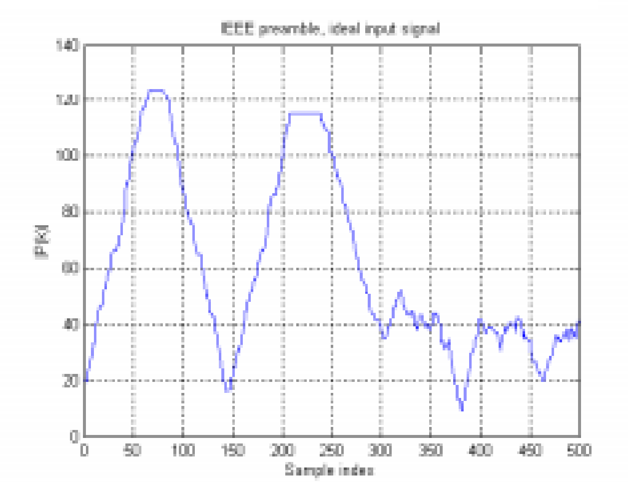
The results for 32 symbols are shown in the next figures:

Figure 5: Probabilities for false alarm and detection failure for a sequence with length 32 symbols

In this case the situation is much better. If the threshold is set to 0.7 a detection rate of more than 95 % and a false alarm probability of less than 1 % results.

In above we have shown that correlator based synchronization methods perform better with the proposed preamble than with the current IEEE preamble. In the following we compare the suitability of the preambles to another synchronization method, delayed signal correlation method (Fig.6).

Using the presented method with the IEEE preamble there is one big problem: the correlator does result pulses with flat sections and no peak exist. The nature of the signal *P(k)* with input signal *r(n)* headed by IEEE preamble is shown in the following two figures. Figure on the left depicts an ideal case with no channel degradation, nor frequency offset, while in the figure on the right a frequency offset was 200 kHz and channel model E [1] (250 ns rms delay spread) was used. In both cases delay *N* was 64 samples and input signal was quantized to one bit.



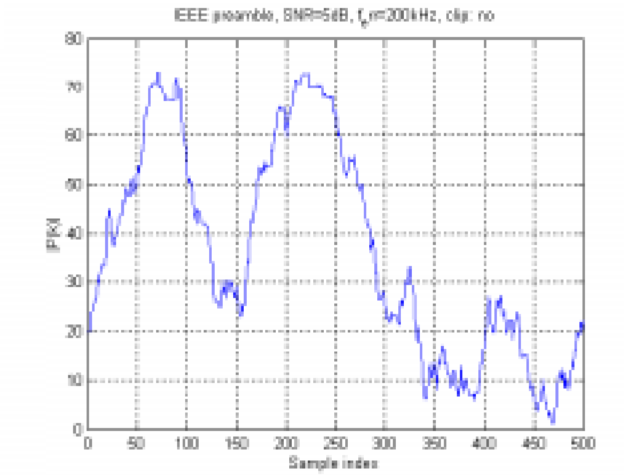


Figure 7: Output of the correlator device (Fig.6) with ideal and distorted signal with IEEE preamble.

The problem arises from the flat top sections generated by the correlator (Fig.6). The first one is a result from the quarter symbols and the latter from the long symbols. In a multipath channel (Fig.7 on the right) the pulses are smeared so heavily that they can't be used for synchronization purposes. They indicate reliably the existence of the preamble, but they do not provide accurate symbol timing, nor can they be used for frequency error estimation. Further, one has to note that the performance of the method presented in Fig.6 doesn't get better with any other delay value *N* or combination of them.

The corresponding curves with input signal *r(n)* headed by the proposed preamble are shown in four following figures. The figures on the left depicts an ideal case: no channel degradation, no frequency offset. The curves in the figures on the right are simulation results assuming 5dB SNR and a frequency offset of 200 kHz. Further, in the curves on the top we have used 48 samples delay and in the curves on the bottom the delay has been equal to 64 samples.

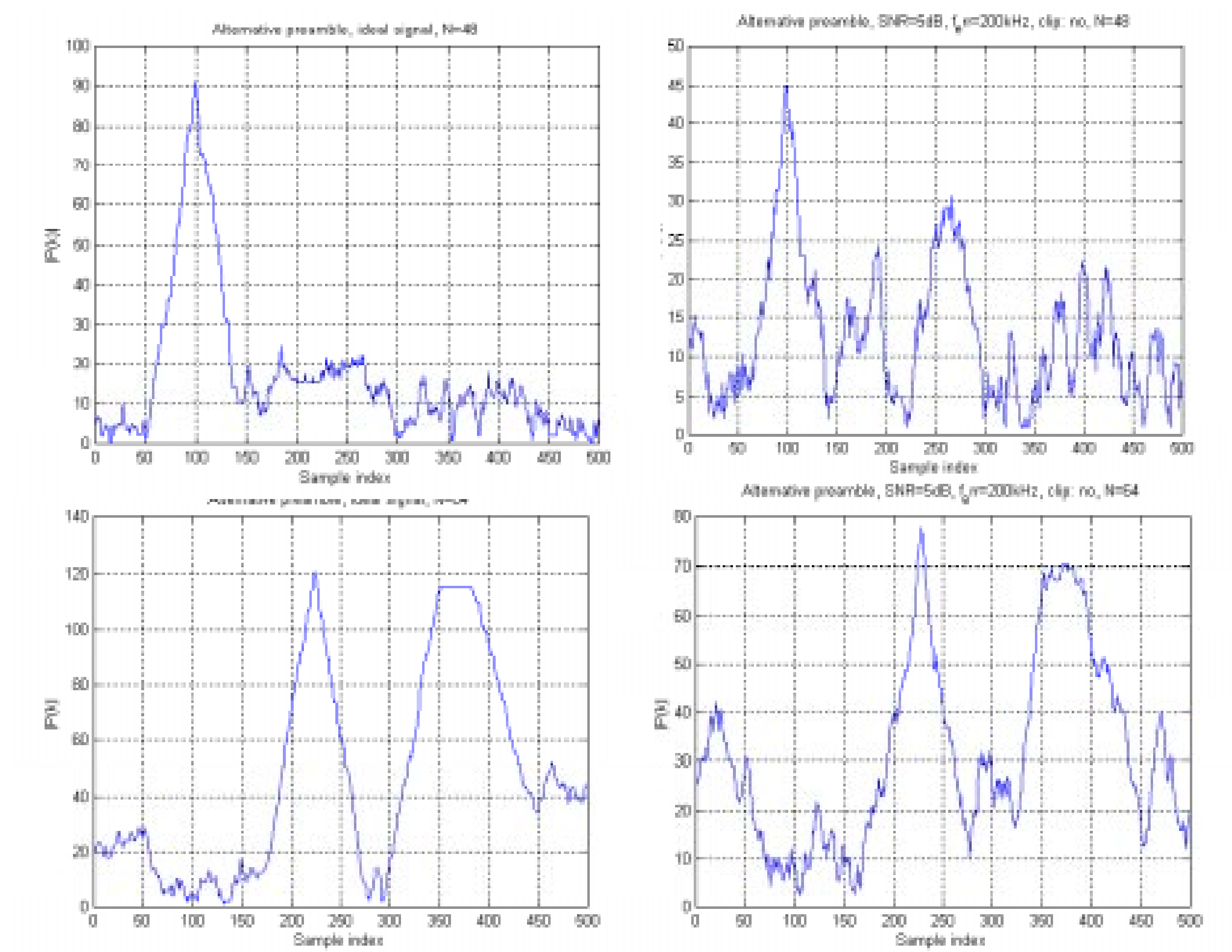


Figure 8: Output of the correlator (Fig.6) with the alternative preamble and two different delay values.

As one can easily see the shorter delay provides a single clear peak from the first section of the preamble. While it can be used to both detect the start of a frame or burst, one can use the correlation peaks provided by the higher delay to confirm the identification and for synchronization purposes. The set of correlation results provides various possibilities to design and implement an effective synchronization procedure.

Conclusions

The simulation results show that the IEEE preamble is not the right choice if AGC level determination and time synchronization have to be performed under difficult side conditions as low SNR, dispersive channel, clipping, and frequency offsets. Additionally, it doesn't allow any other synchronization method but a correlator based one. However, increasing the symbol length from 16 to 32 samples gives a much better performance without generating any essential drawbacks. The lock-in range of the frequency estimator is still sufficiently large and the increased length results in an even higher correlation gain as compared to length 16. Furthermore the effect of ambiguities due to the repetitive structure of the preamble is reduced when switching to length 32, and one can use different kind of synchronization methods. Hence such a preamble should be adopted by HIPERLAN as well as by IEEE.

References

[1] ETSI BRAN PHY subgroup, “Criteria for Comparison”, Document Nr. 30701F.