THE MODEL OF COMMUNICATION CHANNEL IN THE 802.11B STANDARD WIRELESS NETWORK

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Summary The paper deals with software modelling of a communication channel in the 802.11b standard wireless network physical layer. A computer model of signal processing was created to verify possibility of the proposal of localisation system. Functionality of the signal generation and processing model was verified by the Spectrum Analyzer. Simulations run in Simulink/Matlab SW. The Simulink is used for the signal processor model and a pure Matlab software is used for mathematical evaluations of data processor model and for determination of initial conditions.

1. INTRODUCTION

Wireless networks are used increasingly not only for communication but also for localization of wireless user devices (see [1], [2], [3]). Nowadays several localization services, which are based on wireless networks, are available but they serve mainly for various types of advertising in large cities, at shopping centres and so on, where high accuracy of localization is not required.

A computer model of signal and data processing was created to verify possibility of the proposal of localisation system based on time differences of signal arrivals. Simulations run in Simulink/Matlab SW. Simulink is utilized for the signal processor model and Matlab software is utilized for mathematical evaluations and for determination of initial conditions.

2. THE MODEL OF 802.11B STANDARD WIRELESS NETWORK PHYSICAL LAYER

The basis of the model for signal processing is model of physical layer of standard 802.11b wireless network, which is the most widespread standard for wireless data transmission. This model generates the signal of the searched subscriber's station and all clutter signals.

The model utilizes three networks of 802.11b standard in one locality. This situation can occur e.g. at high number of client devices, when a network would not be sufficient for their requirements. This state should not be too frequent, because at planning of network the area should be divided to smaller covering localities which will use channels on principles of similar cell network of GSM. It goes on e.g. particular floors of buildings, possibly only area of a few offices. Consideration of other standard networks should not have significant influence on received signal because these networks work on different principles such as modulation, band allocation. Signal of these networks then appears as clutter for receiver of 802.11b standard.

Basic data rate is 1 Mb/s in described system. Higher bit rates are got only by another coding way eventually by multistate modulations e.g. QPSK modulation at the same bandwidth (see [4], [6]). Usage of higher data rates at user side does not cause significant deterioration of transmitting conditions and from this reason we only consider system with basic data rate at our analysis.

Configuration of communication channel is shown in Fig.1.

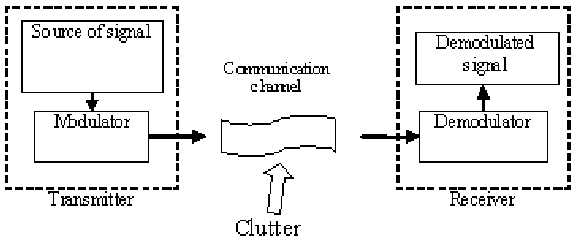

Fig.1. The diagram of communication channel in the 802.11b standard wireless network physical layer

The modulated signal is created by product of pseudo-random data and chip sequence in form Barker code with length 11, which are used for Direct sequence spread spectrum, in our model, see Fig.2.

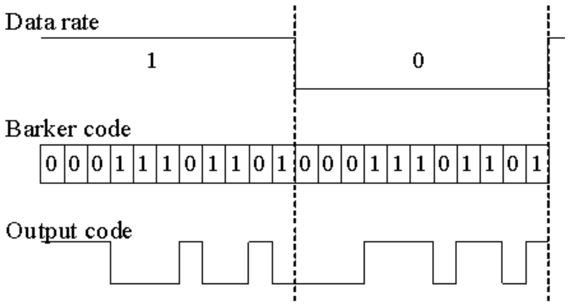

Fig.2. Generation of 802.11b standard output code

Output of this block is assigned for BPSK modulator, see Fig.3.

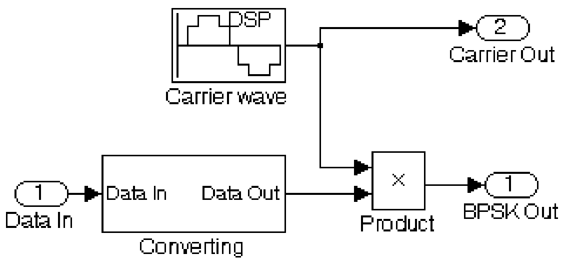

Fig.3. BPSK modulator

First the data signal is convert to binary signal and then it is multiplied by carrier frequency in band 2.4 GHz. Phase change can come in any time, because carrier frequency is not a multiple of bit frequency, which are represented by data rate. The carrier frequency can correspond to any channel of thirteen available channels available for standard 802.11b.

Model assumes with real allocation of frequency channels during network planning, so transmitter, which transmitting on adjacent channel, do not occur in same locality. The occupied bandwidth of the spread-spectrum channel is 22 MHz, so the 2.4GHz band accommodates only three non-overlapping channels spaced 25 MHz apart. These non-overlapping signals are possible to filter very well.

The signals of more distant devices can transmitting in band 2.4 GHz to nearer adjacent channels but due to a longer distance from our device they will have lower signal level. These signals are attenuated more and more in consequence of coming through walls and ceilings (see [5], [7]).

The signal is mixed with carrier frequency of evaluating channel in receiver, see Fig.4. This signal passes through low pass filter with cut-off frequency 6 MHz which is slightly over data rate 11 Mb/s. The low pass Chebyshev filter of degree four gives the best results in our case (described system is aimed to localization purposes). Low-order filters are not sufficiently sharp; on the other hand high-order filters cause excessive delay and distortion of signal. Chebyshev filter of degree four is sharper then Butterworth filter and has only few ripples over the bandwidth.

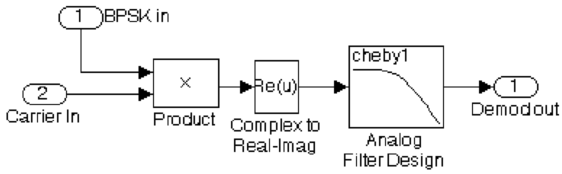

Fig.4. Receiver

After filtering we get the original data sequence multiplied by Barker code, but it is distorted by multipath propagation, side bands interference of other channels working in the same locality and by channels of other devices in further zone. Input band pass filter is determined to noise limitation. Next signal is sampled by sample frequency f_V, which we choose more higher (e.g. twenty times) than Nyquist frequency in aspect of other operation. The high sample frequency simulate analog signal in real system. This sampled signal can be processing in high-level systems. We are also able to estimate original data sequence by correlation with Barker code.

3. RECEIVING SIGNAL ANALYSIS

The receiving device of our system receives not only a direct signal from each transmitter present in the station range, but also reflected signals from walls, ceilings and floors in the building. In the case of outdoor situation, the signals are reflected from buildings and terrain. We suppose that these reflected signals differ from the direct signal only in the amplitude and the delay, see Fig.5. All direct and reflected signals give the total signal $s_{Am}(t)$ at receiving device, which can be written in the following way

$$s_{Am}(t) = \sum_{k=0}^{K} A_k s(t - t_d - \tau_k) \qquad (1)$$

where

- A_k is the amplitude of the k-th reflected signal at the receiving device
- t_d is the delay of the direct signal coming to the receiving device
- τ_k is the delay of the k-th reflected signal in respect to the direct signal

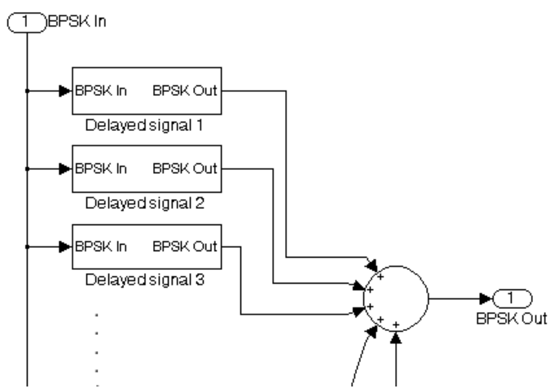

Fig.5. Sum of reflected signals

Total clutter, which is given by sum of signals of networks working on adjacent channels in the same locality (e.g. inside building) and networks which use any channels in further locality, is added to signal $s_{Am}(t)$ in real conditions.

Clutter at receiver device input $e_N(t)$ is defined as white random process with normal distribution. This clutter is limited at receiver input by filter with 200 MHz band width. Total signal at input of receiver is given by

$$s_{B\upsilon}(t) = \sum_{k=0}^{K} A_{\upsilon k} s_n(t - t_\upsilon - \tau_{\upsilon k}) + \\ + \sum_{n=1}^{N}\sum_{k=0}^{K} B_{nk} s_n(t - t_n - \tau_{nk}) + e_{N\upsilon}(t) \quad (2)$$

where

$s_{B\upsilon}(t)$ is signal in υ-th channel with frequency ω_υ

B_{nk} is amplitude of k-th delayed signal of n-th transmitting device

$| B_{nk} | << | A_{\upsilon k} |$

$e_{N\upsilon}(t)$ is clutter in υ-th channel

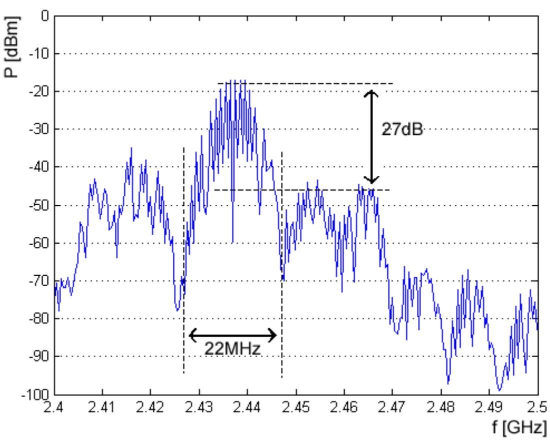

Fig.6. The spectra of generated signals

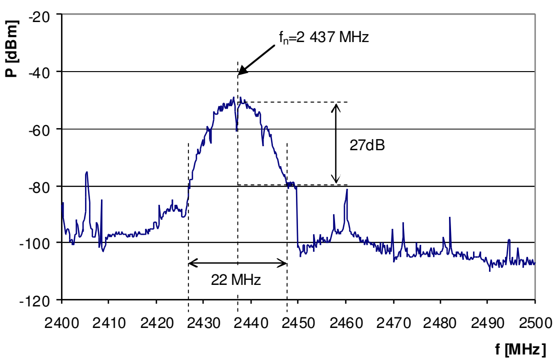

Fig.7. The spectra of measured signals

Functionality of the signal generation and processing model was verified by the AirMagnet's Spectrum Analyzer. This device identifies, classifies, and finds sources of RF interferences that impact the performance of WiFi networks. The comparison of spectra of generated and real signals shows a reasonable agreement, see Fig.6 and Fig. 7.

4. CONCLUSION

The paper deals with a model of a communication channel in the 802.11b standard wireless network physical layer. A feasibility of the signal and interference models was tested by comparing with measured spectra of real signals and clutter. Models of emitted signals and of interference and a model of a wireless multipath communication channel were built in Matlab/Simulink SW.

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