Usage of Ultra Wide Band Signals in Radio Networks

Sergey Bunin

Abstract - **In this paper the pros and cons of IR-UWB signals usage in radio networks are discussed.**

Keywords – **Impulse Radio Ultra Wide Band signals, Radio Networks, Medium Access Control, Data Rate.**

I. Introduction

Usage of impulse radio ultra wide band signals (IR-UWB) in point-to-point communication and radar technologies is widely spread now days [1]. However when they planned to be used in radio networks one must cosider additional aspects which impact the network characteristics.

II. IR-UWB Radio Networks

In networks it is necessary to distinguish and select signals of different users. This means that signals must be orthogonal or, at least, quasiorthogonal. The orthogonality of IR-UWB signals can be achieved by unique time domain representation of signal impulses within each information bit of an user.

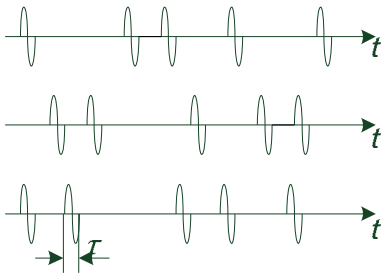

Fig.1 IR-UWB orthogonal signals

More users in the network – more free space must be in each signal to place impulses of signals the rest of users. In other words, the signals must have pretty large mean duty factor $\overline{Q} = T_s / t_i n$ - ratio of bit duration to sum of pulse duration.

Large mean duty factor limits data rate in the network because the sum of pulse duration must be

$$t_i n \le 1 / V\overline{Q}_r \approx 1 / 10NV , \quad (1)$$

where V - data rate, N - number of users, t_i - impulse duration, n - number of impulses in the signal.

And data rate

$$V = 1 / \overline{Q}_r t_i n . \quad (2)$$

Thus the data rate in the network with IR-UWB signals is limited by selected duty factor, impulse duration and number of impulses in the signal.

Sergey Bunin, National Technical University of Ukraine "Kiev Politechnical Institute", 37 Peremoga Ave., 03054, Kiev, Ukraine.

To increase data rate one should decrease impulse duration and/or number of impulses in the signal. Both these mesures decrease signal energy with corresponding consequencies: lower power to noise ratio and communication distancies.

Nowadays it is difficult to imaging use of IR-UWB without any frequency limitations. But such limitations distort pulse forms and, the more important, increase pulse duration. High frequency and especially bandpass limiting makes pulses longer and smaller in amplitude. So the use of very short pulses to increase data rates is not reasonable. FCC limits [2] identify optimum pulse duration of 0.146 ns. The frequency limit makes the pulses duration up to 0.2 ns. Thus in 10 terminals network data rate of a subscriber cannot be higher then 1 mbps and overall rate – 10 mbps.

Signal codes, i.e. impulse time domain positions can be and usually used as destination addresses.

It is reasonable to note that coincidence in time of some impulses does not deteriorate signals reception and even mutially increases their power in case that the coincidence do not exceeds a majority factor (by more then 50 percent).

Another important issue is Medium Access Control (MAC) in radio networks. Practically in all radio networks one or another MAC protocol is used to prevent packet collisions. The MAC usually signifecantly limits network throuput because only one signal transmission permitted while the rest network terminals within radiovisibility zone and hidden terminals must be in stand-bye state.

In cases of IR-UWB usage with large duty factor MAC can be significally simplified or even eliminated. Depending on method of signal reception and type of sinchronization (if any), even the simplest ALOHA protocol can be used. The probability of collisions can be very small and inversely proportional to orthogonality level between signals.

III. Conclusion

Usage of IR-UWB signals in radio networks correspond with positive and problematic issues such as how to maintain high data rates on long communication ranges with significant number of users in the network.

References

[1] L. E. Miller. Why UWB? A Review of Ultrawideband Technology.// Report to NETEX Project Office, DARPA. Wireless Communication Technologies Group National Institute of Standards and Technology.Gaithersburg, Maryland. April 2003.

[2] Federal Communications Commission (FCC) "First Report and Order in The Matter of Revision of Part 15 of the Commission's Rules Regarding Ultrawideband Transmission Systems" ET-Docket 98-153, FCC 02-48, released April 22, 2002.