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Source(s)	Yossi Segal Dr. Zion Hadad RunCom Technoogies LTD. 14 Moshe Levi St., Rishon Lezyyon, Israel Voice: 972-3-9528440 Fax: 972-3-9528805 mailto:zionh@runcom.co.il mailto:yossis@runcom.co.il
Re:	Call for Contribution to develop the Project Authorization Request for a WirelessHUMAN™ standard; issued 2000-07-28.
Abstract	We give a short description of an OFDM system, which is planned to combat the long Delay Spread, Multipath and interference. The system proposed includes adaptive modulations for Uplink and Downlink, adaptive bandwidth allocation and ECC.
Purpose	The document aims to introduce an adaptive system in the Downlink and the Uplink, which has the capabilities of combating Multipath and interference.
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Proposal for an adaptive OFDM system for the WirelessHUMAN™ standard

Dr. Zion Hadad and Yossi Segal

1. Introduction

The following paper introduces several ideas for the development of the WirelessHUMAN™ standard. This paper focuses on an adaptive system, capable to adapt the Bandwidth, modulation, ECC on the Downlink and the Uplink channels.

2. General

The 802.11.a standard has been developed for the same frequencies, which the WirelessHUMAN™ standard aims for, but as an indoor solution. It's PHY mechanisms are wasteful for the long synchronization/equalizing periods they have defined. We therefore propose to change it in order for it to fit the Outdoor channel characteristics, which includes longer spreading time, more Multipath, interferences and the need for higher spectral efficiency and Cellular planning.

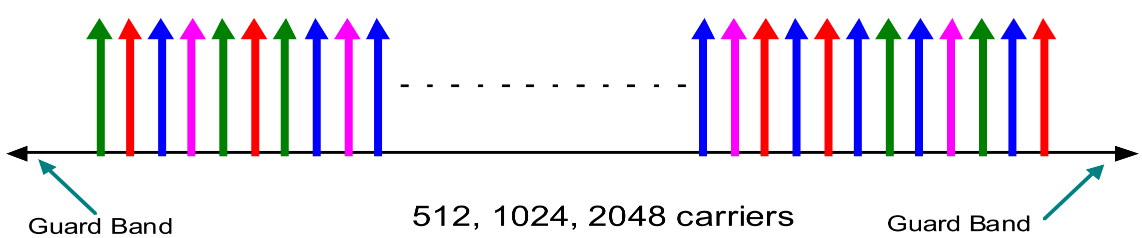
3. Better Combating the Channel

Due to longer spreading time and more Multipath, we propose to prolong the transmission time and the guard time of the symbol. This is achieved by using more carriers. A scheme for transmitting more carriers can contain multiples of the basic allocation of the IEEE 802.11a (of 52 carriers). The number of carrier implies on using larger FFT's as 512, 1024 or 2048 points.

I order to combat Multipath better a basic allocation of carriers are spread all over the spectrum allocated, in order to achieve better frequency diversity.

A better implementation is achieved by using the carriers allocated in small FFT for Guard Band, for user pilots in order to better estimate the user data, and the remaining as Guard Bands.

The next figure illustrates such a scheme, where each color represents a user.



For the Down link a scheme where pilots are spread all over the carriers is the best one for estimation giving up to a 1:10 ratio between data and pilots enabling a very good estimation in the frequency domain, by smart allocation of carriers these pilots could be accumulated in different frames for better estimation.

The Guard Interval (GI), which is OFDM's main tool for combating Multipath is a constant ration of a useful symbol, this GI is an overhead for the symbol time, which enables combating echoes. In order to calculate the GI for different FFT Sizes, we shell take as an assumption a channel using a 16MHz bandwidth (62.5nsec per sample), using different GI for different FFT sizes we get the next results:

FFT size	GI in usec	GI value
512	8	_
1024	8	1/8
2048	8	1/16

4. Channel delay spread

All calculations done in the above section were done in order to combat the delay spread for the 5GHz frequency. When using directional antennas and ranges not more then 5Km, a delay spread of 1-2usec is expected, therefore we should combat at least 5-10usec and the GI should be at least of this amount. When using large FFT the overhead for the GI is smaller comparing to small FFT's, therefore achieving a better throughput of the system using the same bandwidth (better then 802.11a by a factor of 8,16, or 32).

5. Power emission

The transmission in the UNII is determined to power per hertz (the power density). Better ranges would be achieved if the power is dispersed over all the frequency bandwidth allocated, which will demand transmitting more power or using better antennas. Easer solution could be achieved by dividing the power between carriers, which are divided in all the bandwidth, achieving diversity in the frequency domain and power concentration. The power concentration is achieved by transmitting all the energy on a few dedicated carriers (for example when using only 1/8 the carrier 9dB can be achieved).

6. Convergence with the IEEE 802.11a

We propose to leave the smallest allocation of carriers to the size of the IEEE802.11a allocation therefore enabling the use of convergence layers between the WirelessHUMAN™ and the IEEE 802.11a

7. Adaptive modulation and ECC

Best results for a wireless system could be achieved by using adaptive techniques to adapt the modulation and the ECC protection per user, and achieving the best throughput to a system. We propose to use nQAM modulations and a ECC allowing a 10^{-8}-10^{-11} BER as fixed wireless systems today propose. In order to allow combating burst errors and frequency jamming of up to 30% of the frequency range we propose to use Concatenated Reed Solomon and Convolutional coding or a Turbo code scheme.

8. Interference handling

When dealing with interference we should distinguish between two scenarios:

- Interferences form other systems using the same frequency band in the unlicensed band
- Interferences from neighboring cells, depending on the area covered the interferers could spread in Line of Sight (LOS) condition with a R^2 factor of a R^4 for a Non LOS conditions.

In order to combat these interferences we propose to use smart permutation, which will allow protection from neighboring interferers or Frequency blocking up to 30% of the spectrum.

9. Using frequency synchronization

In order to avoid the costly and very long time preambles used for equalization we propose to use carriers and the GI to synchronize to the signals and spare the bandwidth

10. Conclusions

We have proposed the usage of a sophisticated PHY layer designed to combat both Multipath, delay spreads and interference and allow better power concentration, combined with adaptive methods for modulation and ECC which will enable better system capacity, and a possible fast convergence layer to the IEEE 802.11a system.