New Coded Modulation for the Frequency Hoping OFDMA System.

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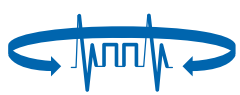
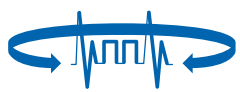
Thirteenth International Workshop on Algebraic and Combinatorial Coding Theory

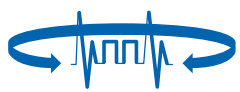


Outline



Introduction

We consider a communication system with multiple transmitters and multiple receivers sharing the same bandwidth.
The transmitters are not synchronized with each other in any way.
Each receiver is synchronized with one transmitter. The synchronization implies the symbol and block synchronization and also the knowledge of a shared pseudorandom sequence.
We will introduce FH OFDMA coded modulation and new statistical decoder that allow for high number of simultaneous transmissions.

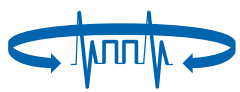


Frequency Hoping Orthogonal Frequency Division Multiple Access Transmitter Design

$$i \in \mathbb{F}_q$$

$$\vec{x} = \begin{pmatrix} \vec{e}_i \\ \mathbf{O} \end{pmatrix} \in \mathbb{F}_2^p, \vec{e}_i \in \mathbb{F}_2^q$$

$$\mathbf{W} = \|\pi_1(\vec{x}) \dots \pi_T(\vec{x})\| \in \mathbf{M}_{p \times T}(\mathbb{F}_2)$$



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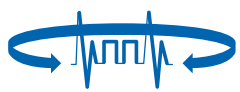

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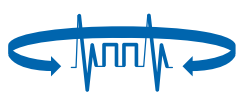
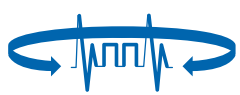


The demodulation

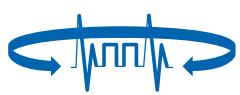
1. Receive OFDM block.
2. Make inverse permutations.
3. Remove the lower part of the matrix.
4. Take the absolute value of each value received.

We get the matrix $\mathbf{Y} = (y_{ij}) \in \mathbf{M}_{q \times T}(\mathbb{R})$



Statistical Decoder Concept

The elements of all the rows of $\mathbf{Y}$ except for the "signal" row are identically distributed.
The elements of the "signal" row have another probability distribution.
So we can you some statistical criterion for the decoder design.



Kolmogorov-Smirnov Criterion

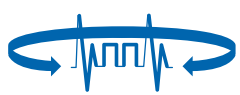
Let X be a sample of length n, and Y be a sample of length m. Let $F_X(t)$ be empirical distribution function for X. If X and Y have the same probability distribution then the following equation holds:

$$\max_t |F_X(t) - F_Y(t)| < \frac{mn}{m+n} K(\alpha),$$

where $K(\alpha)$ is the Kolmogorov function for the significance level α. We use $X_i = \{y_{ij},\ \forall j\}$ and $Y = \{y_{ij},\ \forall i, j\}$.

Remark:

Kolmogorov statistic is the same for pairs (X, Y) and $(X, X \cup Y)$.



Order Statistics

$$r_{ij} = |\{(l, m) : y_{lm} < y_{ij}\}|$$

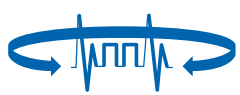
$$R_i = \{r_{ij},\ \forall j\}$$

Theorem

The following equality holds:

$$\max_t |F_{X_i}(t) - F_Y(t)| = \frac{1}{qT} \max_t \max(|R_i^{(t)} - tq|, |R_i^{(t)} - 1 - t(q-1)|),$$

where $X^{(t)}$ is the t-th element of the sorted set X ($X^{(t-1)} \leq X^{(t)}$, $X^{(t)} \in X$).



Order Statistics Normalized Envelope Detection Based Diversity Combining Decoder

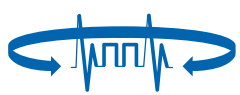
Ref:

S. Ahmed, L-L. Yang, L. Hanzo 'Diversity Combining for Fast Frequency Hopping Multiple Access Systems Subjected to Nakagami-m Fading', IEE 3G and Beyond, pp. 235–239, 2005

OSN decoder operates on order statistics of separate measurements corresponding to different rows of the matrix $\mathbf{Y}$.

$$D_{OSN} = \arg\max_{i=1..q} \sum_{t=1}^{n} \frac{X_i^{(t)}}{\chi_t},$$

where $\chi_t = \sum_{i=1}^{q} X_i^{(t)}$.



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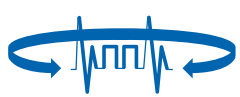
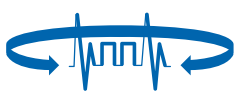


Energy sum decoder

This trivial decoder is

$$\arg\max_{i=1..q} \sum_{t=1}^{T} y_{it}$$



Simulation Parameters

$$Q = 4096$$

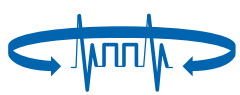
$$T = 8$$

$$q = 256$$

$$p = 3331$$

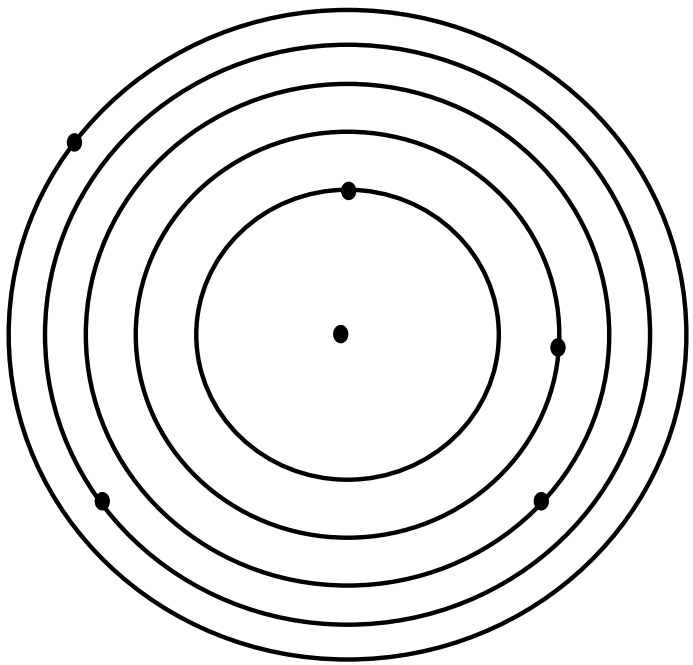
$$SNR = 20dB$$

COST 207 channel

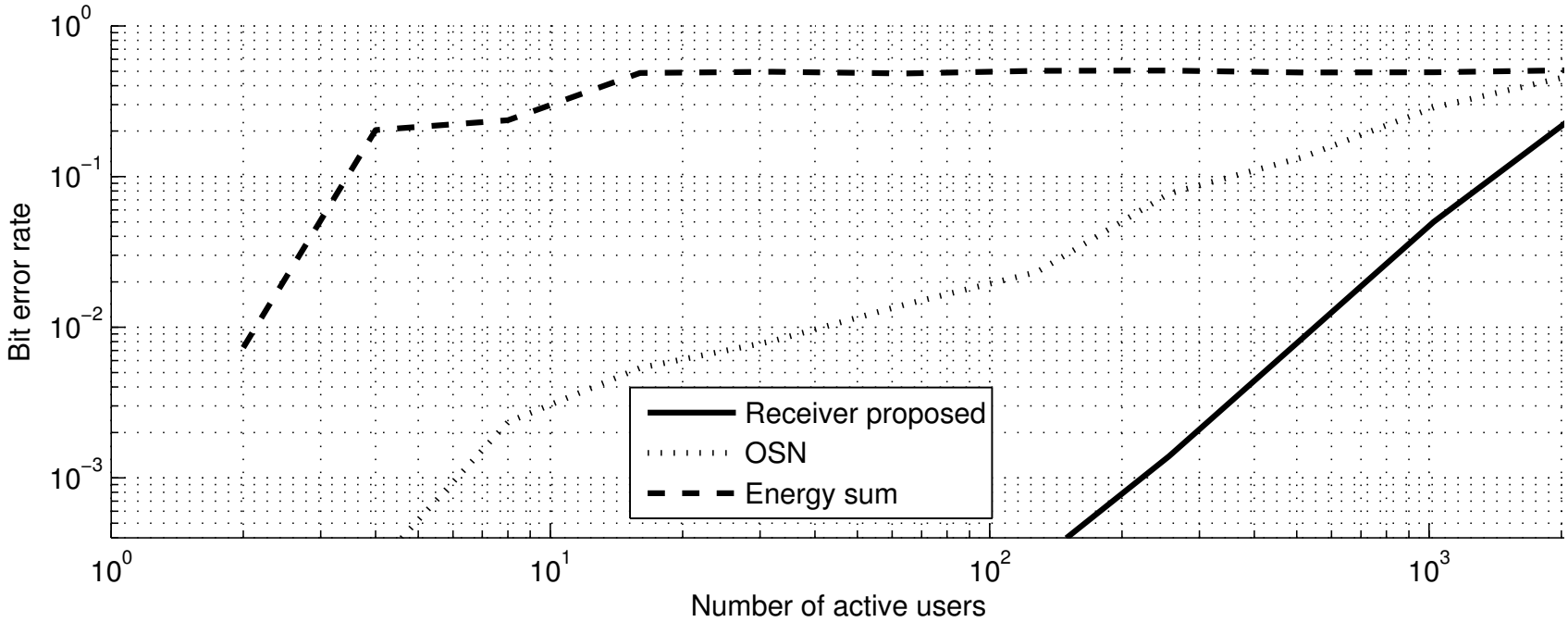


User Distance Distribution

To simulate "natural" transmitter distribution over area, we placed transmitter n at distance $\sqrt{n}$.
This way we have one transmitter in each ring of area 1.
We used Hata model to determine the power of each transmitter at the receiver.



Simulation Results

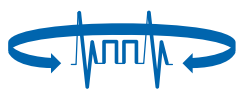


Conclusion

- We have proposed new statistical kind of FH OFDMA decoder.
- We have constructed statistical decoder based on Kolmogorov-Smirnov criterion.
- We have estimated its performance with computer simulation.

Future work

Find statistical criterion with possibility of some analytical performance estimation.



Thank you for your attention!