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MAXIMAL PRODUCTIVITY OF WIRELESS SYSTEM WITH MULTIPOSITION KEYING AND LDPC CODING

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Максимальная производительность беспроводной системы передачи с многопозиционной манипуляцией и LDPC-кодированием

Алгоритм выбора оптимального сочетания многопозиционной модуляции и LDPC кода предлагается в данной статье. Критерием для выбора оптимального сочетания многопозиционной модуляции и LDPC кода является максимальная производительность в зоне покрытия базовой станции мобильной связи.

Every telecommunication system (TS) utilizes physical resources of communication channel for information transmission from sender to receiver independently from propagation medium type: wired, wireless or optical. Particularly, the most widespread TSs today are systems that use wireless communication channel (WTS, – wireless telecommunication system). For WTSs quite important is the question of using the limited communication channel physical resources in allowed bounds, videlicet frequency and power resources. It is possible to use these channel resources in different ways if taking into account the communication methods and technologies; that is expressed in the final analysis in resources efficiency usage on frequency and power efficiency criteria [1, 2]. In result, achievement of maximal efficiency leads to maximal information efficiency when using frequency and power resources [1, 2], that could be considered as a key efficiency criterion for WTS along with such important parameters as bit error rate (BER) and data rate transmission.

Different methods are used for WTS efficiency improvement and redistribution of frequency and power channel resources [1]: multiposition keying (MPK), antinoise coding [2], orthogonal multiplexing, group signal amplification etc. In modern WTS, varied MPK types are used like PSK, QPSK, QAM etc.; the goal of this is a maximal efficiency [1] of frequency resource usage and data rate increasing. At the same time, increasing the MPK index results in noise immunity decreasing on the receiver side [3]. This circumstance is a key factor when the decision is made for switching from one MPK type to other MPK type, as far as one of the most important requirements to WTS is ensuring a necessary BER level alongside with a significance of data rate transmission.

Combining the MPK types and antinoise coding types for channel resources redistribution with goal to guarantee a required BER and achieve maximal transmission data rate leads to important and urgent task of WTS productivity maximization with consideration of space model. Results of this research are presented in current paper for MPK types QPSK, QAM-16 and QAM-64, and for antinoise coding type: low density parity check codes (LDPC) [4]. LDPC is one of the most efficient antinoise coding at present.

Let us consider the scenario of WTS functioning and its parameters. Let base station (BS) beam a signal with power P_{TR}; used frequency band is Δf; communication channel model is with additive white Gaussian noise (AWGN) and the AWGN power spectrum density is N_0. Required value of BER is p_b. The point of space exists for selected MPK type in the distance from the BS L_i (i = 1,2,3), *km*, where i=1 for QAM-64, i=2 for QAM-16, i=3 for QPSK, where required BER p_b is satisfied [2]. Taking into consideration the distance from BS, BER is better (lower) than required value, but in the longer distance L_i BER is worse (higher) than required one (fig. 1).

The task is following: to define optimal combinations of MPK (from the set: QPSK, QAM-16, QAM-64) and antinoise code rates (LDPC code with code length n, *bits* and code rate r_k) by criterion of reaching a maximal productivity Y [5] of WTS using frequency and power resources of communication channel with consideration the WTS spatial model.

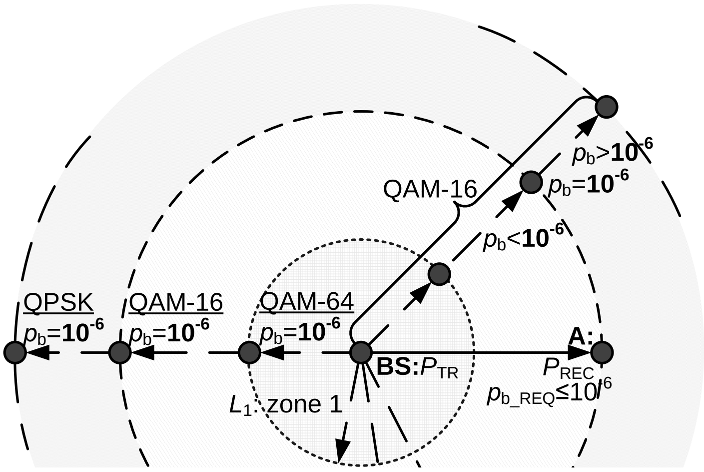


Fig. 1. Coverage areas

The productivity Y in the area with radius L is defined as following:

1. Determination a maximal radius of area (L_3, *km*) where applicable BER is supplied (p_b) and the source data rate is known (V_S, *Mbps*);

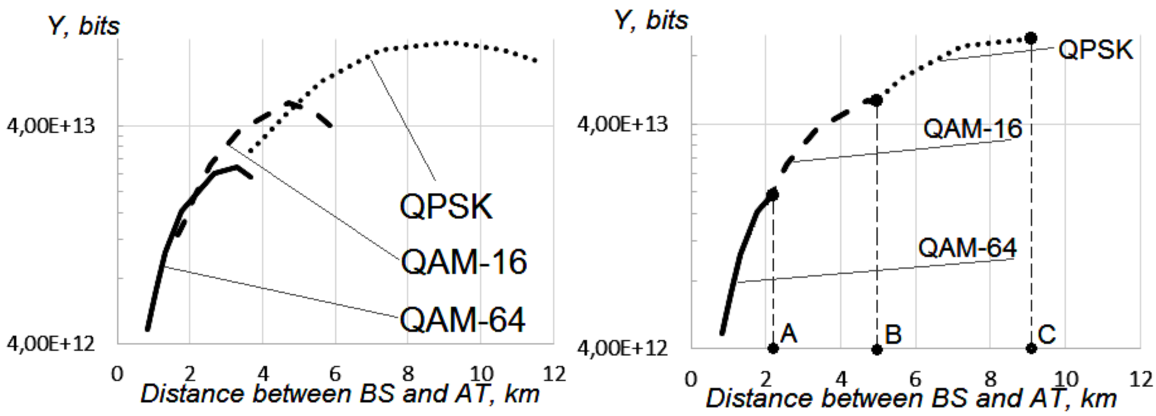
2. Detection of users number (N, *users*) on the occupied area $S=\pi L^2$ on the assumption of population density (q, *users/km*^{2}) that use WTS services: $N=S\cdot q$, *users*.

3. Estimation of requests flow intensity to system (A, *Erlang*) based on average activity of one user (a, *Erlang/user*): $A = a\cdot N$, *Erlang*.

4. Evaluation the system productivity in coverage area (Y, *Mbits*) with specific MPK type and selected BER, in terms of information data rate for one user (V_S, *Mbps*): $Y=V_S\cdot A$, *Mbits*.

Antinoise code rate $r_k=V_S/V_C$ [3] that is needed for compensation the lost BER up to a required level p_b depending on the distance between base station and subscriber terminal, is defined by technique [5]. For instance, if SNR in the receiving point is 22 *dB*, then antinoise code with code rate r_k=0.9 should be used to satisfy $p_b=10^{-6}$; in the case when SNR in the receiving point is 17 *dB*, then antinoise code rate r_k=0.5 should be used and so on. This technique is used for definition the appropriate code rate in the case of extension the coverage area with goal to achieve a required BER level at the receiving point $p_b=10^{-6}$ for MPK types QPSK, QAM-16, QAM-64 and LDPC code word length n=1000 *bits*.

Thus, along with decreasing the antinoise code rate r_k purposely to extend the coverage area bounds [5], the total productivity Y increases, but the specific moment rises when the antinoise code rate r_k is lower than some optimal value r_{k_OPT} and then it doesn't lead to further increasing of productivity Y. Characteristic of productivity Y is shown on fig. 2,a,b as a function of distance L.



a) б)

Fig. 2. Productivity Y for coverage area with QAM MPK types, $p_b=10^{-6}$, n_{LDPC}=1000 (a) and maximal coverage productivity and points of MPK types / antinoise code switching (b)

It is displayed on the fig.2,a that together with growing distance between base station and subscriber terminal, and decreasing the antinoise code rate accordingly, the extremum of productivity exists. This is a point of space where further code rate decreasing and larger area coverage brings to decreasing the total productivity *Y*. So, outside of this point using current MPK type and further code rate decreasing is not efficient and it is needed to switch to other MPK with lower MPK index $k=\log_2 M$.

The coverage area productivity is shown on the fig. 2 for optimal combination of MPK type (QPSK, QAM-16, QAM-64) and antinoise code (LDPC, n=1000 *bits,* r_k>0,25) to satisfy the criterion of maximal productivity *Y* for covered area (Table 1).

In accordance with mentioned parameters, the points of decision making about switching the MPK type and coding rate are the points of distance between base station and subscriber terminal with the following SNR (Table 1).

Table 1: Points of decision making to switch MPK type and antinoise code rate

Point	***SNR, dB***	***L, km***	***MPK***	r_k
A	16.2	2,5	QAM-64	0,55
B	10.7	5,0	QAM-16	0,42
C	4.3	9,1	QPSK	0,50

Conclusion. The algorithm for selecting the optimal combination of multiposition keying type and antinoise code is proposed in this paper for the purpose of reaching maximal productivity in the coverage area.

It is shown that utilization of antinoise codes gives a possibility to extend the coverage area with satisfaction of the required BER along with code rate and information data rate decreasing. A compromise between multiposition keying type and antinoise code rate is characterized by productivity extremum, after which further decreasing of code rate is unreasonable. Such trend is observed for all the investigated multiposition keying types (QPSK, QAM-16, and QAM-64). As a result of this, it is possible to talk about some optimal (maximal) productivity and switching between different multiposition keying types and antinoise codes in taken combinations set in the found points of decision making to switch over.

The proposed technique and algorithm are universal for any wireless telecommunication system parameters values. The results given in the research could be used for transmission systems development with adaptive selection of MPK types and antinoise codes with goal to reach maximal cumulative productivity for telecommunication system in the base station coverage area.

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