4. Langton, Charan. Partial Response signaling and Quadrature Partial Response (QPR) modulation. Tutorial 16 [Text] / C. Langton – Signal Processing and Simulation Newsletter, 2011.
5. Сукачев, Э.А. Введение в теорию сигналов с управляемой межсимвольной интерференцией : Монография [Текст] / Э.А. Сукачев, П.А. Шкулипа – Одесса: ВМВ, 2011. – 200 с.
6. Золотарев, В.В. Помехоустойчивое кодирование. Методы и алгоритмы. Справочник [Текст] / В. В. Золотарев, Г. В. Овечкин – М.: Горячая Линия-Телеком, 2004. – 126 с.
7. Когновицкий, Л.В. Межсимвольная и межканальная интерференция в системах передачи цифровой информации [Текст] / Л.В. Когновицкий, Л.О. Ржига – М.: Изд-во МЭИ, 1998.
8. Брескин, В.А. Спектральная эффективность линейного кода RZ [Текст] / В.А. Брескин, А.Д. Мазур, Д.М. Розенвассер // Наукові праці ОНАЗ ім. О.С.Попова. – Одеса, 2011. – №2.
9. Breskin V.A. Effect of optical channel bandwidth on the immunity of NRZ and RZ linear codes / V.A. Breskin, A.D. Mazur, D.M. Rozenvasser // TCSET-2012 – Lviv-Slavske, Ukraine, 2012. – p. 365.
10. Tapp, T. L. Extended hamming and BCH soft decision decoders for mobile data applications [Text] / T. L. Tapp, A. A. Luna, X. Wang, S. B. Wicker // IEEE Transactions Communications. – 1999. – Vol. 47, no. 3. – p. 333–338.
11. Брескин В.А. Увеличение пропускной способности оптического канала волоконно–оптической системы передачи [Текст] / В.А. Брескин, А.Д. Мазур, Д.М. Розенвассер // Электроника и связь. – Киев, 2012. – №6.
12 Chen, S. Decision-feedback equalization using multiple-hyperplane partitioning for detecting ISI-corrupted M-ary PAM signals [Text] / S. Chen, L. Hanzo, B. Mulgrew // IEEE Transactions Communications. – 2001. – Vol. 49, no. 5. – p. 760–764.

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ANALYSIS OF STOCHASTIC CHARACTERISTICS FOR CARRIER SENSE MULTIPLE ACCESS

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Представлена задача аналізу алгоритму багатостанційного доступу для систем CSMA/TDMA із зостосуванням у сенсорних мережах. Використання комбінованого методу доступу дозволяє мінімізувати конфліктні ситуації. Проведений аналіз показав характерне повільне зменшення коефіцієнту використання канала при збільшенні активних абонентських датчиків

Ключові слова: абонентський вузол, доступ, заявка, таймслот, конфлікт, коефіцієнт використання каналу

Представлена задача анализа алгоритма многостанционного доступа для систем CSMA/TDMA применительно к сенсорным сетям. Использование комбинированного метода доступа позволяет минимизировать конфликтные ситуации. Проведенный анализ показал характерное плавное снижение коэффициента использования канала при увеличении активных абонентских датчиков

Ключевые слова: абонентский узел, доступ, заявка, таймслот, конфликт, коэффициент использования канала

1. Introduction

In wireless communication systems:, Wi-Fi, WiMAX, in the cellular and sensor systems throughput, link utilization, quality of service QoS largely depend on the choice of multiple access method (MA) (MAC Access Protocol). Over recent years MA is usually developed within modernization techniques with carrier sense (CSMA Carrier Sense Multiple Access), derived from the ALOHA method [1-3]. In its simplest form, this method is based on the fact that subscriber stations or sensor nodes scan in the selected frequency band and time window size T they start to send information, if the access point, the base station (BS) or a node, that collects sensor information, are in standby mode [4-6]. Otherwise, the attempt to transmit is repeated. Such MA method is simple and reliable in implementation, it does not require clock synchronization. However, ALOHA has some drawbacks: the actual capacity of the system reduces proportionally to the number access elements and their activity, coefficient of channel utilization is reduced as well.

Combined MA method is more promising [7], it is based on the union of CSMA TDMA (Time Division Multiple

Access) - the access method with the division of information flows over time. Conflict-free transmission at MD TDMA is achieved through tight clock synchronization of a network and sequence of packets from each of the objects. In practice, when all subscribers are active, system performance is reduced as well. This MA method has also the name of polling.

Let us consider operation of the combined MA method in details. It should be noted that one of these methods MA - Binary Exponential backoff (BEB), has gained popularity among specialists [8]. The main feature of the BEB method is that during ordinary conflict repeated access is allowed for i-subscriber station (sensor node) through exponential time interval (backoff). There exist an other implementation of backoff, when the choice of a successful is made randomly. At the same time slot is selected on the basis of random distribution P_i, in which the selection of first slots I = 1,2…has low probability, but for the following slots I = …n-1,n the probability increases:

$$P_i = \frac{(1-d)d^n}{1-d^n} d^{-n}, \qquad (1)$$

where d<1 is chosen according to the number of slots [9]. Let's analyze the combined MA method.

2. The Probabilistic Model of the Combined MA

Useful indicator of the channel can be represented as the ratio

$$k = \tau_y / \tau_n, \qquad (2)$$

where τ_y - the time spent on the successful transmission of one packet, τ_n - the average time system spends for transmission of one packet. It is obvious that k≤1.

Let's denote probabilities connected with characteristics of time:

P_k - the probability of conflict;

P_y - the probability of a successful solving of the conflict;

P_p - the probability of packet expectance in the queue during conflict soling.

These probabilities form an full event group, that's why

$$P = P_k + P_y + P_p = 1. \qquad (3)$$

Despite the fact that the system the period T is divided into slots for subscriber node (SN) an average window size is smaller because of the backoffs. The window size W is a random variable. Its average value is:

$$W_0 = (W-1)/2.$$

Let's determine the probability of the channel use. Considering (2) we have:

$$P(m,W) = \frac{\tau_y P_y}{\tau_n \cdot P_k + \tau_n \cdot P_y + \tau_p P_p}. \qquad (4)$$

Let us find the value of probability. The probability that the jth successful slot is idle is equal to the probability that none of the SN did not choose this timeslot. Considering that m nodes may be involved the conflict, the probability that a node selects the slot in time t is equal to $1/W_0$, so:

$$P_t = (1 - 1/W_O)^m. \qquad (5)$$

3. Description of the function of the combined MA method model

Each MA algorithm usually consists of two other algorithms: ACA – algorithm for channel access and ARC - conflict resolution algorithm. ACA regulates the procedure for subscriber access to the medium, while ARC specifies how to separate conflicts between packages during simultaneous transmission of two or more objects. Conflict resolution time is τ_p.

We derive the following assumptions, which are usually performed in practice:

1. Suppose cellular or sensor system has N-subscriber nodes. Signal propagation time t_p between each of the i-nodes and base (central) station t_p = R/C is much less than mean square value of instability in the system of clock synchronization, where R is the distance between SN_i and BS, C- the speed of light. All SN and BC are synchronism.
2. Each SN has an information package, ready for transmission and tries to pass it to the BS as soon as possible in accordance with the MAC protocol.
3. Packet transmission is made after the initial backoff of i-th SN if the corresponding information space is free. If the channel is busy, the SN stops backoff and receive a package from BS. At the end of the reception it continues attempts of transmission with a random value of backoff.
4. MAC protocol has two different types of backoff - the initial (pre-transfer) and reloading one for cases when the channel is defined as occupied.

At the same time, on the same lines, we determine the probability that a given timeslot which will be used for successful transmission, is equal to probability that one SN selects this timeslot and all others will choose other timeslots:

$$P_y = \sum_m (1/W_o) \cdot (1 - 1/W)^{m-1} = (m/W_O)(1 - 1/W_O)^{m-1}. \quad (6)$$

Values of collision probability are derived from (2)

$$P_k = 1 - P_y - P_p. \qquad (7)$$

Substituting (5) and (6) to (7) we get:

$$\begin{aligned} P_k &= 1 - (m/W_O)(1 - 1/W_O)^{m-1} - (1 - 1/W_O)^m = \\ &= 1 - (1 - 1/W_O)^{m-1}(m/W_O + 1/W_O - 1). \end{aligned} \qquad (8)$$

As a result, the required probability is expressed as:

$$P(m,w) = \frac{\tau_y (m/W_O)(1-1/W_O)^{m-1}}{\tau_n (1 - (1-1/W_O)^{m-1}(m/W_O) + 1/W_O - 1) + \tau_n (m/W_O)(1-1/W_O)^{m-1} + \tau_p (1-1/W)^m}. \quad (9)$$

To obtain quantitative data for the activity factor (2) we can obtain distributions (9) and find an appropriate expectation. However, while we use mean values and then substitute them into $P(m,W_0)$ we will recieve an estimation of the k coefficient. Calculated values obtained by the formula (9) are presented graphically in Fig. 1. For definiteness, we took the following initial data: the initial screen 32, the reloading window 16. As we expected, the coefficient k decreases with the increase of active SNs. A small slope at the beginning of the graph is obviously connected with drawbacks of the model.

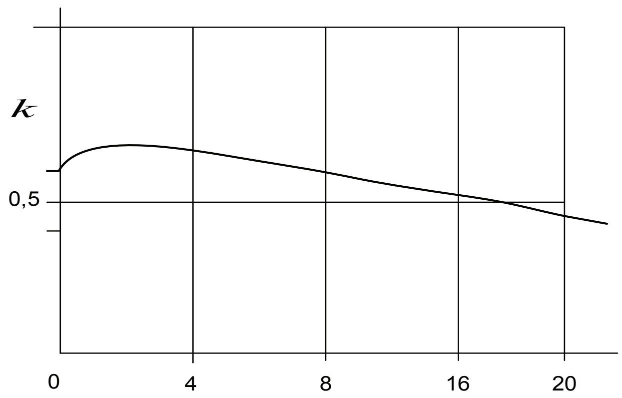

Fig. 1. Schedule dependence probability uses of timeslots for success transfer such subscriber numbers of nodes

We present here the results of comparisons of the BEB protocol and polling method, obtained in our study [10]. Fig. 2 shows a dependence curve of the average packet delay on the parameter D = np/L, where n is the number of active SNa in BEB technology, P is the probability of a request, L is the number of mini-windows that receive requests from SN to send a package.

Obviously N characterizes an average load of the system.

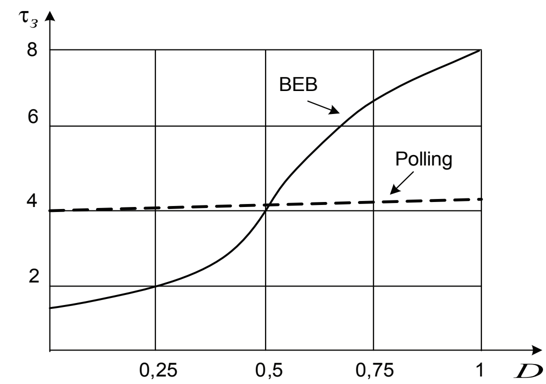

Fig. 2. The curve of the dependence of the average packet delay on the average load

4. Conclusions

1. The obtained value of the probability of useful channel utilization in complex technology CSMD / TDMA the analysis of which showed that the increase of the number of active sensors, subscriber stations, etc., causes gradual reduce of channel utilization index.

2. Comparative effectiveness of BEB technology related to group of CSMA / TDMA showed that the given method of multiple random access has the advantage in relatively low loads. With the increase of load one should proceed to the regular methods of access (polling).

References

1. Popovskij, V.V., Saburova, S.O., Olejnik, V.F. (2006). Matematichni osnovi teoriï telekomunikacijnih sistem. In: Popovs'kogo, V.V. Harkiv: TOV "Kompanija SMIT". 564p.
2. Popovskij, V.V., Olejnik, V.F. (2011). Matematicheskie osnovy upravlenija i adaptacii v telekommunikacionnyh sistemah. Harkiv: SMIT. 362p.
3. Popvskij, V., Barkalov, A., Titarenko, L. (2011). Control and Adaptation in Telecommunication Systems: Mathematical Foundations. Springer. 173p.
4. Wireless Sensor and Actuator Networks: Technologies, Analysis and Design. (2008) Academic Press.
5. Teplickaja, S.N., Hussejn, Ja.T. (2012). Energy-efficient algorithm for self-organization in wireless sensor networks. Eastern-European Journal Of Enterprise Technologies, 2(9(56)), p.25-29.
6. Aparcin, A.S. (2011). K issledovaniju ustojchivosti reshenij polinominal'nogo uravnenija Vol'tera 1 roda. Avtomatika i telemehanika. № 6, p.95-114.
7. Yu. Y., Giannakis G.B. (2007). High-throughput random access using successive interference cancellation in a tree algorithm. IEEE Transactions Inform. Theory. V.53, № 12, p.4628-4639.
8. Tur B., Hussein Yahya (2012). Successive Interference Cancellation Method in Tree Algorithms of Random Multiple Access. Lviv, Slavske: TCSET. p.232.
9. Andreev, S.D., Pustovalov, E.V., Tjurlikov, A.M. (2009). Drevovidnyj algoritm razreshenija konflikta, ustojchivyj k nepolnomu pogasheniju interferencii. Avtomatika i telemehanika. № 3, p.78-96.
10. Naors I. Anad, Husejn, Ja.T. (2011). Sovershenstvovanie mehanizmov sluchajnogo mnozhestvennogo dostupa v sistemah besprovodnoj svjazi. Visnik NTU HPI. № 25, p.108-115.