ELECTRONICS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 2006. No. 8(72)
ELEKTRONIKA IR ELEKTROTECHNIKA

TELECOMMUNICATIONS ENGINEERING
T 180
TELEKOMUNIKACIJŲ INŽINERIJA

Analysis of the Technological Expenditures of Common WLAN Models

A. Kajackas, L. Pavilanskas
Telecommunications Engineering Department, Vilnius Gediminas Technical University,
Naugarduko str. 41, LT-03227 Vilnius, Lithuania, e-mail: algimantas.kajackas@el.vtu.lt, lukas.pavilanskas@el.vtu.lt

Introduction

The use of modern telecommunications networks and interactive access of DSL features is so extensive that most of customer demands are fulfilled. In the locations where people usually rally – airports, universities, and other “hot-spot” environments, the access points are realized by using the widely common WLAN equipment based on IEEE 802.11 technology [1], [2], [3], [4]. Initial versions of this standard are implemented for the similar “hot-spot” conditions, where a lot of randomly moving customers may be observed. The finite quantities of data usually are transmitted by such customers. In such conditions the Wireless LAN (WLAN) equipment is executing the packet transmission and packet switching function. The common method of customer’s access to the wireless network is contention-based random multiple-access. The facility of newest versions of this standard group is more improved: IEEE 802.11g supports the physical throughput of 50 Mb/s; IEEE.11e provides certain QoS features [5].

The WLAN equipment is not expensive; therefore it is used for realization of networks with small quantity of customers and for fixed customer premise access channels. With the growth of service gamma, multimedia becomes the major part of all data being transmitted by wireless access points– a lot of different signals which are formed by the implementations, characterized by different protocols. It is important, that some features of the IEEE 802.11 standard WLAN technology become overlapped when it’s used in obtained specific conditions.

Many research works are accomplished, which analyze the wireless or radio channels access – WLAN protocols and WLAN features in different aspects [6]. It is proved that in many cases the capacity of the physical WLAN channel is not effectively utilized. Practically the achieved data transmission throughput – goodput – is less than throughput of the physical channel [7]. The reasons for that are commonly known.

The first reason is that the transmission of every data array must be increased by appropriate headers of specific data transmission protocols (TCP, UDP, and etc.), or in other words by the complement data of the technological purpose. Therefore, amount of transmitted data is increase.

The second reason lies in the operation of contention-based random multiple-access, when many various durations are employed for avoidance of possible collisions. Due to this, longer durations emerge when the physical channel is not used or can’t be used.

We made the detailed technological WLAN analysis of efficiency of physical resources utilization and technological overlapping of IEEE 802.11 standard. Analysis was performed by comparing two different modern technologies: transmission by packets and transmissions by channels. Above, for the each WLAN transmitted packet formation block headers of the different protocols are attached to the data. The distinctive feature of transmission by packets technology is transmission of source, destination, and other addresses in the header.

The distinctive feature of transmission by channels technology is that the data blocks are transmitted over the networks by the special organized channels. Before each session of connection the special signalization packets are transmitted for channel aggregation. After the finish of connection session other special signalization packets are transmitted for connection termination. The data blocks are transmitted by channels without any addresses. If transmission is executed by virtual channels the certain indicators are attached, for example in ATM networks.

Two different technologies of transmission were selected for method analysis – transmissions by channel and packet transmission is compared. Technologies of the packet-switching were developed for transmission of detached packets. In the modern packet-switching networks many real-time (RT) signals are transmitted which reflected by series of packets, known by us. For transmission of such series the channel switching technology is better. We think that it is expedient to look for methods to create the new generation radio networks, in which communications resources will be dynamically allocated according to the requirements of channel and packet switching technologies.

The design of such networks with integrated channel and packet switching technologies is the difficult and many-staged process. This proceeding is the first from the series of tasks. In this paper the analysis of technological redundancy of WLAN technologies is introduced. In this paper summary of the analysis of technological redundancy is presented. By the reference to the results the overlapping of support of detached technological component is proposed. The distinguished technological components are as follows: Support of protocols of the distinct OSI layers (protocol headers); Physical channel equipment preparation process (PLCP header and PHY preamble); Error protection (FCS and ACK retransmission); Packet switching – routing (IP and MAC address); Physical channel random fair occupation (IEEE 802.11 DCF version [1]); Physical channel controlled occupation (IEEE 802.11 PCF version [1]); Channel reservation; Support of QoS.

Abbreviations

ACK – Acknowledgment; CSMA/CA - Carrier Sense Multiple Access/Collision Avoidance; CTS – Clear To Send; CW – Contention Window; DCF - Distributed Coordination Function; DIFS – DCF InterFrame Space; FCS – Frame Check Sequence; IP – Internet Protocol; LLC – Logical Link Control; MAC – Medium Access Control; MPDU– MAC Protocol Data Unit; OFDM – Orthogonal Frequency-Division Multiplexing; OSI - Open Systems Interconnection; PCF – Point Coordination Function; PHY – Physical Layer; PLCP – Physical Layer Convergence Protocol; PPDU – PLCP Protocol Data Unit; PSDU – PLCP Service Data Unit; QoS – Quality of Service; RTS – Request To Send; SIFS – Short InterFrame Space; TCP – Transport Control Protocol; TDMA – Time Division Multiplex Access; UDP – User Datagram Protocol.

OSI layers and IEEE 802.11 standards

In WLAN like in other packet communication networks the various protocols are used for data packets and for management of packets flows. Each protocol "known attributed task", when specific such protocol data (header[1]) is appended to the data. Each protocol adds a different header, so in a typical TCP/IP packet, as it is transmitted, we have a MAC header, an IP header and a TCP header. Between IP and MAC headers we have the LLC header also. IEEE 802.11 use the same IEEE 802.2 LLC and 48-bit addressing as other IEEE 802.x LANs, allowing very simple bridging from wireless to IEEE wired networks, but the MACs are unique to WLAN's. The LLC is responsible for the logical link functions of one or more logical links [8]. With growth of number of used protocols the number of headers appended to the main User Data array is growing.

Fig. 1 shows the diagram of appropriate WLAN protocol headers, in other words, it is schematic of the "overgrowth" of technological data. In the upper OSI layer the User Data is showed, where the specific headers, which depends on transmitted data, may be added to. However, such headers depend on specific user applications and do not make any different and specific influence to multimedia data communications over WLAN's. Therefore, such headers of upper layers are attached to User Data, and this is not analyzed in this research.

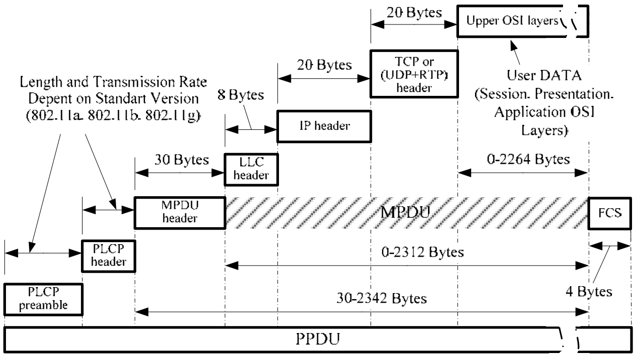

Fig. 1. PPDU of the IEEE 802.11 standard [1], [2], [3], and [4]

In the modern networking the TCP or UDP protocols are used for the transmission of most data. These protocols are inseparable from IP protocol. This reflects in the UDP or TCP and IP headers. User Data conjunction with header of TCP or UDP protocol and with IP header compose the TCP/IP or UDP/IP datagram[2].

The TCP/IP or UDP/IP encapsulation in MPDU over LLC protocol and MAC protocols is made. For the transmission of MPDU in the IEEE 802.11 networking the MAC with FCS and PLCP headers with PLCP preamble must be added. The bottom part of frame pyramid, showed in the Fig. 1, reflects the formatted PPDU, which is transformable to the PHY signal. The header lengths of obtained protocols are showed in Table 1.

Table 1. Expenditure of header transmission

OSI layers	Protocol header	NRT traffic, Bytes	RT traffic, Bytes
Transport	H_{RTP}	-	12
	H_{TCP}	20	-
	H_{UDP}	-	8
Network	H_{IP}	20	
Data Link	H_{LLC}	8	
	H_{MAC}	34	
Physical	H_{PLCP}	6	
Total of overhead:		**88**	

If customer data N_{DATA},[Bytes] of not real-time traffic (NRT) is transmitted the specific (TCP) header will be attached. Therefore, the count of outgoing bytes will be

$$N_{\mathrm{NRT}} = H_{\mathrm{TCP}} + N_{\mathrm{DATA}}, [\mathrm{Bytes}]. \qquad (1)$$

Respectively, for RT data transmission it is

$$N_{\mathrm{RT}} = H_{\mathrm{RTP}} + H_{\mathrm{UDP}} + N_{\mathrm{DATA}}. \qquad (2)$$

So, in Network Layer (NL) count of outgoing bytes will be

---

[1] Header - Information added by the protocol in front of the payload in the packet for its own use.

[2] For the data transmission by IP networks the form of TCP/IP and UDP/IP datagram is universal – the lower OSI layer does not make any influence.

$$N_{\mathrm{NL}} = H_{\mathrm{IP}} + N_{\mathrm{RT}} = H_{\mathrm{IP}} + \\ + H_{\mathrm{RTP}} + H_{\mathrm{UDP}} + N_{\mathrm{DATA}}. \quad (3)$$

Eventually, MPDU composed in the Data Link Layer for RT will be

$$N_{\mathrm{MPDU}} = H_{\mathrm{MAC}} + H_{\mathrm{LLC}} + N_{\mathrm{NL}} = \\ = H_{\mathrm{MAC}} + H_{\mathrm{LLC}} + H_{\mathrm{IP}} + H_{\mathrm{RTP}} + \\ + H_{\mathrm{UDP}} + N_{\mathrm{DATA}}, \text{[Bytes]}. \quad (4)$$

The common sum of headers in MPDU or overhead is

$$H_{\mathrm{MPDUover}} = H_{\mathrm{MAC}} + H_{\mathrm{LLC}} + H_{\mathrm{IP}} + \\ + H_{\mathrm{RTP}} + H_{\mathrm{UDP}}. \quad (5)$$

It is important, that in the IEEE 802.11 standard WLAN's each transmitted packet of N_{DATA} bytes the overhead of H_{MPDUover} bytes will be transmitted too.

PHY of IEEE 802.11a

The PPDU format of the IEEE 802.11a PHY is shown in Fig. 2 [2], which includes PLCP preamble, PLCP header, MPDU, tail bits, and pad bits, if necessary. The PLCP preamble field with the duration of $t_{\mathrm{PLCP\ Preamble}}$ is composed of 10 repetitions of a short training sequence (0,8μs) and two repetitions of a long training sequence (4μs). The duration of PLCP header is $t_{\mathrm{PLCP\ Preamble}} = 16\mu\mathrm{s}$. The first 24 bits of PLCP header are transmitted with BPSK modulation and rate-1/2 convolution coding (the duration of this part is 4μs). The "Service" field is transmitted at the data rate and constitutes a single OFDM symbol, with the duration of $t_{\mathrm{PLCP\_SIG}} = 4\ \mu\mathrm{s}$. The full duration of PLCP header is $t_{\mathrm{PLCPheader}} = 8\ \mu\mathrm{s}$. The SERVICE field of the PLCP header and the PSDU (with 6 "zero" tail bits and pad bits appended), denoted as PSDU are transmitted at the data rate described in the "Rate" field and may constitute multiple OFDM symbols.

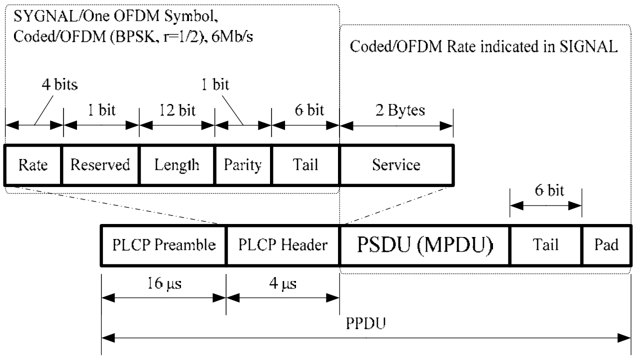

Fig. 2. IEEE 802.11a PPDU frame format

In specification of IEEE 802.11a standard the different operation modes (m) are specified. Values of the supported data rates and appropriate modes are presented in Table 2. For each transmission the channel occupation of the OFDM signal is 4 μs.

Table 2. Data rates and modes in the IEEE 802.11a

m	1	2	3	4	5	6	7	8
***R*PHY, Mbps**	6	9	12	18	24	36	48	54
N_{DBPS}	24	36	48	72	96	144	192	216

Time needed to transmit PPDU by the PHY channel is

$$T_{\mathrm{PPDU}} = \tau_{\mathrm{PLCPpreamble}} + \tau_{\mathrm{PLCPheader}} + \\ + \tau_{\mathrm{MPDUover}} + \tau_{\mathrm{DATA}}. \quad (6)$$

The duration of transmission of packet and its parts τ_{DATA} of 802.11a PHY may be evaluated by the expression:

$$\tau_{\mathrm{DATA}}(m) = 4 \cdot \frac{8 \cdot N_{\mathrm{DATA}}}{N_{\mathrm{DBPS}}(m)}, \quad (7)$$

where N_{DATA} – amount of data in bytes; N_{DBPS} – amount of data in bytes when one OFDM signal of 4 μs duration is transmitted. Based on the above analysis, to transmit a frame with N_{MPDU} its data payload over the IEEE 802.11a PHY using PHY mode (m), the transmission duration is:

$$T_{\mathrm{PPDU}} = 22 + \tau_{\mathrm{MPDUover}}(m) + 4 \cdot \frac{8 \cdot N_{\mathrm{DATA}}}{N_{\mathrm{DBPS}}(m)}, [\mu\mathrm{s}]. \quad (8)$$

Where:

$$\tau_{\mathrm{MPDUover}} = 4 \cdot \frac{8 \cdot N_{\mathrm{MPDUover}}}{N_{\mathrm{DBPS}}(m)}, [\mu\mathrm{s}]. \quad (9)$$

One packet technological redundancy

The efficiency of usage of the Data Link channel is often analyzed in publications [9] and may be expressed by:

$$\gamma_{\mathrm{MPDU}} = \frac{N_{\mathrm{DATA}}}{N_{\mathrm{MPDU}}} = \frac{N_{\mathrm{DATA}}}{N_{\mathrm{MPDUover}} + N_{\mathrm{DATA}}}. \quad (10)$$

This way overhead index is always less than 1. Packet overhead is the technological appendage. Normalized value of technological redundancy may be expressed by the relation:

$$\varepsilon_{\mathrm{MPDU}} = \frac{N_{\mathrm{MPDUover}}}{N_{\mathrm{DATA}}} = \frac{N_{\mathrm{MPDU}} - N_{\mathrm{DATA}}}{N_{\mathrm{DATA}}} = \\ = \frac{N_{\mathrm{MPDU}}}{N_{\mathrm{DATA}}} - 1; \quad (11)$$

$$\varepsilon_{\mathrm{MPDU}} = \frac{1}{\gamma_{\mathrm{MPDU}}} - 1. \quad (12)$$

Dependence of probability of index $\varepsilon_{\mathrm{MPDU}}$ on data packet length is showed in the Fig. 3. For the comparison, the technological redundancy index in the channel multiplexing systems PCM-30 is equal $\varepsilon_{\mathrm{PCM}} = 0{,}033$.

The technological redundancy index of the physical channel is expressed by the relation:

$$\varepsilon_{\text{PPDU}}(m) = \frac{T_{\text{PPDU}}(m) - \tau_{\text{DATA}}(m)}{\tau_{\text{DATA}}(m)} = \frac{22 + \tau_{\text{MPDUover}}(m)}{\tau_{\text{DATA}}(m)}. \qquad (13)$$

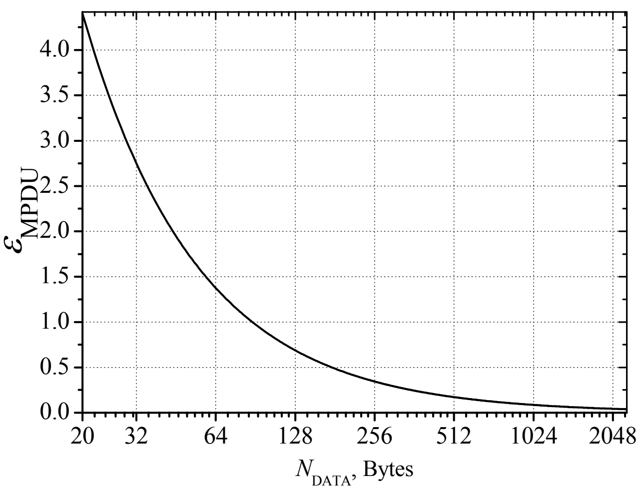

Fig. 3. Dependence of index $\varepsilon_{\text{MPDU}}$ on data packet length

The dependence of the technological redundancy of PHY (PPDU frame) on packet length of transmitted data for RT or NRT traffic is showed in Fig. 4.

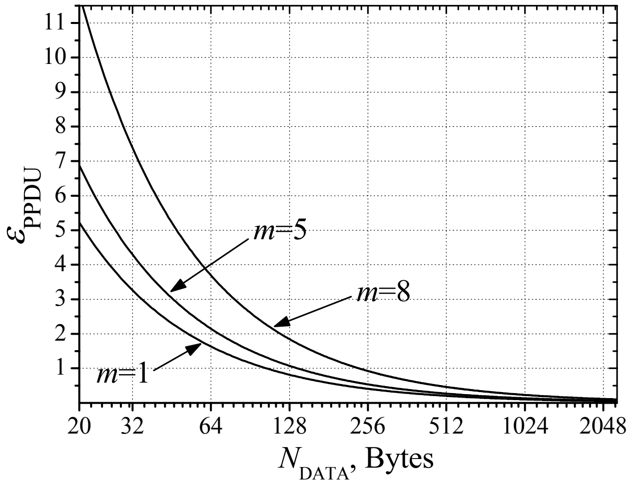

Fig. 4. Dependence of index $\varepsilon_{\text{PPDU}}$ on packet size

As demonstrated by the graph the index of technological redundancy of PHY depends on the length of transmitted packet. It notably increases when the small data packet is transmitted.

Determined by channel access technological redundancy

A channel access mechanism is a way to divide the main channel resources between nodes, by regulating its use. The channel access mechanism is the core of the MAC protocol. Main classes of channel access mechanisms in WLAN's are TDMA, CSMA/CA and polling.

Basic 802.11 MAC behaviours allow interoperability between compatible PHYs through the use of the CSMA/CA protocol and a random back-off time following a busy medium condition [1]. The main principles of CSMA/CA are listening before talk and contention. This is asynchronous message passing mechanism.

While the PHY layer differs in IEEE 802.11, IEEE 802.11a, IEEE 802.11b, and IEEE 802.11g, the access mechanism and MAC remains the same. The main access mechanism, called DCF, is based on CSMA/CA [1]. A wireless terminal willing to transmit a data packet senses the current channel state. If the channel has been detected as idle, the station waits a DIFS time interval. If no other transmission takes place during the DIFS period, the station starts its packet transfer immediately after the DIFS has elapsed. In, addition, in the DCF all directed traffic uses immediate positive ACK. The retransmission is scheduled by the sender if no ACK is received. Description of DCF operation showed in Fig. 5.

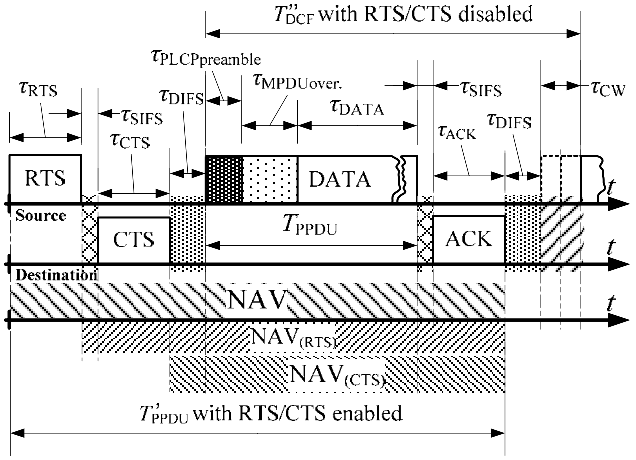

Fig. 5. Time intervals of the IEEE 802.11

Random back-off arrangement is used to resolve medium contention conflicts. When RTS/CTS mechanism is not used in the IEEE 802.11 technologies the time needed to transmit one packet may be expressed:

$$T'_{\text{DCF}} = \tau_{\text{CW}} + T_{\text{PPDU}} + \tau_{\text{SIFS}} + \tau_{\text{ACK}} + \tau_{\text{DIFS}}, \qquad (14)$$

where τ_{SIFS} - duration of technological time interval – SIFS; τ_{DIFS} - duration of technological time interval - DIFS; τ_{MPDU} - time needed to transmit MAC frame; τ_{ACK} - time needed to transmit ACK frame; τ_{DATA} - time needed to transmit data; $\tau_{\text{MPDUover.}}$ - time needed to transmit packet overhead. The τ_{CW} – duration of the time of channel access, which may be calculation expressed by the physical parameter, named Slot Time – τ_{SlotTime} (9 µs for IEEE 802.11a/g_{long} and 20 µs for 802.11b/g_{short}), and by the index of CW - k_{CW} ($\{15 \div 1023\}$ for IEEE 802.11a/g, and $\{31 \div 1023\}$ for IEEE 802.11b) [1], [2], [3], and [4]:

$$k_{\text{CW}} = \left[0, \min\{k_{\text{CW}\min} + 1\}\right]^{i+1} - 1, k_{\text{CW}\max}; \qquad (15)$$

$$\tau_{\text{CW}} = \text{Rand}(k_{\text{CW}}) \cdot \tau_{\text{TimeSlot}}. \qquad (16)$$

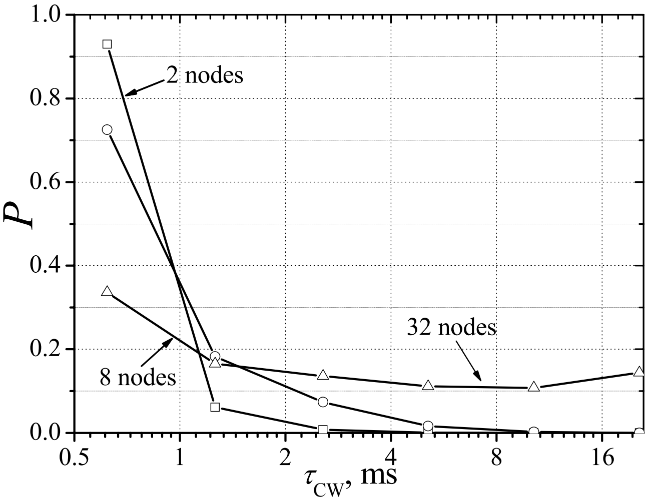

Fig. 6. Dependence of τ_{CW} distribution probability for 2, 8, and 32 nodes

The time period allocation for one PPDU transmission in IEEE 802.11 standard specification is named the network allocation network – NAV. In this period the channel is busy for transmission one PPDU of the series. If the terminal detects a busy channel, the station selects a slot out of its initial contention window (CW). After the current transmission is completed, the station waits for a DIFS – τ_{DIFS}. When the DIFS has expired, the sender reduces its congestion window unless another station starts its transmission or the τ_{CW} value reaches zero. The simulation results of distribution rate of τ_{CW} for different count of nodes in WLAN showed in Fig. 6.

When in the WLAN two or more nodes operate the possibility that the data packets might be lost, because the possibility of collision occurrence increases. For the collision avoidance the RTS/CTS mechanism [1] may be used optionally. The RTS/CTS mechanism is quite simple (Fig. 5). The source station tries to acquire a channel as soon as it notices that media is free and immediately sends a RTS packet. Destination analyzes incoming RTS packet and answers with CTS packet confirming that it is ready to receive. Respectively, the NAV's of the RTS ($\mathrm{NAV}_{\mathrm{RTS}}$) and CTS ($\mathrm{NAV}_{\mathrm{CTS}}$) is allocated simultaneously. As we can see in Fig. 5, destination answers to the RTS packet after SIFS. In such situation only RTS packets are lost not User Data compare with situation when RTS/CTS mechanism is not used. However, the minimal time needed to transmit one packet is increased:

$$T''_{\mathrm{DCF}} = \tau_{\mathrm{CW}} + 3\tau_{\mathrm{SIFS}} + \tau_{\mathrm{RTS}} + \tau_{\mathrm{CTS}} + \\ + T_{\mathrm{PPDU}} + \tau_{\mathrm{ACK}} + \tau_{\mathrm{DIFS}}, \qquad (17)$$

where τ_{RTS} – the duration of RTS frame; τ_{CTS} – is the duration of CTS frame. However, in situation when RTS/CTS mechanism for IEEE 802.11a is used the $\tau_{\mathrm{MPDUover.}}$ expansion is equivalent, but the durations are longer, because in that case for channel reservation RTS/CTS packets with durations τ_{RTS} and τ_{CTS} and two SIFS – τ_{SIFS} (Fig. 5) are needed additionally. The durations of different technological durations of IEEE 802.11 technologies are shown in Table 3.

Table 3. Durations of τ_{SIFS}, τ_{DIFS}, τ_{CWmin}, and τ_{CWmin} in µs

Standard	τ_{SIFS}	τ_{DIFS}	τ_{CWmin}	τ_{CWmin}
IEEE 802.11a	16	34	300	20460
IEEE 802.11b	10	50	620	20460
IEEE 802.11g	10	50	300	20460

The best way to reflect redundant expenditures of DCF in IEEE 802.11 WLAN with channel access (CSMA/CS) for one packet transmission is relation of technological redundancy, and may be expressed by the relation:

$$\xi'_{\mathrm{DCF}}(m) = \frac{T'_{\mathrm{DCF}}(m) - \tau_{\mathrm{DATA}}(m)}{\tau_{\mathrm{DATA}}(m)}. \qquad (18)$$

The calculation of estimation of full technological redundancy (18) is complicated and random for every packet of series, because τ_{CW} variable is random. The duration of CW estimation the average back-off defines the back-off duration for "lightly loaded networks", i.e. when each station has access to the channel after the first back-off attempt. Upon this assumption, k_{CW} is minimal – k_{CWmin} [10]. Consequently, the average back-off duration is then: $\tau_{\mathrm{CW}} = \tau_{\mathrm{TimeSlot}} \times k_{\mathrm{CWmin}} / 2$. From such point of view the dependence of expenditures of full technological redundancy of data transmitted by one packet with channel access phase on packet length is shown in Fig. 7.

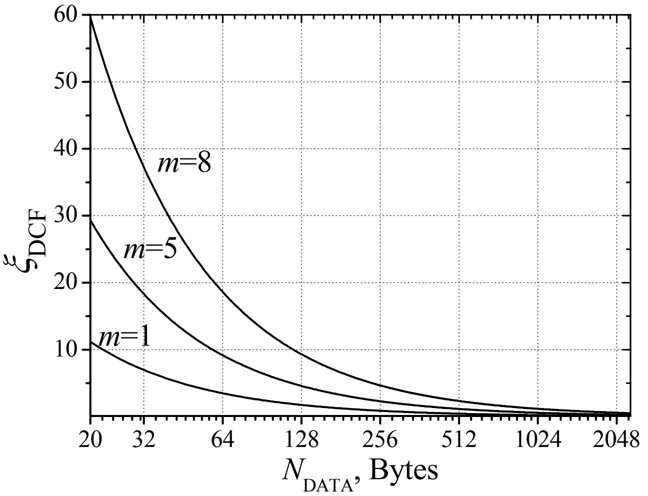

Fig. 7. Dependence of full technological redundancy on packet length

As demonstrated by the graph the index ξ'_{DCF} of PHY and expenditures of channel access depend on the length of transmitted packet. It notably increases when the small data packet is transmitted. Presented graph is made for DCF version with disabled RTS/CTS mechanism. With enabled RTS/CTS mechanism situation is worse, because for channel access the additional time expenditures τ_{RTS}, τ_{CTS}, and $3\tau_{\mathrm{SIFS}}$ are used.

Classified conclusions

In the modern networks WLAN technologies are bottleneck. The presented work shows how data packet is overgrown by different headers and other guard times. Practically the achieved data transmission throughput – goodput – is less than throughput of the physical channel. In the previously published works real throughput and goodput dependence on various factors was presented.

In here in work the technological times expenditures of one packet transmission over universal IEEE 802.11 protocol network are systematically analyzed. These times are extending the physical channel access time for one packet transmission. It is the contributions for support of separate protocols. Technological time expenditures significantly enhance the technological redundancy compare with traditional TDMA technologies.

In the work the technological redundancy of universal network of IEEE 802.11 protocol when the sender must send to receiver series of data packet is analyzed. By pursuance the analysis of technological redundancy the purpose of each time interval were highlighted. Finding the possibilities of creation of adaptive WLAN protocols, witch may adapt by applied tasks conditions is advisable. Such protocols will utilize the physical radio channel effectively. One of predictable decisional way is the implementation of dynamic channel switching method.

References

1. **ISO/IEC 8802-11**, ANSI/IEEE 802.11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications // Standard, IEEE: 1999.
2. **ISO/IEC 8802-11**, ANSI/IEEE 802.11a: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification: High-Speed Physical Layer in the 5 GHz Band // Standard, IEEE, 1999.
3. **ISO/IEC 8802-11**, ANSI/IEEE 802.11b: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification: Higher-Speed Physical Layer Extension in the 2.4 GHz Band // Standard, IEEE, 1999.
4. **ISO/IEC 8802-11**, ANSI/IEEE 802.11g: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification: Further Higher Data Rate Extension in the 2.4 GHz Band // Standard, IEEE, 1999.
5. **Ni Q. Romdhani L., Turletti T.** A Survey of QoS Enhancements for IEEE 802.11 Wirelesses LAN // Journal of Wireless Communications and Mobile Computing. – Wiley, 2004. – Vol. 4, Issue 5. – P.547–566
6. **Bianchi G.** Performance Analysis of the IEEE 802.11 Distributed Coordination Function // IEEE Journal on Selected Areas in Communications, IEEE, 2000. – Vol. 18, No. 3. – P. 535–547.
7. **Qiao D., Choi S., Shin K. G.** Goodput Analysis and Link Adaptation for IEEE 802.11a Wireless LANs // IEEE Transactions On Mobile Computing, IEEE: 2002. – Vol. 1, No. 4, P. 278.
8. **ISO/IEC 8802-2**, ANSI/IEEE 802.2: Logical Link Control Specifications // Standard, IEEE, 1998.
9. **Xiao Y., Rosdahl J.** Throughput and Delay Limits of IEEE 802.11 // IEEE Communications Letters, IEEE: 2002. – Vol. 6, No. 8. – P. 355–357.
10. **Ferr´e P., Doufexi A, Nix A., Bull D.** Throughput Analysis of IEEE 802.11 and IEEE 802.11e MAC // IEEE Wireless Communications and Networking Conference, WCNC. – 2004, Vol. 2.

Submitted for publication 2006 05 30

A. Kajackas, L. Pavilanskas. Analysis of the Technological Expenditures of Common WLAN Models // Electronics and Electrical Engineering. – Kaunas: Technologija, 2006. – No. 8(72). – P. 19–24.

Data presented of detailed technological WLAN analysis of efficiency of physical resources utilization and technological redundancy of IEEE 802.11 standard. Analysis performed by comparing two different modern technologies: the transmission by packets and transmission by channels. For the each WLAN transmitted packet formation headers of the different protocols are attached to the data block. Because of this the technological redundancy is increased. The various technological insertions determine increase of technological redundancy also. The contribution of each additional data blocks and time intervals is noted. Evolution of the possibilities of creation of adaptive WLAN protocols, witch may adapt to applied tasks conditions are pursued for analysis. Such protocols will utilize the physical radio channel effectively. One of predictable decisional way is the implementation of dynamic channel switching method. Ill. 7, bibl. 8 (in English; summaries in English, Russian and Lithuanian).

А. Каяцкас, Л. Павиланскас. Анализ технологических избыточностей в моделях доминирующих технологий WLAN // Электроника и электротехника. – Каунас: Технология, 2006. – № 8(72). – С. 19–24.

Представлен детальный анализ эффективности использования физических ресурсов и технологической избыточности в сетях стандарта IEEE 802.11. Анализ осуществляется путем сравнения двух базовых технологий с коммутацией пакетов и коммутацией каналов. При формировании каждого пакета, как известно, к блоку данных присоединяются заголовки различных протоколов. Эти заголовки и увеличивают технологическую избыточность. Технологическую избыточность увеличивают и в технологических целях вставляемые пустые интервалы времени. Анализируется назначение каждого интервала. Выясняются возможности создания адаптивных WLAN протоколов, которые, адаптируясь к условиям прикладной задачи, более эффективно использовали бы физический радиоканал. Ил. 7, библ. 8 (на английском языке; рефераты на английском, русском и литовском яз.).

A. Kajackas, L. Pavilanskas. Vyraujančių WLAN modelių technologinių sąnaudų analizė // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2006. – Nr. 8(72). – P. 19–24.

Pateikta fizinių išteklių panaudojimo efektyvumo bei technologinio perteklumo IEEE 802.11 standarto WLAN tinkluose detali analizė. Analizė atliekama lyginant dvi skirtingas technologijas: perdavimus paketais ir perdavimus kanalais. Kaip žinoma, prie kiekvieno WLAN tinklu perduodamo duomenų bloko, formuojant paketą prijungiamos įvairių protokolų antraštės. Šios antraštės ir didina technologinį perteklumą. Perteklumą didina ir įvairūs technologiniai intarpai tarp paketų. Atliekant analizę, išryškinamas kiekvieno papildomų duomenų bloko bei laiko intarpo indėlis. Plėtojant tyrimus, siekiama nustatyti galimybes kurti adaptyviuosius WLAN protokolus, kurie prisitaikytų pagal taikomojo uždavinio sąlygas ir dėl to efektyviau panaudotų fizinį radijo kanalą. Vienas iš numatomų sprendimo būdų – įdiegti dinaminį kanalų komutacijos metodą. Il. 7, bibl. 8 (lietuvių kalba; santraukos anglų, rusų ir lietuvių k.). Il. 7, bibl. 8 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).