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ANALYSIS OF TECHNICAL CHARACTERISTICS OF THE NETWORK WITH POSSIBILITY TO SELF-ORGANIZATION

At present, wireless technology is widely used in our everyday life and in military networks. In the sources, in the future, their percentage will only increase, according to an the analysis conducted. In this article, the analysis of technical characteristics and the classification of network routing protocols with the possibility of self-organization based on the main features of the organization and the mechanisms of the operation of the protocols. These mechanisms include the mechanism for updating route information, based on the method of storing route information, the topology of information organization and the use of protocols specific resources. The authors of the famous scientific papers in which the simulation was conducted do not fully describe the dependence of the influence of such criteria as the speed of the nodes, change of the network area, change of the number nodes in the network, change of the number of hops to the addressee to work routing protocols. The analysis of modern research directions in scientific editions and the tendencies of the development of routing protocols, analysis of routing protocols modeling data provided by the authors of the simulation was conducted. While the review of the simulation results, a description of the behavior of the protocols in different scenarios of modeling and commenting on the logic of the work of the protocols is carried out in accordance with the given classification, which subsequently makes it possible to determine the appropriate features of the protocols in accordance with the categories. Analysis of the advantages and disadvantages of network routing protocols with the ability to self-organization when changing the following criteria affecting the operation of protocols such as change the number of nodes in the network with the possibility of self-organization, the operation of protocols depending on the intensity of change in topology (speed of nodes), change the size of the area the network, which in turn also affects the number of nodes that redirect packets for delivery to the addressee. The dependence of the routing protocols on the use of higher level TCP and UDP protocols was also analyzed, where the coefficient of delivery of packets from the source to the addressee was analyzed. The main advantages and disadvantages of the main routing protocols of networks with possible self-organization that were considered by the authors of scientific works in modeling, such as AODV, DSDV, OLSR, and DSR, are highlighted. The definition of the actual and perspective direction of scientific work in further researches was conducted.

Keywords: networks with possible self-organization; Ad hoc; radio network; wireless network; multi-hop; base station; multicast; traffic; decentralized networks; special wireless network; intelligent mobile nodes; real-time mode; classification of routing protocols.

Introduction

At present, wireless technology is widely used in our everyday life and in military networks. As the analysis in the sources [1-31] suggests, in the future, their percentage will only increase. This feature determines the relevance of this direction for conducting scientific research.

In our time, work is underway on the introduction of data transmission systems using networks with the ability to self-organization (Ad Hoc Networks).

The main task of networks with the ability to self-organization are:

- building a network-based infrastructure failure;
- an increase of efficiency of use of radio frequency resource;
- ensuring adaptation of networks to external factors;
- reduction of the cost of deployment and operation of the network in comparison with the classical principles of construction.

The analysis of recent publications [9, 19, 28, 30, 31] indicates that current research is being carried out to improve the routing protocols of Ad-hoc networks, which are further implemented in modern data transmission technologies.

A decentralized network with the ability to self-organizing consists of routers and mobile devices that are interconnected and simultaneously serve both the client and the router.

In the classic version of the construction of wireless networks, all customers are connected to the router and data transfer occurs only through it. In a decentralized network, each of these devices can move in different directions, with the result of the move to break and establish new connections with neighboring devices (hosts) [19].

In the well-known publications [9, 19, 28, 30, 31] analysis of the technical characteristics of routing protocols was conducted, however, this analysis is superficial and requires deepening and improvement in the part describing the effects of individual indicators on the efficiency of communication networks with the possibility of self-organization.

Therefore, ***the purpose of this article is*** to analyze the characteristics of the routing protocols of ad hoc networks.

Presentation of the main material

Ad hoc wireless network (WANET) is a wireless decentralized network that does not require a pre-existing infrastructure, nor does it have a permanent structure where the client devices (node) are equivalent and dynamically interconnect themselves, forming a network. Each of these devices participates in routing by forwarding information to the destination via other devices. In this case, determining which device to transmit information is determined by the network connectivity. A special wireless network consists of a multitude of mobile hosts (hosts) that are connected wirelessly. The network topology in such a network can constantly change unpredictably and by chance [19].

Routing protocols that determine the transmission paths from the source node to the destination node used in traditional wired networks cannot be directly applied in special wireless networks, which are characterized by features such as [1, 6, 8, 9]:

- high dynamics of change of topology;
- an absence of the established centralized administration infrastructure (base station or access point);
- the limited bandwidth of wireless communications;
- an occurrence of false packets during broadcasting by a radio channel;
- limited power supply;
- the effect of intentional obstacles and other negative factors.

Taking into account the above, you can define the following requirements for routing protocols [1, 8, 9]:

- a short time of construction of the route in the conditions of high dynamics of change of network topology;
- high reliability of delivery of packages provided a constant change of interconnection;
- the minimum amount of official information transmitted on the network;
- ability to quickly detect and restore broken links;
- Detection and prevention of routing loops;
- Support of high scalability of the network with preservation of the given parameters;
- maintain quality of service (Quality of Service).

Fig. 1 shows the classification of routing protocols used in communication networks with the ability to self-organize [1, 6, 9].

Routing protocols can be divided into three main categories such as proactive (tabular) is a protocol that stores information about the routes of the entire network as a rule in tabular form and periodically exchanges information (tables) about all known routes usually throughout the network. Each time a node requests a packet transmission to the destination, it performs an appropriate path search algorithm and topology information in the data tables. Proactive protocols include DSDV (Destination-Sequenced Distance-Vector Routing Protocol), WRP (Wireless Routing Protocol), CGSR (Cluster-Head Gateway Switch Routing Protocol), STAR (Source-Tree Adaptive Routing Protocol), OLSR (Optimized Link State Routing Protocol), FIS (Fisheye State Routing Protocol), HSR (Hierarchical State Routing Protocol), GSR (Global State Routing Protocol).

The advantages of these protocols are a low latency of the route definition, the constant relevance of route information, which is effective at low dynamics of changing the network topology, a relatively small amount of service traffic at a significant load on the network.

Disadvantages can be taken away: High bandwidth requirements for high-dynamic networks, low scalability, and high memory requirements require some time to climb the network before data transfer [1, 2, 6, 8, 9].

Reactive (up-to-date) protocols that do not support network topology information, these protocols occasionally do not exchange routing information; they get information about the path to the destination when needed, ie upon request, using the connection setup process. Reactive protocols include DSR (Dynamic Source Routing Protocol), AODV (Ad-hoc on-demand distance routing protocol), ABR (Associative-Based Routing Protocol), SSA (Signal Stability-Based Adaptive Routing Protocol), FORP (Flow Oriented Routing Protocol), Preferred Link-Based Routing (PLBR).

The advantages of these protocols are a small amount of service information with low data transfer activity and a low memory requirement (usually only cache memory is used).

The disadvantages include a high delay in the route setup process and low scalability [1, 2, 6, 8, 9].

Hybrid routing protocols combine the best of proactive and reactive protocols. For example, nodes at a certain distance from the corresponding node or within a particular geographic region are in the routing zone of the node. For routing in this zone, a tabular approach is used. For nodes located in this zone, the approach to the request is used: Hybrid protocols include CEDAR (Core-Extraction Distributed Ad Hoc Routing), ZRP (Zone routing protocol), ZHLS (Zone-Based Hierarchical Link State Routing Protocol).

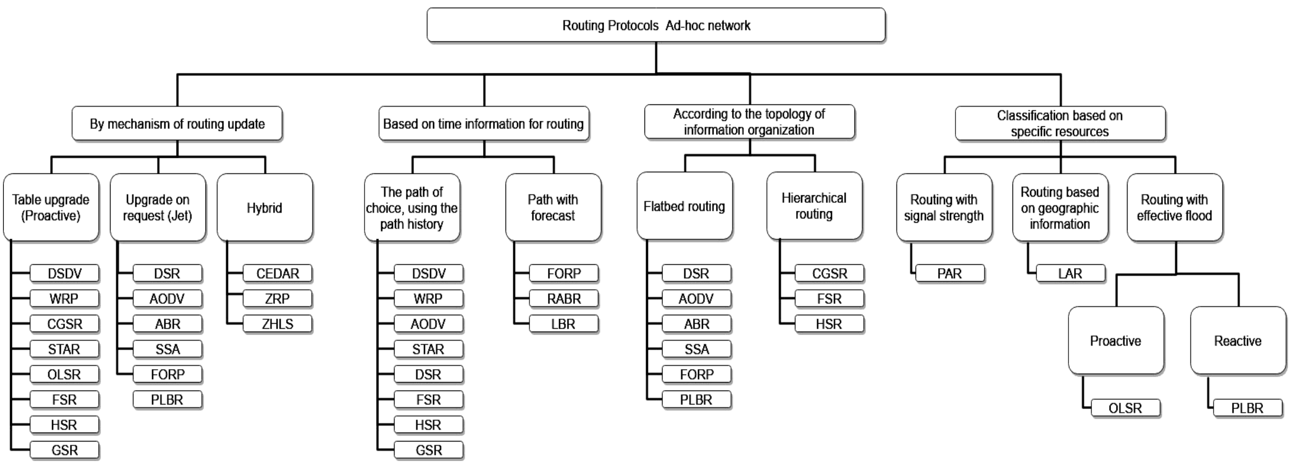

Fig. 1. Classification of routing protocols for ad hoc networks [1, 6, 9]

The advantages of hybrid routing protocols are quick connection setup, less overhead than table and jet protocols.

The disadvantages of these protocols are high requirements for storing and processing information about routes in comparison with reactive protocols [1, 2, 6, 8, 9].

Classification of routing protocols based on timely saves information of a route that is temporarily stored on a node because ad-hoc networks are very dynamic and data breaks are much more frequent than wired networks, the use of time information that determines the duration of wireless connections and the duration work of the chosen paths. Protocols falling into this category can be divided into two types [1, 6, 9]. Ad-hoc wireless networks by a mechanism for updating information:

Protocols that use pre-assembled and processed route information to the destination are generally used by the routing table. These protocols include DSDV, WRP, AODV, STAR (Source-Tree Adaptive Routing Protocol), DSR, FSR, HSR, GSR [1, 2, 6, 8, 9].

Protocols with a prediction of route identification. Protocols belonging to this category use information about the expected future status of wireless connections for routine routing decisions. In addition to the duration of wireless connections, information about the future status also includes information on the duration of the site, prediction of the location and prediction of the availability of the communication channel, etc. The forecasting protocols include FORP, RABR, LBR [1, 6, 9].

The advantages of protocols with a prediction of protocol routing are high adaptability of protocols to high-dynamic topology changes, QoS support.

The disadvantages of protocols with a prediction of a route determination are dependence on the infrastructure, which protocols are additionally used to search for the shortest route such as GPS, etc., which, in the absence of this infrastructure, affects the efficiency of the protocol, a high cost of the computing resource.

Protocols based on topology routing. For example, the hierarchical topology is used on the Internet, which reduces the amount of information and load of the core-level routers. In ad-hoc networks, as a rule, in comparison with the networks used for transmitting a signal using a wired signal transmission environment, there is a smaller number of nodes, and a flat and hierarchical topology is used for routing [1, 6, 9].

Protocols of Route Plane Topology. Protocols falling under this category use the schema of flat addresses, similar to the scheme used in LANs of the IEEE 802.3 standard [31]. It involves the presence of a global unique addressing mechanism for nodes in the Ad-hoc wireless network. These protocols include DSR, AODV, ABR, SSA, FORP, PLBR [1, 6, 9].

Hierarchical topology routing protocols use the logical hierarchy in the network and the associated addressing scheme. The hierarchy can be based on geographic information, or it can be based on hop distance. Protocols of this category include CGSR, FSR, HSR.

The advantages of hierarchical topology routing protocols include: reducing the size of routing tables, improving scalability and reducing service traffic.

The disadvantages of routing protocols in the hierarchical topology include high consumption of computing resources.

Protocols based on the use of specific resources such as PAR (Power-Aware Routing Protocol), LAR (Location-Aided Routing Protocol), OLSR and PLBR [1, 6, 9].

Routing protocols that build a route based on the power of the signal with a minimum level of radiation power or minimize the use of the battery of the site. This category of routing protocols aims to minimize the consumption of a very important resource in wireless ad-hoc networks, namely the power of the battery. Routing decisions are based on minimizing energy consumption both locally and globally over the network. Protocols in this category are PAR. To determine the route in the protocols of this category, the following indicators can be taken into account [1, 6, 9]:

- minimum energy consumption per package. This indicator includes several nodes from the source to the destination, to achieve even energy consumption throughout the network;
- the maximum connection to the network, to balance the traffic load, this difficult to achieve due to the mobility of nodes;
- the minimum difference in power levels of nodes, for load distribution, energy consumption remains equal between nodes, almost optimal performance is ensured by routing the packet to the least downloaded next hop;
- the minimum cost of a package, where the cost depends on the battery charge (for example, less energy - more value) and uses it as a metric, it is easy to calculate (available batteries), and this indicator processes traffic on the network.

Protocols that build geographic data routes improve routing efficiency and reduce overhead on control, effectively using available geographic information. Protocols of this category are LAR [1, 6, 9].

In the scientific paper [30] is given six scenarios with simulation of routing protocols AODV, DSDV and OLSR, according to the above-mentioned these protocols belong to different classes of routing protocols, which in turn will make it possible to compare the effectiveness of approaches search route in routing protocols data also before the simulation of the included TCP and UDP protocols, which correspond to the higher transport level of the OSI model.

In the first scenario of this work [30, p. 90-100] the basis of a design by the example of the road from two lanes where the speed on the front page for the units moving speed of 28 meter per second in the second 33 meter per second speed as a result of the difference should be observed as a result of increasing delays increase the distance between objects and respectively, to increase the number of relay packets for delivery to the addressee. In the next step, the simulation speed of objects change under first strip speed of objects is 28 meter per second, the second strip movement at a speed of 55 meter per second, which should create a more frequent change of network topology.

And so let's look at the results obtained by the author and try to draw the appropriate conclusions.

So, according to Table 1 [30], the author provides such data delays based on the use of the transport protocol TCP, a speed of 28 m / s of the first band and 33 m per second of the second lane.

Table 2 [30] also shows the delay in data transmission taking into account the use of UDP transport protocol, the speed of 28 m / s of the first band and 33 meter per second of the second lane. Indicators of the number of sent and received UDP transport protocols (Table 3) [30] due to the peculiarities of their work. It is in contrast to the TCP protocol, which, in the case of failure to deliver or accept the mistake of requesting it to be re-sent, non-delivered or accepted segments with an error are simply deleted. This feature of the UDP protocol demonstrates the effectiveness of delivering packets from sender to destination.

After analyzing the data provided in the graphs [30], the data rates of TCP and UDP higher-level protocols with respect to time can be inferred for the stability of the transmission of data from source to destination at the frequency change of the network topology (Table 4).

Table 1 – **A time delay in data transmission using TCP transport protocol [30]**

Routing protocol	Minimum delay value	Maximum delay value	Average delay value	Initial delay	Average value
AODV	0.0050919920	0.6537681730	0.1716732224	0.28866014	0.50010847
OLSR	0.0098262930	6.3630483810	0.1767772492	0.28858440	0.50025779
DSDV	0.0045719920	0.2477734980	0.1231930545	0.28865030	0.50019508

Table 2 – **Time delay data rates when using the UDP transport protocol [30]**

Routing protocol	Minimum delay value	Maximum delay value	Average delay value	Initial delay	Average value
AODV	0.027840518	47.185497177	0.8358558674	0.96577239	0.497221200
OLSR	0.012571992	13.178178803	0.8198667509	0.70803833	0.507178314
DSDV	0.012651992	5.984668514	0.9500924252	1.04989802	0.4983542355

Table 3 – **The number of UDP packets sent and delivered [30]**

Routing protocol	Number of sent packages	The number of packets accepted	The ratio of delivered packages
AODV	12990	10356	80%
OLSR	12495	9202	74%
DSDV	13333	8887	67%

Table 4 – **Percentage of data transmission stability time**

Routing protocol	Time of data transmission (sec), at different rates of motion of the object		Percentage of time without disturbing data transmission (%) at different rates of motion of the object	
	33 м/s, TCP/UDP	55 м/s, TCP/UDP	33 м/s, TCP/UDP	55 м/s, TCP/UDP
DSDV	56/163	88/87	77/32	20/21
OLSR	44/47	35/52	82/80	68/53
AODV	32/4	28/10	87/98	75/91

Summarizing the analysis of the results of the first scenario, we can conclude that in AD-HOC networks with increasing dynamics of network topology change, the AODV protocol shows a more reliable and stable data transfer compared to DSDV and OLSR protocols. AODV routing protocol is less susceptible to topology changes due to route search only if packet transfer is required. But this protocol is inferior to the maximum speed of data transmission and the delay time before the data transfer in networks with low dynamics of changing the network topology, this is achieved by the fact that proactive protocols store the route table and, if necessary, transmit the package does not search the route to the addressee and directly take the route already available from routing table.

In the publication S. Mohapatra and P.Kanungo [31], the authors conduct modeling of routing protocols of AD-HOC networks using the NS2 emulator. In this paper, the authors studied the effect of three variables such as node speeds, namely the speed of change of the topology, which is demonstrated in the form of graphs in Fig. 6-9, the size of the network area is shown in the graphs in Fig. 10-13 and the number of nodes in AD-HOC networks are shown in the graphs in Fig. 2-5. The rest of the parameters in the simulation were unchanged.

The authors were given the following simulation parameters [31]:

- routing protocols DSR, DSDV, AODV and OLSR;
- simulation time for 150 second;

- type of traffic CBR / UDR (Constant Bit Rate / User-Defined Routing);
- package size 512 bytes;
- IEEE 802.11 Channel Level;
- number of nodes 10, 20, 30, 40, 50;
- network size m2 200, 400, 600, 800, 1000;
- delay time with. 0, 30, 90, 120, 150.

Fig. 2 [31] has the best performance with the DSR protocol because this protocol does not periodically send routing tables and does not send hello packets to neighboring nodes. Somewhat worse results show DSDV and the more heavy load of the channel is the official information displayed by the protocols AODV and OLSR. In Fig. 3 [32], as expected in accordance with previous modeling work, the AODV and DSR protocols traditionally have a high packet delivery rate. DSDV parameters are much worse than others due to the fact that changing the topology of the network's proactive protocol takes time to update routing on the nodes, which is why in rather dynamic networks, packets are sent over an outdated route. Such a mechanism is the reason for the low packet delivery coefficient to the addressee. The OLSR protocol, compared to AODV and DSR, has slightly worse delivery rates for packets to the recipient, although the routing table's basic principle is also proactive. Unlike DSDV, the protocol OLSR periodically exchanges routing tables has an addition on its armament trigger partial routing table in case of changing the topology or state of the site.

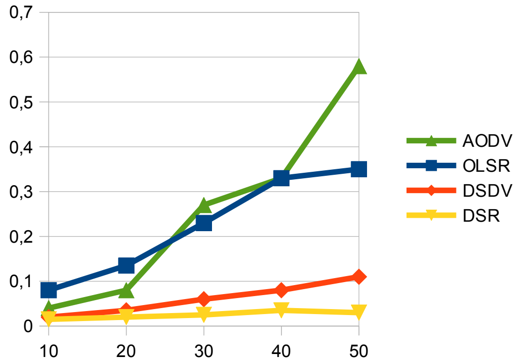

Fig. 2. The ratio of official information to data, depending on the number of nodes [31]

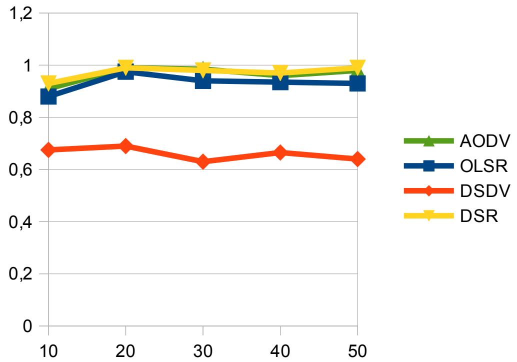

Fig. 3. Coefficient of the delivered data from the source to the addressee, depending on the number of nodes [32]

In the demonstrated result in Figure 4 [31], the author points out a high delay in the DSDV protocol with the number of nodes 10, according to my belief, and taking into account the operation of the protocol, this indicator is rather dubious as the routes in the memory of the node are constantly present and the transfer of packets is executed instantly. after being found in memory, this method minimizes the latency of the start of packet forwarding, as unlike reactive routing protocols, there is no need to search the route.

The speed, depending on the number of punctures AODV shows Fig. 5 [31] is the worst result that is characteristic of him in connection with the need to constantly search the route before sending a package that increases the time delay and the amount of official information. Traditionally higher data rates show proactive DSDV and OLSR protocols.

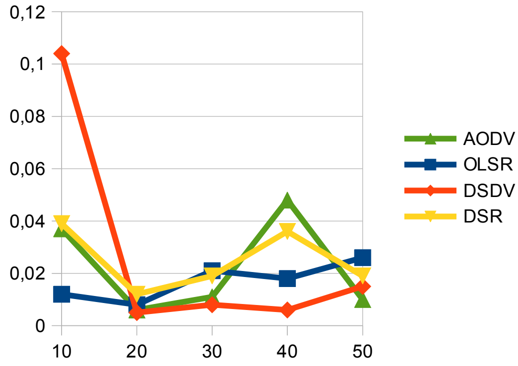

Fig. 4. The time of delivery of packages from the source to the addressee, depending on the number of nodes [31]

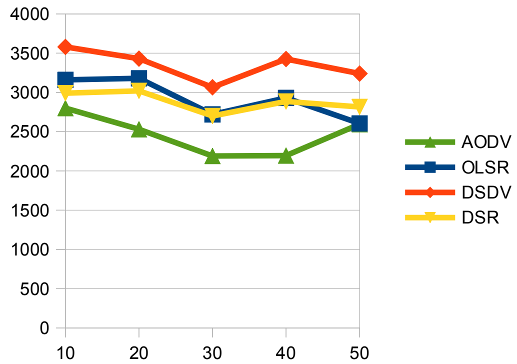

Fig. 5. The speed of data transmission from source to destination, depending on the number of nodes [31]

The first scenario of this work was designed to expand the network by increasing the number of nodes in the network.

The second scenario [31] focuses on the properties of protocols for node mobility, the change in the delay parameter from 0 to 150 seconds in increments of 30 seconds, in this case, for 150 seconds, this is a practically constant and relatively unchanged network, 0 means constant movement of nodes.

With regard to the dependencies of routing protocols on the speed of nodes in Fig. 6 [31], there is a significant dependence of the AODV protocol where the amount of service information increases at the speed of the nodes, the DSR protocol shows the best indicators of the ratio of service information to the data.

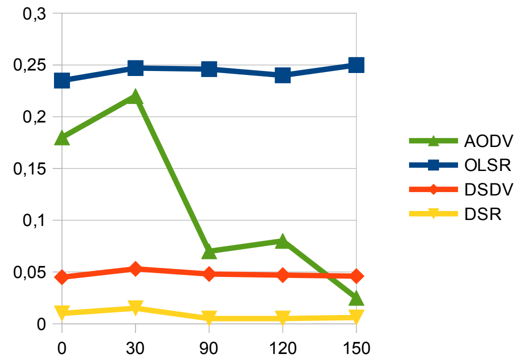

Fig. 6. The ratio of official information to data, depending on the time delay

Also, the AODV and DSR protocols have traditionally shown (Fig. 7) [31] the highest percentage of delivery of packets from source to destination, while the DSDV protocol has a low packet delivery rate at high node density, and this indicator is gradually improving with decreasing nodal activity.

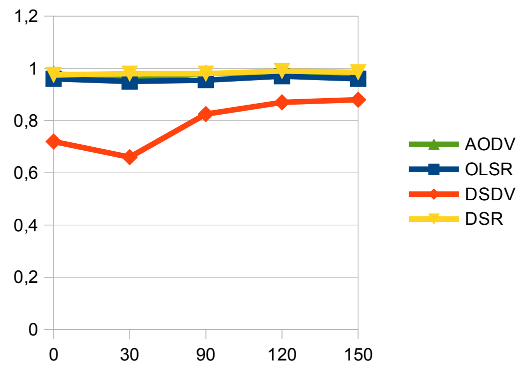

Fig. 7. The amount of data delivered from the source to the destination, depending on the mobility of nodes [31]

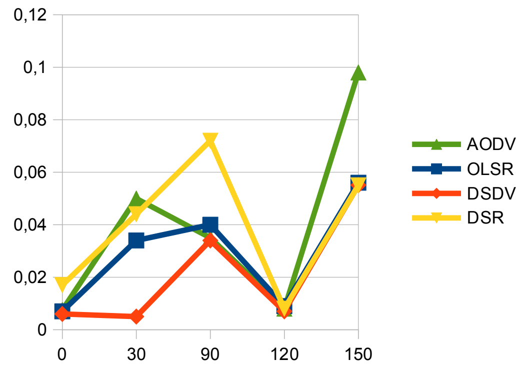

Fig. 8. The time of delivery of the package from source to destination, depending on node mobility [31]

The data is provided by the author of the time of delivery of the package from source to destination, depending on the mobility of the nodes presented in the paper [31] in Fig. 8 are quite contradictory so traditionally reactive protocols have a longer delivery time and proactive protocols have a shorter delivery time but with a delay of 120 seconds on the chart there is a large decline in delivery time and a sharp 150 increase in time. Judging by the logic, the diagram should look a little different. So with the high intensity of the nodes and, consequently, the frequent change in the topology of the network, routing protocols have to respond more often to these changes by looking for and calculating the route to the addressee, which in turn increases the time for delivery of the packet from the source to the addressee. The time for delivery of the packet will decrease with a decrease in the intensity of the change in the network topology by spending less time and resources on the route search. These changes should especially affect the proactive routing protocols. So, unlike proactive routing protocols, the delivery time of packets should be slightly higher than the proactive ones and, accordingly, the impact curve of node mobility should be more moderate, since, in fact, reactive protocols are searched for each route before each packet is transmitted.

So in view of the above, the diagram of the dependence of the data transfer rate in relation to the mobility of objects should look like (Fig. 9) [31]. In this case, with a decrease in the mobility of objects, the speed should increase.

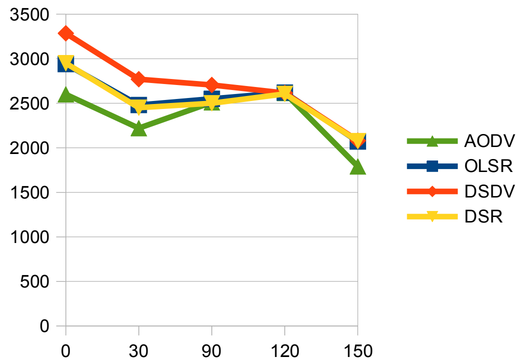

Fig. 9. The speed of data transmission from source to destination, depending on the mobility of nodes

The next stage of the modeling [31] the author changes the 200x200 network size factor: 400x400, 600x600, 800x800 and 1000x1000 meters. In this simulation, with each step increasing the size of the network, the number of intermediate packets transfers from the source to the destination increases, which in turn should increase the route search time and the time the packets are transmitted to the destination.

Analyzing the results of the simulation where the variable coefficient is the size of the network. You can observe completely predictable properties of protocols. Thus, in Fig. 10 [31], DSR and AODV protocols traditionally have OLSR and DSDV protocols with a significantly higher traffic factor due to the need to find a route to the destination before sending the packet. In Fig. 11 [31], it is observed that the AODV and DSR protocols show substantially similar high packet delivery rates to the destination and the worst performance in the OLSR protocol and the lowest DSDV indicator may be due to constraints The protocol, in particular, the maximum range of the route cannot exceed 2 redirects.

On the diagram (Fig. 12) [31], the delivery time of the packets to the destination, we see a faster transmission time in the DSDV and OLSR protocols ahead of the AODV and DSR, because there is no need to pre-route the route before the package is sent.

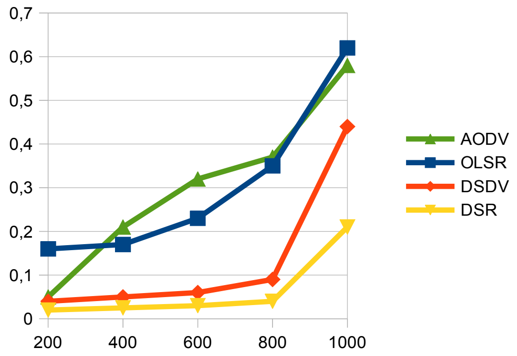

Fig. 10. The ratio of official information, depending on the size of the network area

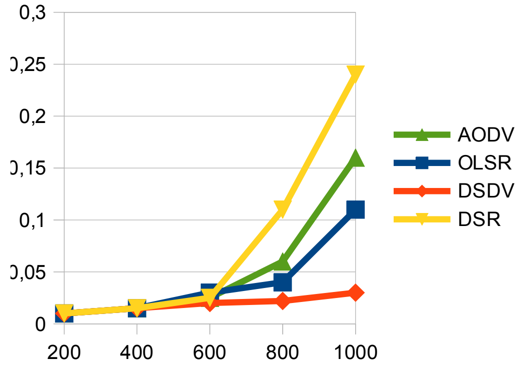

Fig. 12. The time of delivery of packages from the source to the addressee, depending on the size of the network area

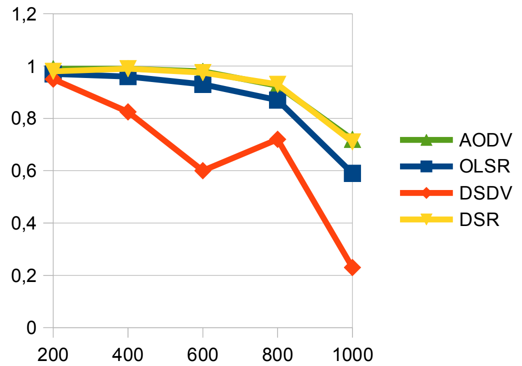

Fig. 11. The rate of delivery of packages from the source to the destination, depending on the size of the network area

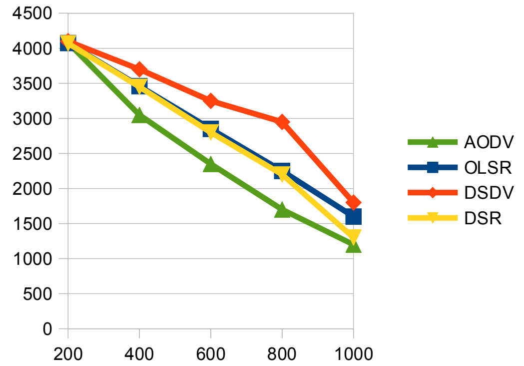

Fig. 13. The rate of data transmission from the source to the destination, depending on the size of the network area

Also, a similar situation is observed at speeds on Fig. 13 [31] data transfers in DSDV and OLSR protocols show a higher speed, unlike the AODV and DSR protocols.

The main problems are related to the design of the routing protocol and the different classifications of routing protocols for ad-hoc wireless networks, which should be addressed by a special wireless routing protocol, there are node mobility, rapid topology changes, limited bandwidth, hidden and detected problems with the terminal, limited capacity the battery, the properties of the channels in time, as well as the dependence on the location. Different approaches that can be used to classify protocols include a classification based on the type of topology service approach used by the routing topology, the use of temporal information, and the type of specific use of resources considered for decision-making purposes for routing.

Conclusion from this explosion

According to the results of the research, the The study analyzed and conducted the classification of AD-HOC network routing protocols, taking into account the specifics of networks that can be used in special-purpose networks and rescue services. These networks have high dynamics in changing the network topology, lack of infrastructure, the need for rapid deployment and network convergence, the random change in the number of nodes in the network, the possible impact of interference and interception of information, all these criteria significantly affect the operation of routing protocols.

So the best adaptive properties to the above criteria are the jet and hybrid routing protocols. Taking into account the analysis of the modeling results and the classification of the AD-HOC networks and, in accordance with the tasks set forth in the further research and development, it is advisable to pay attention to DSR and AODV routing protocols with the best packet delivery rates and better performance in high-end networks.

In accordance with the foregoing, attention should be paid to further research on routing protocols which have inherent properties of adaptation to high dynamic changes in network topology, reduced number of transfer of service information to maintain network operation, high packet delivery rates, but the available routing protocols use one or several criteria to determine the route and to increase the efficiency of routing protocols in future scientific works pay attention go to take into account more criteria for determining the route in the routing protocols.

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Аналіз технічних характеристик мережі з можливістю до самоорганізації

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На теперішній час технології бездротових мереж широко використовуються у нашому повсякденному житті та в мережах військового призначення. Як свідчить проведений в джерелах аналіз, в подальшому їх відсоткова частка буде лише збільшуватися. В цій статті проводиться аналіз технічних характеристик та класифікація протоколів маршрутизації мереж з можливістю самоорганізації за основними особливостями організації та механізмів роботи протоколів, такими як механізм оновлення інформації маршруту, спосіб зберігання інформації маршруту, топологія організації інформації та на основі використання протоколами конкретних ресурсів. Авторами відомих наукових праць в яких проводилося моделювання, проведено неповний опис залежності впливу таких критеріїв як швидкість руху вузлів, зміна площі мережі, зміна кількості вузлів в мережі, зміна кількості пересилаємих пакетів до адресату на роботу протоколів маршрутизації. Проведено аналіз сучасних напрямків дослідження в наукових виданнях та тенденції розвитку протоколів маршрутизації, аналіз даних з моделювання протоколів маршрутизації, які надані авторами моделювання. Під час огляду результатів моделювання проводився опис поведінки протоколів у різних сценаріях моделювання та коментування логіки роботи протоколів відповідно до наданої класифікації, що в подальшому надало можливість визначення особливостей протоколів у відповідності до категорій. Аналіз переваг та недоліків протоколів маршрутизації мереж з можливістю до самоорганізації при зміні критеріїв, що впливають на роботу протоколів, таких як зміна кількості вузлів в мережі з можливою самоорганізацією, робота протоколів у залежності від інтенсивності зміни топології (швидкості переміщення вузлів), зміни розміру області мережі, яка в свою чергу також впливає на кількість вузлів, що перенаправляють пакети за для доставки до адресату. Проаналізовано також залежність роботи протоколів маршрутизації щодо використання протоколів вищого рівня TCP та UDP, зокрема проаналізовано коефіцієнт доставки пакетів від джерела до адресату. Виділено основні переваги та недоліки основних протоколів маршрутизації мереж з можливою самоорганізацією, які розглядалися авторами наукових праць із моделювання, таких як AODV, DSDV, OLSR та DSR. Проведено визначення актуального та перспективного напрямку наукової роботи в подальших дослідженнях.

Ключові слова: мережі з можливістю самоорганізації; Ad hoc; радіомережі; бездротова мережа; multi-hop; базова станція; багатоадресний трафік;, децентралізовані мережі; спеціальні бездротові мережі; інтелектуальні мобільні вузли; режим реального часу; класифікація протоколів маршрутизації.

Анализ технических характеристик сети с возможностью самоорганизации

А. Л. Налапка, А. В. Шишацкий

В настоящее время технологии беспроводных сетей широко используются в нашей повседневной жизни и в сетях военного назначения. Как свидетельствует проведенный в источниках анализ, в дальнейшем их процентная доля будет только увеличиваться. В даной статье проводится анализ технических характеристик и классификация протоколов маршрутизации сетей с возможностью самоорганизации по основным особенностям организации и механизмам работы протоколов, таких как механизм обновления информации маршрута, способа хранения информации маршрута, топология организации информации, а также на основе использования протоколами конкретных ресурсов. Авторами известных научных трудов по моделированию сетей во многих случаях проводилось неполное описание зависимости влияния таких критериев как скорость движения узлов, изменение площади сети, изменение количества узлов в сети, изменение количества пересылок пакетов в адресату на работу протоколов маршрутизации. Проведен анализ современных направлений исследования в научных изданиях и тенденции развития протоколов маршрутизации, анализ данных по моделированию протоколов маршрутизации, предоставленных авторами трудов по моделированию. При анализе результатов моделирования проводится описание поведения протоколов в различных сценариях моделирования и комментирование логики работы протоколов в соответствии с предоставленной классификацией, в дальнейшем дается возможность определения характерных особенностей протоколов в соответствии с категориями. Анализ преимуществ и недостатков протоколов маршрутизации сетей с возможностью к самоорганизации при изменении критериев, влияющих на работу протоколов, таких как изменение количества узлов в сети с возможностью самоорганизации, работа протоколов в зависимости от интенсивности изменения топологии (скорости перемещения узлов), изменение размера области сети, которая в свою очередь также повлияет на количество узлов, перенаправляют пакеты для доставки к адресату. Проанализирована также зависимость работы протоколов маршрутизации от использования протоколов высшего уровня TCP и UDP, где рассмотрен коэффициент доставки пакетов от источника к адресату. Выделены основные преимущества и недостатки часто используемых протоколов маршрутизации сетей с возможностью самоорганизации, которые рассматривались авторами научных работ по моделированию, таких как AODV, DSDV, OLSR и DSR. Проведено определение актуального и перспективного направления научной работы в дальнейших исследованиях.

Ключевые слова: сети с возможностью самоорганизации; Ad hoc; радиосети; беспроводная сеть; multi-hop; базовая станция; многоадресный трафик; децентрализованные сети; специальные беспроводные сети; интеллектуальные мобильные узлы; режим реального времени; классификация протоколов маршрутизации.