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AD-HOC AND WIRELESS MESH NETWORKS FOR A MOBILE PEER-TO-PEER COLLABORATION

AD-HOC UN BEZVADU REŽĢTĪKLI MOBILAI SADARBĪBAI

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Keywords: ad-hoc networks, mobile collaboration, peer-to-peer collaboration, wireless mesh networks

Abstract - The use of the mobile ad-hoc (MANET) and wireless mesh networks is spreading as well as research on the different applications of these technologies. Combination and convergence of several wireless network technologies (UMTS, WiFi, WiMax etc.) is pawing a way to ubiquitous instant connectivity allowing effective mobile peer-to-peer collaboration such as videoconferencing, "wireless office" and many other.

In this paper an analysis of possible mobile pear-to-peer collaboration scenarios with different network configurations and routing protocols will be presented. Different peer-to-peer collaboration scenarios in such networks are analysed and criteria for optimisation of traffic routing are elaborated. The efficiency of DSDV and AODV routing protocols is compared for several network configurations. The results obtained are based on the network simulation with the Network Simulator (NS2) software in the grid cluster.

Introduction

Most typical applications in the mobile ad-hoc (MANET) and wireless mesh networks are related to file transfer, access to databases and download of data which are common for fixed networks as well. Existing wireless communication technologies are already at such development stage that ubiquitous instant connectivity and rich multimedia communication could be enabled. This provides opportunities to execute effective mobile peer-to-peer collaboration such as videoconferencing, "wireless office" and many other applications.

Still there are unsolved problems related to specific features of such wireless networks. MANETs may have dynamic behaviour with moving nodes and appearing-disappearing nodes. Therefore the transmission routes are changing and the effective routing protocols must be chosen best fitted to particular kind of application. There are already developed routing algorithms providing high throughput and transmission bit-rate. In each case it is important to elaborate specific criteria for optimization of traffic routing providing the stated QoS conditions.

Different peer-to-peer collaboration scenarios in such networks are possible and they are analyzed in using general model based on social network theory [1] or for specific conditions as, for example, pedestrian or vehicular mobility [2]. In each application case links between peers and mobility conditions may be different and therefore subject for individual optimisation.

Videoconferencing and video streaming are among very demanding applications in peer-to-peer collaboration and therefore a subject of optimization. A multi-source streaming approach is developed to increase the robustness of real-time video transmission in MANETs by introducing scalable video coding extension of H.264/MPEG4-AVC with different layers for assigning importance for transmission [3].

In this paper an analysis of possible mobile pear-to-peer collaboration scenarios with different network configurations and routing protocols will be presented. Different peer-to-peer collaboration scenarios in such networks are analysed and criteria for optimisation of traffic routing are elaborated. The efficiency of routing protocols DSDV and AODV is compared for videoconferencing application in the network with 20 nodes. The results obtained are based on the network simulation with the Network Simulator (NS2) software in the grid cluster.

Collaboration scenarios

Collaboration among peers in virtual environments and in social networks becomes very topical now. Wireless technologies are creating conditions for ubiquitous instant connectivity even being mobile. Ad-hoc and wireless mesh networks are good examples on how several available technologies could be put in use for this purpose.

Different peer-to-peer collaboration scenarios in such networks are possible. For close peer-to-peer communication in small project group the so-called Caveman Model proposed by Watts could be applied [4]. In this model each peer communicates directly with another peer in the group. Not always it means that they are in direct reach and therefore communication with several hops in ah-hoc network must be analysed as well.

For larger communities and for collaboration among several project groups different approach with central node (star configuration) may be more efficient. Then communication (files, video etc.) is performed via central node to central node of other local community.

This means that multi-hop conditions (3-5 hops) and eventual mobility paths of one or more nodes and speed options are making analysis very complex. As there are many different routing protocols available the optimization task becomes even more complex. Such simulation task becomes demanding in respect to the computing performance and availability of grid computing resources is an advantage.

Routing protocols

There are many routing protocols proposed for MANET's. Taking into account changing configuration and conditions in the network routing protocols must have different features than in fixed communication networks. Existing protocols could be classified as reactive, proactive and hybrid routing protocols. Their main features are presented in the Table 1.

Table 1

Comparison of routing protocol types

Reactive	Proactive	Hybrid
A route calculation when it's needed.	A route calculation before it's needed.	Reactive-proactive features combined.
Doesn't keep routing info all the time.	Keeps routing info all the time.	Some information kept, but another updated

Proactive protocols exchange route data at periodic intervals to update the routing information. Such exchanged route data is placed into tables in each device and provides information on routing prior to devices requiring route data. A proactive routing protocol reduces network latency, but can have a relatively high overhead.

MANET routing protocols performing route maintenance only when information needs to flow on a new route are reactive ones. Another name for the reactive protocol is "on-demand". As the exchange of routing information occurs just when needed, the overhead associated with an on-demand routing protocol is typically less than for a proactive routing protocol, but it can increase latency.

Lack of standards for routing protocol is the reason that there are so many. The most popular ones are:

- distance vector protocols – DSDV (Destination-Sequenced Distance Vector), AODV (Ad Hoc On-demand Distance Vector), DSR (Dynamic Source Routing), ODMRP (On-Demand Multicast Routing Protocol);
- link state protocols – OLSR (Optimized Link State Routing Protocol) , hybrid protocol HWMP (Hybrid Wireless Mesh Protocol).

For implementation of wireless mesh networks with WiFi tools the standard 802.11s is under development. It chooses HWMP for its standardization. It's a hybrid combination of On-demand Distance Vector Routing algorithm and tree based routing algorithm.

Analysis shows that different routing protocols have advantages in different application scenarios and mobility conditions according to Table 2 [5].

Table 2

Network conditions and optimal routing protocols

Conditions	Routing protocol
Small network and low mobility	DSR
Small network and high mobility	AODV
Large network and low mobility	AODV HWMP
Large network and high mobility	HWMP

In the NS2 simulation software AODV, DSDV and DSR routing protocols are available and two of them are used in current work.

Optimization criteria

To carry out optimization of peer-to-peer data communication criteria must be analysed and the most appropriate ones chosen to maintain QoS.

Data transmission parameters

The main parameters characterising efficiency of packet data transmission in videoconferencing application are data transmission rate or bandwidth and packet latency. These are parameters determining QoS level of the system.
There are also some other related parameters used in communication networks:

- End to End delay (E2E)
- Round-Trip Time (RTT)
- Packet loss rate or Packet Delivery Ratio (PDR)
- Maximum Throughput

The Network Simulator (NS2) software allows simulation of Packet Delivery Ratio (PDR), Routing Load (RL), End to End (E2E) delay, Throughput [6], as well as Average throughput, Ratio of dropped packets by no route (NRTE), Ratio of dropped packets by interface link queue overflow (IFQ) [7] which are very important parameters specific for MANETs.
These parameters will be used in simulation as criteria to compare routing protocols and maintain QoS conditions.

Quality of Service conditions for peer-to peer videoconferencing

Videoconferencing is one of most demanding multimedia applications in peer-to-peer collaboration and therefore could be chosen as a model application for optimization of the routing protocols and network configuration.
For simulation purposes a simple low quality videoconferencing is used. In Table 3 video resolutions and appropriate bitrates are summarised for MPEG-4 least demanding standard Levels for simple-based profiles [8].

Table 3

MPEG-4 video resolution and bitrates

Level	Resolution	Max.bitrate	Max. objects
L0	176x144	64 kpbs	1 simple
L1	176x144	64 kbps	4 simple
L2	252x288	128 kbps	4 simple

Videoconference traffic measurements

Experiment was carried out to determine real traffic parameters of videoconferencing application.
Packet sniffer (Wireshark) was used to capture packets of ongoing videoconference between two sites using Tandberg Edge75 system.
Typical characteristics for such videoconference are: 2 constant bitrate (CBR) audio/video streams in each direction, UDP transport protocol, and average packet size 250 bytes. There was additional TCP traffic of service information present.
These parameters later were used in NS2 simulations as a typical traffic data for videoconferencing to analyze possibility of videoconference in multi-hop ad-hoc networks.

Computer simulation

Network Simulator 2 (NS2) was used and trace files were later analyzed with tool written in MATLAB – Tracegraph.
Network with 20 nodes and with 1-star topology was chosen (Fig. 1). Results obtained for it could be used as a base to make presumptions for all other network configurations and scenarios.
Close peer-to-peer communication in small group could be simulated in this configuration if just 1 or 2 hop links are chosen.

Throughput measurements for static scenario

In first simulation videoconference application was tested if link is maintained via multi-hop network. Static scenario (no node movement) with 1 central and 20 surrounding node was used for the simulation. Central node behaves as gateway to internet or other cluster of nodes. Nodes can communicate each other directly.

To represent videoconference conditions bidirectional data streams were transferred between two nodes. Central node was chosen as one of nodes as if video streams are coming from outside world. To represent several options observable in the multi-hop ad-hoc network different number of intermediate nodes were chosen. In Fig.1 possible multi-hop links are shown but each of them was tested separately.

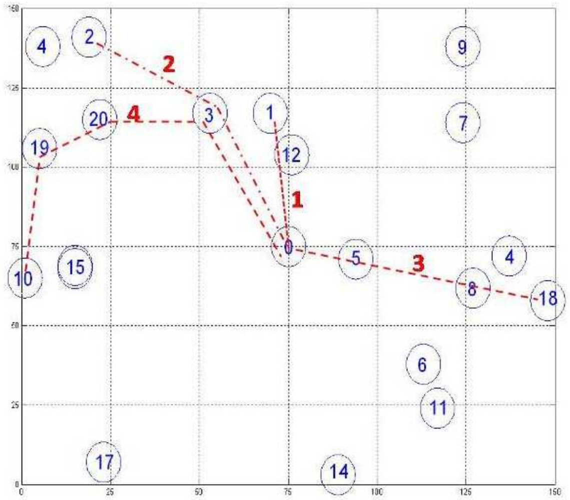

Fig.1. Network topology and multi-hop paths

To make the simulation more realistic additional TCP traffic was added from central node to each of surrounding nodes To generate random size files Parreto distribution was used with average file size 10 Kbytes (as observed in real HTTP traffic).

Results in Table 4 and Table 5 show that by increasing number of hops maximum allowable (threshold) bit rate for videoconference's data streams decreases. Increasing bit rate above this threshold results in network overload and much longer delays.

Table 4

Maximum bit rates

Nr. of hops	Max bit rate for data stream in one direction	
	Only CBR	CBR + random TCP (+ ~100 kbps)
1	200 kbps	100-150 kbps
2	130 kbps	50-60 kbps
3	82 kbps	35 kbps

Table 5

End-to-end packet delays

Nr. of hops	Delay for data stream one direction	
	Only CBR	CBR + random TCP (+ ~100 kbps)
1	8 ms	8 ms
2	12 ms	12 -15 ms
3	18-20 ms	20 ms

Dramatic increase of end-to-end delay has been observed while transmitting traffic with 3 hops if network becomes overloaded (Fig. 2).

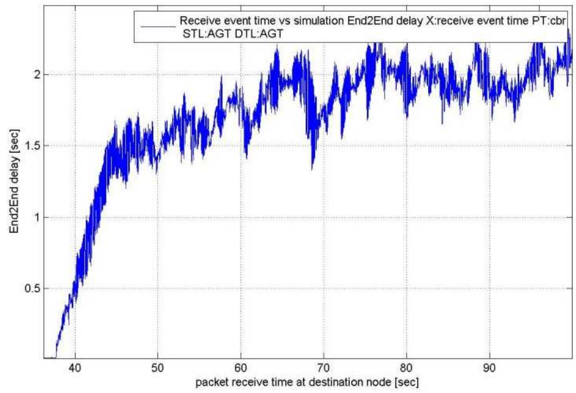

Fig.2. Packet delay in overloaded network

Another downside observed was pretty high packet delay variation (jitter) for streams going through more than 1 hop. In Fig. 3 can be seen typical jitter for traffic going through 3 hops.

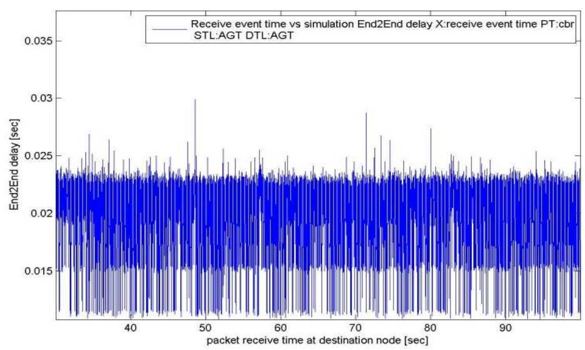

Fig.3. Typical packet delay and its variation

Delays and bitrate fall happens because of collision avoidance mechanisms. NS2 by default uses CSMA/CA (Carrier sense multiple access with collision avoidance). Increasing number of nodes and traffic influences performance and can even lead to packet loss. Not being able to transfer packet because of busy channel and due to collisions packets are delayed in interface queues and dropped after queue overflow [9].

If we look at MPEG-4 standards (Table 3) which defines throughput of channel for different screen resolution we can see that 82 kbps is enough to provide 1 low quality videoconferences session.

Obtained results can show only general trends and reveal most common problems, because for simulation just default technical specifications and network standards available in NS2 were used. To obtain more precise data we should apply technical specifications and standards of real hardware available in market today.

DSDV and AODV comparison for mobile scenario

Very important network feature to maintain QoS in videoconferencing is stability of network throughput. While network nodes can move away from it's original position the traffic may be disrupted and routing protocol must restore the link. Ability of DSDV and AODV protocols to maintain stable traffic has been simulated.

The same 1 star scenario is used for simulation. Node movement speed is chosen 3 m/s and CBR traffic 80 kbps in each direction. In Fig. 4 and Fig. 5 are presented simulation results for DSDV and AODV routing protocols, respectively. From the graphs traffic stability and recovery time for two protocols could be compared.

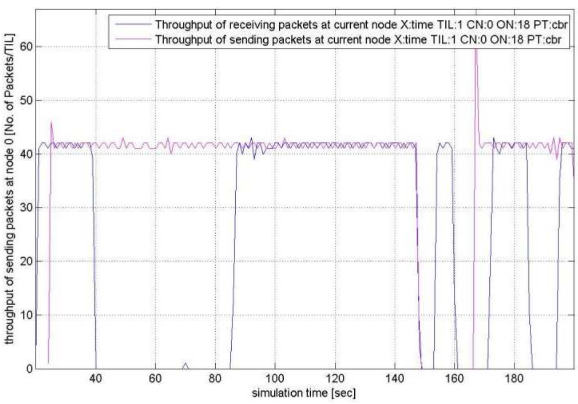

Fig.4. Throughput stability for DSDV protocol

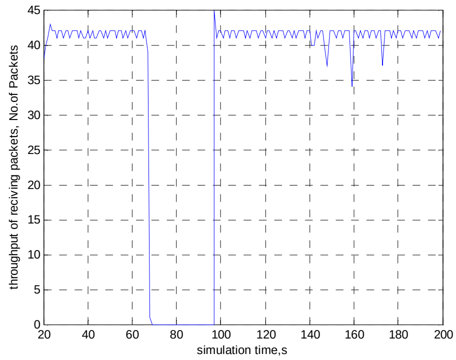

Fig.5. Throughput stability for AODV protocol

One can observe wider gaps in the first graph (Fig. 4) showing that DSDV protocol reacts slower to route changes than AODV protocol.

Conclusions

The analysis of possible mobile pear-to-peer collaboration scenarios with different network configurations and routing protocols is made.

The efficiency of routing protocols is compared for several network configurations. Simulation results show that in mobile scenario DSDV protocol reacts slower to route changes then AODV.

For peer-to-peer videoconferencing applications comparison of achievable max bitrate is made for different network configurations and number of intermediate nodes (hops).

Simulation and experimental testing confirm that increasing number of nodes simultaneously transferring data influences performance. Videoconferences resolution (bitrate) should be decreased to avoid network overload otherwise it may lead to packet loss. In configuration where traffic goes through 3-hops maximum throughput of channel was only 82 kbps that is enough for low quality videoconference. Other traffic presented in network can also considerably decrease available throughput.

The results obtained are based on the network simulation with the Network Simulator (NS2) software in the grid cluster.

Acknowledgment

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L. Cikovskis, J. Kūliņš, S. Vdovins. I. Slaidiņš, B. Žuga. Ad-hoc un bezvadu režģtīkli sadarbībai

Arvien vairāk tiek lietoti mobilie ad-hoc tīkli un režģtīkli, tāpēc paplašinās arī pētījumu apjoms par dažādiem šo tehnoloģiju lietojumiem. Dažādu bezvadu tehnoloģiju (UMTS, WiFi, WiMax u.c.) apvienošana un konverģence liek pamatus virzībai uz visaptverošu atrašanos nepārtrauktā pieslēgumā komunikāciju tīkliem. Tas savukārt ļauj nodrošināt efektīvu mobilu sadarbību starp partneriem (peer-to-peer), kā, piemēram, videokonferences, "bezvadu biroju" un daudzus citus lietojumus.

Šajā rakstā ir veikta partneru iespējamo sadarbības scenāriju analīze dažādām tīkla konfigurācijām un dažādiem maršrutēšanas protokoliem, kā arī veikta datormodelēšana ar NS2 datplūsmas maršrutēšanas optimizēšanai

Šī pētījuma galvenais mērķis ir veikt videokonferences datplūsmas modelēšanu statiskā un mobilā vairāklēcienu tīklā, lai novērtētu iespējamo efektivitāti un atklātu iespējamās problēmas. Līdz šim iespējas pārraidīt apjomīgas multimediju datplūsmas, tādas kā videokonference, dažādām tīkla konfigurācijām un maršrutēšanas nosacījumiem MANET tīklos vēl nebija pietiekoši izpētītas.

Vispirms tika veikts eksperiments, lai noteiktu reālos datplūsmas parametrus videokonferencei. Reālas videokonferences datplūsmai starp diviem punktiem tika tvertas paketes un analizēti to statistiskie parametri, kuri vēlāk tika izmantoti datormodelēšanā.

Galvenā uzmanība datormodelēšanā tika vērsta uz diviem galvenajiem videokonferences datplūsmu raksturojošiem parametriem – datu pārraides ātrumu un pakešu aizkavējumu (latentumu). Maksimāli iespējamie datu pārraides ātrumi tika noteikti mainot videokonferences datplūsmas pārraidē iesaistīto mezglu skaitu. Tika analizētas arī tādas problemātiskas parādības kā tīkla pārslodze un pārāk liels pakešu aizkavējums starp galapunktiem.

Datormodelēšana tika veikta 20 mezglu tīklā ar vienu centrālo mezglu, kas reprezentē vārteju. Tika analizēti tīkla savienojumi ar ne vairāk kā trīs lēcienu attālumā no vārtejas. Nelielu grupu (peer-to-peer) komunikāciju arī var modelēt šādā tīklā, ja izmantosim tikai 1 vai 2 lēcienu tīkla savienojumus. Lai modelēšanas apstākļi būtu tuvāki realitātei, papildus videokonferences datplūsmai, tīklā tika realizēta HTTP datplūsma no centrālā mezgla uz visiem apkārtējiem mezgliem.

Papildus vēl tika novērtēta tīkla pārraides parametru stabilitāte mobilā scenārijā. Tā kā tīkla mezgla punkti var kustēties un mainīt savu sākotnējo atrašanās vietu, tad datplūsma var tikt pārtraukta un maršrutēšanas protokolam ir jāatjauno tīkla savienojums. Tīkla parametru stabilitāte un spēja datplūsmas ceļa nomaiņu veikt īsā laikā ir ļoti svarīgi tīkla parametri, lai nodrošinātu videokonferences pakalpojuma kvalitāti (QoS).

Veicot datormodelēšanu tika novērtēta un savstarpēji salīdzināta maršrutēšanas protokolu DSDV un AODV spēja nodrošināt stabilu datplūsmu. Tika salīdzināta DSDV un AODV maršrutēšanas protokolu efektivitāte vairākām tīkla konfigurācijām.

Rezultāti iegūti veicot tīkla datormodelēšanu ar programmatūru Network Simulator (NS2) grid klāsterī.

L. Cikovskis, J. Kūliņš, S. Vdovins. I. Slaidiņš, B. Žuga. Ad-hoc and Wireless Mesh Networks for Mobile Peer-to-Peer Collaboration

The use of the mobile ad-hoc (MANET) and wireless mesh networks is spreading as well as research on the different applications of these technologies. Combination and convergence of several wireless network technologies (UMTS, WiFi, WiMax etc.) is pawing a way to ubiquitous instant connectivity allowing effective mobile peer-to-peer collaboration such as videoconferencing, "wireless office" and many other.

In this paper an analysis of possible mobile pear-to-peer collaboration scenarios with different network configurations and routing protocols is made, as well as simulation for optimisation of traffic routing for videoconferencing application is performed.

The main aim of the work is the modelling of videoconferencing traffic in static and mobile multi-hop network to measure efficacy and reveal possible problems. Until now opportunities of transmission of rich multimedia applications, such as videoconferencing, in MANETS are not yet investigated in detail for different network configurations and routing conditions. First, the experiment was carried out to determine real traffic parameters of the videoconferencing application. Packets were captured of ongoing videoconference between two sites and these parameters were later used in simulations.

The main focus was on two data transfer parameters characterising efficiency of videoconferencing - bandwidth and packet latency. Maximum allowable bandwidth thresholds were measured varying number of nodes involved in videoconference data transfer. Such problems as network overload and high packet end-to-end delays were also analyzed.

For simulation 20 node network topology was used with one central node representing internet gateway. Network link with maximum node distance of 3 hops away from gateway was used. Close peer-to-peer communication in small group could be simulated in this configuration as well if just 1 or 2 hop links are

chosen. To make the simulation more realistic in addition to videoconference's data streams random HTTP traffic was added from central node to each of surrounding node.
Additionally, we studied stability of network throughput in mobile scenario. While network nodes can move away from their original position the traffic may be disrupted and routing protocol must restore the link. Stability and low route change times are very important network features to maintain QoS in videoconferencing. Ability of DSDV and AODV to maintain stable traffic has been simulated and compared.
The results obtained are based on the network simulation with the Network Simulator (NS2) software in the Grid cluster.

Л. Циковскис, Я. Кулиньш, С. Вдовин, И. Слайдиньш, Б. Жуга
Использование Ad-hoc и безпроводных сотовых сетей для мобильного взаимодействия
В современных условиях более интенсивного использования мобильных ad-hoc и сотовых сетей увеличивается объём исследований в области различных применений этих технологий. Объединение и конвергенция безпроводных технологий (UMTS, WiFi, WiMax и т.д.) закладывает основы для исследования всеобъемлющих, находящихся в непрерывном соединении, комуникационных сетей. Это, в свою очередь, позволяет обеспечить эффективное мобильное взаимодействие между партнёрами (peer-to-peer), например, видеоконференции, „безпроводной офис” и другие области.
В данной статье проведён анализ сценариев взаимодействия между партнёрами при различных конфигурациях сети и протоколах маршрутизации, а также осуществлена симуляция для оптимизации маршрутизации трафика видеоконференций. Главная черта работы – моделирование видеоконференций в статических и мобильных многоузловых сетях для измерения их эффективности и обнаружения возможных проблем. До сих пор возможности передачи качественных мульитмедийных приложений, таких как видеоконференции, в мобильных сотовых сетях (MANET) не исследованы детально для различных сетевых конфигураций и условий маршрутизации. Прежде всего был проведен эксперемент для определения реальных параметров трафика видеоконференций. При проведении двухсторонней видеоконференции произведён захват пакетов и данные параметры позднее использовались в симуляциях.
Основное внимание уделено двум параметрам передачи данных, характеризующих эффективность видеоконференций – пропускной способности и латентности пакетов. Измерен максимально возможный порог пропускной способности при изменяющемся количестве узлов, принимающих участие в передаче данных видеоконференций. Также проанализированы проблемы перегрузки сети и высокой задержки пакетов.
Для симуляции выбрана 20-ти узловая сетевая топология, в которой один центральный узел предназначен для выхода в Интернет. Использовалась конфигурация сети с максимальным расстоянием 3 узла до шлюза. Проведена симуляция закрытой связи между партнерами в пределах маленькой группы при наличии одного или двух промежуточных узлов. Для создания более реалистичной симуляции использовался произвольный HTTP видеоконференционный поток данных, посылаемый из центрального узла к каждому из окружающих.
Дополнительно изучена стабильность пропускной способности сети при использовании мобильного сценария. Стабильность и минимальные изменения времени определения маршрута являются очень важным свойством сети для обеспечения качества обслуживания в видеоконференциях. Пока сетевые узлы сдвигаются по отношению к оригинальной позиции, трафик может быть прерван и протокол маршрутизации должен восстановить связь. Проведена симуляция и сравнение способности DSDV и AODV обеспечивать стабильный трафик.
Результаты получены при помощи компьютерного моделирования с использованием программы Network Simulator (NS2), работающей в сотовом (grid) кластере