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# Performance Analysis of One Model of Communication and Information System in Military Operation

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**ABSTRACT**

This paper presents a model of communication and information system in military operations. Here OPNET MODELER simulation package is applied because it is suitable for network modelling, topology and capacity planning. Simulation of different types of IP traffic and monitor their performance to optimise the functionality of network elements, management performance network applications, and as well as in research and development of new network technologies. Application of the method of mass service are determined by the capacity needed for voice transmission on the links in the model and using the OPNET MODELER simulation program are analysed performance modeled communication information system in data transmission. The results of the simulation are presented through target the service settings: workload links communication and information system, e-mail download response time, http page download response time and packet loss in data transfer. The aim of the research has shown that modeled communication information system with defined elements (nodes), the capacity of links (according to the specification of telecommunication devices) and defined traffic can respond to the requirements of command forces in the military operation in terms of telecommunication service. The results of the analysed service target parameters show that modeled communication and information system provides an efficient flow of information and the tra nsfer of voice and IP data for the needs of command and control in military operations.

**Keywords:** Model; Simulation; Performance analysis; Communication-information system; Military operation

## 1. INTRODUCTION

Communication information system (CIS) is an association of functional elements that comprise the collection, transmission, protection, electronic processing, display, storage and distribution of information. Communication information system is consisted of different networks[1-3]. Military CIS is established for needs of the system of command and control forces in military operations[4,5]. The architecture of communication and information system determined by the structure of forces the army to be used in carrying out various tasks[6]. The paper modelled power three levels of command in the military operation (battalion (BN) - brigade (BDE) - division (DIV)) and appropriate military CIS[7].

Modelled communication and information system is characterised by mobility, ability to work under field conditions and the provision of telecommunications capacity and customer service to meet the needs of command and control forces in the operation. Elements of a communication and information system consist of access and network nodes. They are connected to radio-relay links. The base of nodes consists of mobile switching centers (MSC). Mobile switching center is asynchronous transfer mode (ATM) switch that implement time-division multiplexing (TDM) and internet protocol (IP) component in the ATM system transmission and switching. Radio-relay devices are part of nodes and connect nodes established radio-relay links. Access nodes of three command levels provide various customer services (voice, file, email, data, etc.)[8-11].

Performance of the communication and information system for the purposes of command and control ($C^2$) system in military operations, the methods of operation research and simulations have been applied. The capacity of voice traffic is determined by applying the queuing theory. Using a software package OPNET MODELER are simulated possibility modelled communication and information system to transfer IP data.

In the simulation scenario, network elements are defined, the traffic types (services and applications), as well as the mode of operation of various user profile and its need for service. They are followed by target performance model with a special emphasis on the occupation of the most critical links in terms of the maximum traffic loads. The results of the simulation scenarios are shown as corresponding graphs for analysis of packet data transmission through the described network.

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Analysis of the system performance using simulation software is very significant because it provides a simpler, more efficient and cost-effective consideration of the possibilities of the system and optimisation of telecommunication network in operational use. The paper is assumed network connectivity between elements communication and information system. In this paper impacts of the relief, vegetation, weather conditions, failures and reliability have not been considered because the version of the used simulation package does not allow that.

## 2. CONCEPT OF MILITARY OPERATION

Modern management theory allows defining military operation as a unified project (enterprise, process) in which a variety of combat and noncombat activities are engaged with human and material resources under a unified command, in a certain space and time, making a unique overall goal. By applying the concept of the project management it is establishes efficient organisation that allows the best possible use of the available methods of planning, organising, managing and control in order to effectively implement the project[12].

In principle, military operations have the following phases: preparation, execution and stabilisation and disengagement. In the preparatory phase of the operations are implemented operations planning, organising forces, fill in the required resources, training and development of operational forces. Execution military operations includes the organisation of command and leadership, action and counteraction, logistic and other support, maneuver, combat support, force protection and civil-military cooperation. In the final phase is carried out gradually disengagement forces after achieving the objective of the operation, and elimination of consequences of military operations[13].

The first step in operational planning is the forming (creation) and the development of operational models. It is the result of a thought process in which the analysis of the operating environment and setting their own and the enemy's forces in a logical relationship, and visualisation presents the basic ideas commander for the execution of operations which are related tasks forces and end state. "The operating model in all cases should be a reflection of the commander's understanding of the operating environment displayed text and / or graphic." The formulation of an operational model is achieved by defining the operational environment, defining and identifying the problem and operational solving the problem[14].

In the paper are modelled the army forces in military operation in the area of 60 km x120 km. Forces consists of one division (operational group) strength of four brigade with 10 battalions (two infantry battalion, two mechanised battalion, one tank battalion, two artillery squadron, one battalion of anti-aircraft defence, one engineering battalion and one logistic battalion). Battalions and brigades deploy basic command posts and division deploys basic and logistics command post. Analysis of the communication and information system for the purpose of the command and control in these conditions was treated for three-level command (battalion - brigade - division) in the preparation phase and execution phase of the operation in two sessions. Each level of command has specificity in terms of the number of users to command positions that require communication services and the need for bandwidth.

## 3. MODEL OF COMMUNICATION INFORMATION SYSTEM IN THE MILITARY OPERATION

Telecommunication-information support of the military operations is process in which plans, organizes and realizes communication and information system to transfer, protection, electronic data processing, storage, and display information. It creates the necessary conditions for the functioning of the command and control of forces engaged in military operations. Planning, organising and implementing the telecommunication-information support is trying to find optimum model communication information system, creating the organisational structure and the setting elements of the communication and information system in the area operated in a unified technological unit, establish, maintain and use telecommunications and user services[15].

Model communication and information system is defined modelled forces in operation. Important characteristics of the system are: allows operation in the field conditions (climatic-mechanical properties of devices), system is mobile in the sense that the elements of the system allow the following of commands and military units in the area of the operation and provide the necessary telecommunication capacity and services to the user. One approach to modeling telecommunication system for forces in a military operation in support of civil authorities showed by Pavlović and Karović[16].

Model communication and information system makes an integrated radio-relay networks (backbone) which connects the mobile switching centers access and network nodes. Access nodes are deployed on command posts modelled forces in operation (battalion-brigade-division). Network nodes are deployed in the area of operation. Communication and information system provides voice and IP data through the same transport network. Quality of service in the nodes is defined so that the voice services and service data completely separated by the bandwidth that is reserved for them.

The radio relay network has the function of interconnecting the switching nodes per each type of interface. The radio relay network comprises TADIRAN GRC-408E 8Mb/s radio relay devices, connected in a ring structure, which have the following interfaces: E1 G.703, E2 G.703 and V.11. Model defaults network connectivity, line of sight between the radio relay device, and using V.11 8192kb/s interface.

Mobile switching center is made by military tactical internet switch (MTIS) which are essentially ATM switches with a special internet protocol card (IPC) intended for routing IP traffic. MTIS stations are enables to circuit switched voice service to be switched through the ATM connection and IP traffic through IP over ATM. At the command post (access nodes) is established voice service using digital and analog telephones and local area network (LAN) connected on MSC with Eth 100Mb/s links. Local area networks contain a different number of users depending on the level of command or formation command (at the command battalion 10 users, brigade 19 users and division 34 users). Exchange data through the IP part of the network consists of two types of services (e-mail and web service)[7,17,18].

Through the network, e-mail service is exchanged in two ways, continuously throughout the period of preparation and execution of operation, in discrete time intervals when different levels of command exchange typed orders and reports (mails mostly higher memory value). WEB (http) service type is consisted of a search various data on servers, continuously during the preparation and execution of the operation. Network elements connected with each other in the mobile communication and information system is shown in Fig. 1[7,17].

Network nodes are displayed in green colour and deployed in the brigade area of operations (30 km x 60 km or more). The condition is to be secured line of sight. Battalion and brigade access nodes are shown as combat vehicles and they are connected to the appropriate network node associated brigade. The access nodes of the division are shown in blue colour and deployed at the height of the first and second operating echelon. Figure 2 shows the topology of battalion, brigade and division access nodes.

All access nodes have LAN with the appropriate number of users. There are six redundant servers in the network on command post of the brigade and division. They allow the using different applications in communication and information system.

## 4. SIMULATION OF MODEL COMMUNICATION INFORMATION SYSTEM

OPNET MODELER application was used to simulate model of communication information system. Application is intended to simulate different types of computer networks. It represents a commercial solution for modelling the computer networks, the simulation of different types of IP traffic and monitors their performance to optimise the functionality of network elements. Application is applicable in the following aspects of communication networks: management performance network applications, topology planning and scheduling of computer networks, as well as in research and development of new network technologies. It can be used in the installation of new communication and information networks, as well as in the improvement of the existing and new network elements

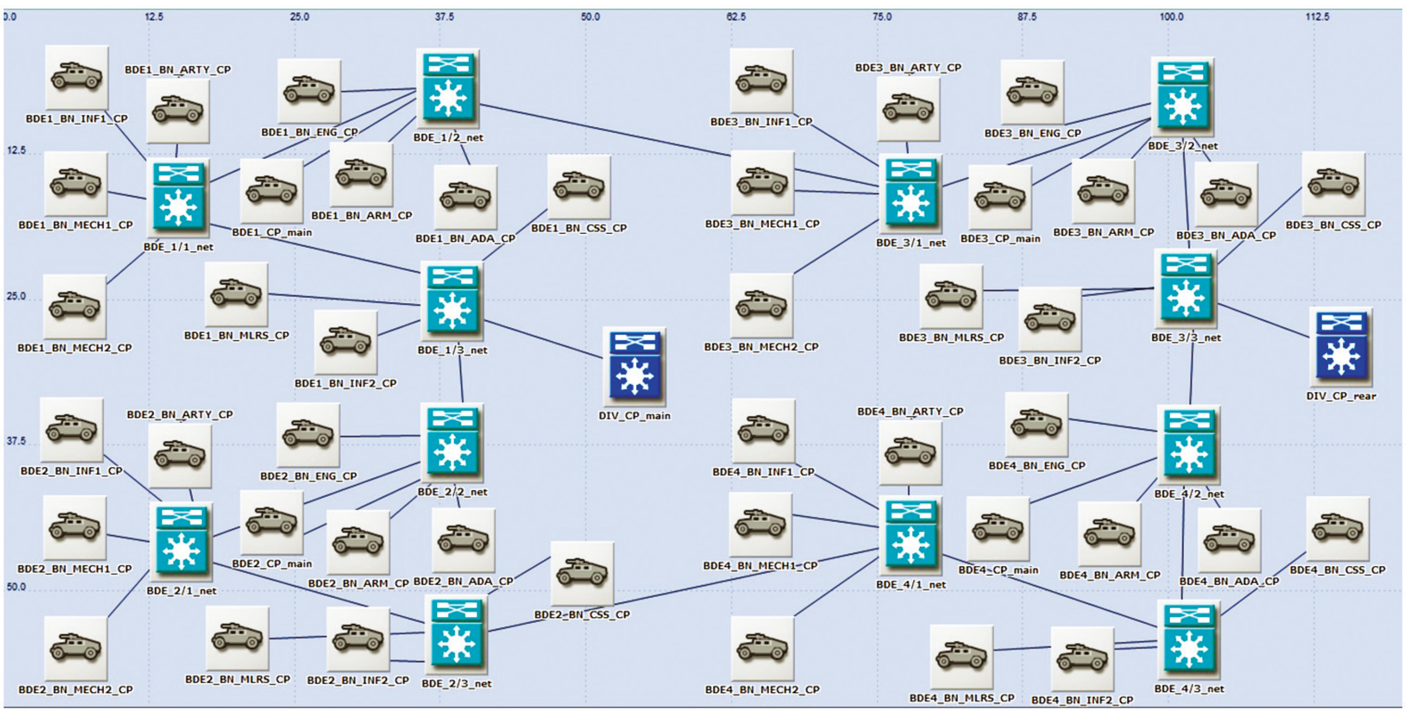

**Figure 1. Topology of communication information system in military operation.**

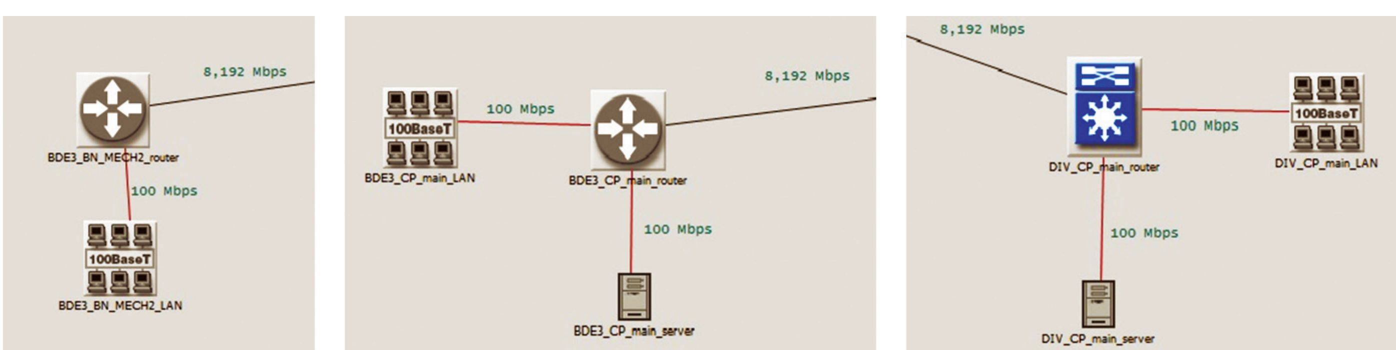

**Figure 2. Topology of access nodes (a) battalion, (b) brigade i, and (c) division.**

with new services[19].

The software package meets the structural and replicative validity or veracity and adequacy of the application. The development and establishment of a communication and information system, checking network connectivity and verification of network and $C^2$ service was performed on the simulation, but without affecting the environment (relief, vegetation, weather conditions) and enemy electronic warfare. Experiment on the real system would require huge costs.

Computer simulation is made through several phases and activities:

- Scenario definition (defining nodes, LAN, links, servers, applications, user profiles, the connection of LAN, the service and user profile, definition of telecommunication traffic)
- Determination of the target the service settings
- Simulating the process of transferring information and
- Displaying simulation results.

Simulation scenario has 58 nodes (46 access and 12 network nodes), 46 LAN with 584 users and 220 upload and download links (116 links with V11 interface and 104 to the Eth interface) in total. Configured LAN segments are defined by a corresponding number of PC terminals associated to their user profiles which have implemented an application with a different mode of operation. It defined traffic characteristics and described the traffic simulation model. Network has six redundant servers and they have applications listed in Table 1. Servers provide services for military units in its part of the network but they are also redundant. They take over the functionality other servers in the event of failure of one of them.

To define the telecommunication traffic was carried the research needs for services in the real system and collected empirical data on the type and amount of information - acts (operational orders, additional orders, reports, other information) to be exchanged between the elements of the three levels of command in the military operation. The analysis of operational and additional orders, reports and short messages have come to their average size, as shown in the column stored value services in Table 1. Attached e-mail operational orders 1, 2 and 3 levels of command are contained operational orders (OPORD) with contributions of OPORD and scheme operations on a topographic map according to Instructions for operational planning.

Size of operational orders determined ‘high traffic’ when documents are not compressed, or ‘low traffic’ when the documents are compressed. In the simulation model it is defined seven different e-mail services and one WEB service for the preparation phase and execution phase of the modelled military operations. It is shown in Table 1. There are operational orders, additional orders, and reports attached to the e-mail. They are transmitted exclusively from the administrative computer in the command military unit. Background e-mail constitutes written correspondence (short messages) between members of different commands and units.

In this research, the targeted service parameters: workload links, e-mail download response time, http page download response time and speed packet loss per unit time, are determined. Simulation lasted 15 h and 50 min and represents duration of the preparation and execution phase of military operation. The results are shown by graphs of the target service parameters depending on the duration of the simulation.

## 5. RESULTS

Within establishing a radio-relay links between MTIS nodes, it is defined capacity separately for voice traffic and to transmit IP data. It is formed a trunk at the link whose total capacity ($C_t$) is divided into capacity for circuit switched services - voice traffic ($C_{cs}$) and IP traffic ($C_{ip}$).

$$C_t = C_{cs} + C_{ip} \tag{1}$$

The number of telephone channels ($n$) for voice traffic on the link is determined by the following relation:

$$n = \frac{C_{cs}}{64\,kb/s} \tag{2}$$

For the purpose of the link capacity reservation for voice traffic, the queuing theory is applied, respectively the Erlang-B formula. Markov chains and Erlang distribution analysis is

**Table 1. Description services in the simulation model**

| Type of service | The runtime service | Number of PC to perform service in the LAN | Stored value service |
|---|---|---|---|
| E-mail additional order | Continuously throughout the duration of the operation | Administrative PC in the LAN on comand post | 100 kB |
| Background e-mail | Continuously throughout the duration of the operation | Whole LAN | 2 kB |
| Operational order 1. level (DIV) | 1 h after begining simulation (in preparation phase operation) | Administrative PC in the LAN on comand post | 4 MB/1.2 MB |
| Operational order 2. lever (BDE) | 3 h after begining simulation (in preparation phase operation) | Administrative PC in the LAN on comand post | 3.5 MB/0.75 MB |
| Operational order 3. level (BN) | 5 h after begining simulation (in preparation phase operation) | Administrative PC in the LAN on comand post | 3.2 MB/0.3 MB |
| Report 1 | After 1. session execution phase operation | Administrative PC in the LAN on comand post | 80 kB |
| Report 2 | After 2. session execution phase operation | Administrative PC in the LAN on comand post | 80 kB |
| WEB (http) service | Continuously throughout the duration of the operation | Whole LAN | *Searching* (default) |

shown in more detail[20,21].

$$s = 1 - p_n = 1 - \frac{\dfrac{\lambda^n}{n!\mu^n} \cdot \dfrac{1}{k_s^n}}{\sum_{k=0}^{n} \dfrac{\lambda^k}{k!\mu^k} \cdot \dfrac{1}{k_s^k}} \qquad (3)$$

where is $s$ probability of servicing

$p_n$ Probability that system will not serve

$A$ Intensity of voice traffic, $A = \dfrac{\lambda}{\mu}$

$\lambda$ Intensity of the arrival of calls

$\mu$ Intensity of servicing of calls

$k_s$ Availability

$n$ Number of channels.

By studying voice traffic between the elements of the three levels of command empirical data of voice traffic, or the number of calls, duration of calls and time between calls were collected. Voice traffic is different for different command levels, but on the basis of obtained data was defined the maximum intensity of the voice traffic ($A$<5), which was applied to calculate the number of telephone channels by links. Applying the Erlang-B Eqn. (3) for sufficient probability of servicing ($s$>0,9), and availability ($k_s$≈1) is necessary to provide 512 kb/s (8 telephone channels of 64 kb/s) for voice traffic on the link. The remaining capacity of 7680 kb/s is defined for IP transmission. Figure 3 shows the analysis of the dependence of the parameters: probability of servicing ($s$), intensity of the voice traffic ($A$) and availability ($k_s$) to the number of channels $n$=8.

The results of the targeted service parameters after the simulation process IP data transmission in the scenario are shown in the following figures.

Figure 4 shows the results of analysis of the most loaded link utilisation in the network for e-mail service and WEB service (for 'low traffic' and 'high traffic') during the simulation. Parameter utilisation of the most loaded link is important because of network congestion. The most loaded link is a link BDE_1.BDE_1/2_net <-> BDE_3.BDE_3/1_net download (see Figure 1) which connects the network nodes 1st brigade and 3rd brigade. From the Figure 4 it can be concluded that the occupation of the most loaded link comes up to 100 per cent at the time of handover of operational orders ('high traffic') in the preparation phase of the operation. During other times of simulation, the most loaded link is loaded with less than 40 per cent capacity.

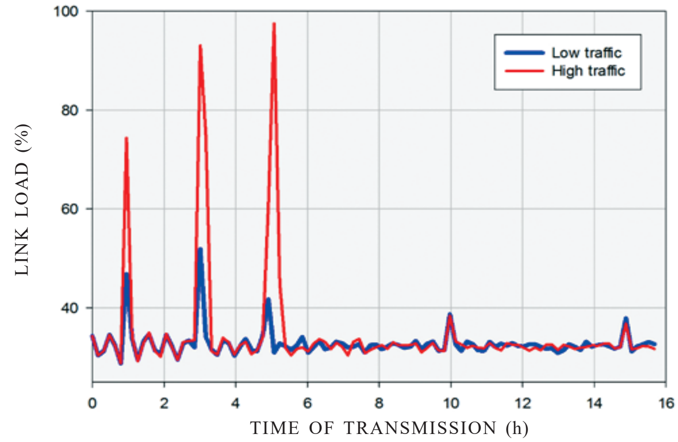


**Figure 4. Most loaded link bandwidth in the network.**

Table 2 shows the results of 20 most downloaded links in the communication and information system. The results are expressed through the type of link between different units (download or upload), minimum link load (%), average link load (%), maximum link load (%), and standard deviation of load. It is characteristic that all links are not equally loaded in the network. Large numbers of links are minimally loaded. Further analysis of link load and application of service quality policy can optimize the network in order to achieve as efficient a data transmission as possible.

The e-mail download response time during the data transfer in the simulation is shown in Figure 5. It is shown that the average e-mail download response time is below 5 s, which is most noticeable during the transfer of 'high traffic'. It is at the time of handing over an operational order from the command post of the brigade and the battalion, when it arrives for more than 40 s.

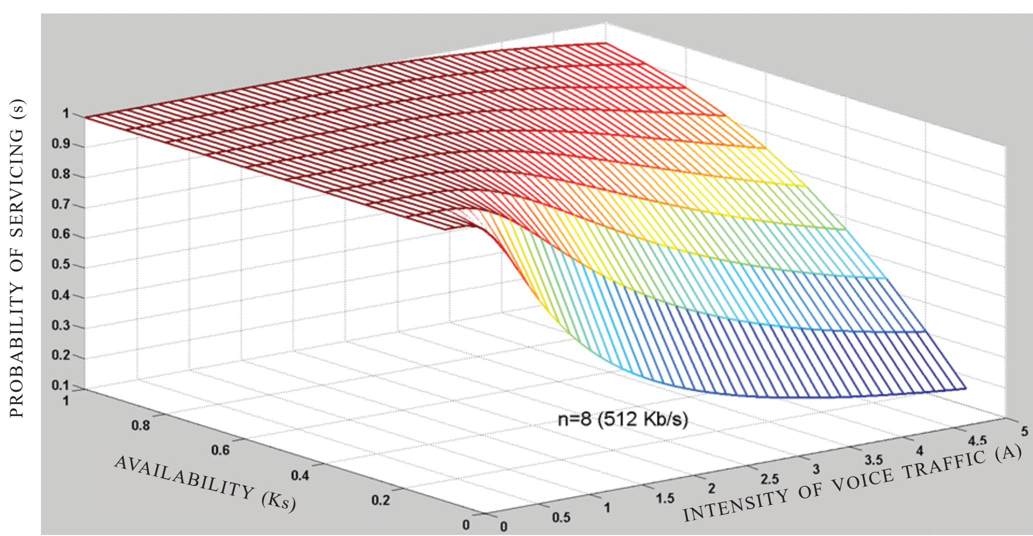


**Figure 3. Dependency parameters of voice traffic.**

**Table 2. The most loaded links bandwidth in the network**

| Rank | Object name | Minimum (%) | Average (%) | Maximum (%) | Std Dev |
|---|---|---|---|---|---|
| 1 | BDE_1.BDE_1/2_net <-> BDE_3.BDE_3/1_net <-- | 29.354 | 35.938 | 100.000 | 11.962 |
| 2 | BDE_1.BDE_1/2_net <-> BDE_3.BDE_3/1_net --> | 28.744 | 34.760 | 97.484 | 10.977 |
| 3 | BDE_1.BDE_1/1_net <-> BDE_1.BDE_1/2_net <-- | 25.373 | 30.966 | 100.000 | 10.602 |
| 4 | BDE_3.BDE_3/1_net <-> BDE_3.BDE_3/2_net <-- | 22.797 | 28.009 | 94.424 | 9.328 |
| 5 | BDE_1.BDE_1/1_net <-> BDE_1.BDE_1/2_net --> | 21.423 | 27.646 | 95.468 | 10.188 |
| 6 | BDE_3.BDE_3/1_net <-> BDE_3.BDE_3/2_net --> | 21.051 | 26.911 | 92.451 | 10.073 |
| 7 | BDE_1.BDE_1/1_net <-> BDE_1.BDE_1/3_net --> | 21.178 | 26.009 | 87.998 | 9.126 |
| 8 | BDE_1.BDE_1/1_net <-> BDE_1.BDE_1/3_net <-- | 18.128 | 23.624 | 81.350 | 8.640 |
| 9 | BDE_1.BDE_1/3_net <-> BDE_2.BDE_2/2_net --> | 19.207 | 23.389 | 81.846 | 8.302 |
| 10 | BDE_3.BDE_3/1_net <-> BDE_3.BDE_3/3_net --> | 19.192 | 23.102 | 78.076 | 7.827 |
| 11 | BDE_3.BDE_3/1_net <-> BDE_3.BDE_3/3_net <-- | 18.443 | 22.944 | 77.513 | 8.546 |
| 12 | BDE_1.BDE_1/3_net <-> BDE_2.BDE_2/2_net <-- | 16.869 | 21.706 | 75.849 | 7.801 |
| 13 | BDE_3.BDE_3/3_net <-> BDE_4.BDE_4/2_net <-- | 16.746 | 20.792 | 72.125 | 7.810 |
| 14 | BDE_3.BDE_3/3_net <-> BDE_4.BDE_4/2_net --> | 16.740 | 20.247 | 71.382 | 7.094 |
| 15 | BDE_3.DIV_CP_rear <-> BDE_3.BDE_3/2_net --> | 16.219 | 19.466 | 55.801 | 6.217 |
| 16 | BDE_1.DIV_CP_main <-> BDE_1.BDE_1/2_net --> | 16.120 | 19.347 | 55.539 | 5.922 |
| 17 | BDE_3.DIV_CP_rear <-> BDE_3.BDE_3/2_net <-- | 14.419 | 18.196 | 52.405 | 5.924 |
| 18 | BDE_1.DIV_CP_main <-> BDE_1.BDE_1/2_net <-- | 14.165 | 18.147 | 58.251 | 6.167 |
| 19 | BDE_4.BDE4_CP_main <-> BDE_4.BDE_4/2_net --> | 14.260 | 17.769 | 62.073 | 6.740 |
| 20 | BDE_2.BDE_2/1_net <-> BDE_2.BDE_2/2_net <-- | 14.738 | 17.709 | 68.706 | 6.825 |

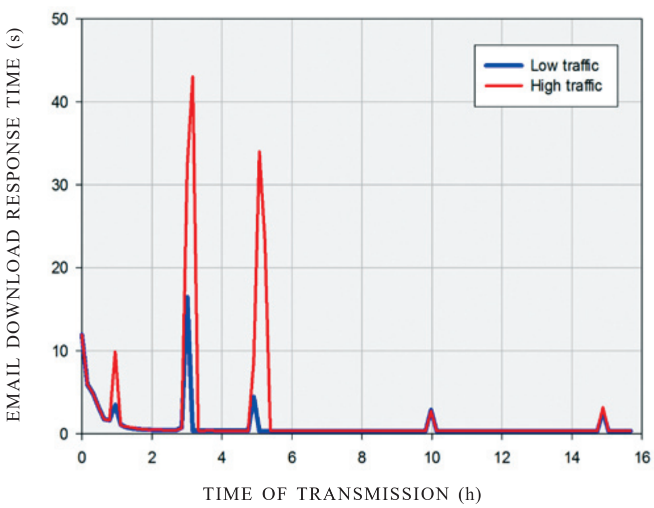


**Figure 5. E-mail download response time.**

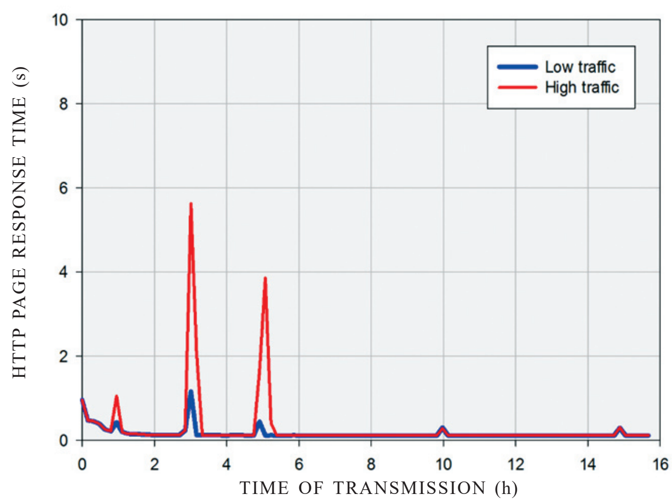


**Figure 6. HTTP page download response time.**

Figure 6 shows the http page download response time during data transfer in the simulation. In general, the page download response time is limited to less than one second. At critical moments of handing over the operating orders to high traffic, the page download response time is up to 5 s.

Figure 7 shows the results of packet loss rate analysis for e-mail and the WEB service in the simulation. There is small number of packet loss, or 55.5 packets per second. Also, the number of lost packets is constant throughout the duration of the simulation. It is independent of the size of the transmitted information and the traffic capacity.

Traffic loss refers mainly to the loss of the routing protocol packet (open shortest path first protocol is used in simulation (OSPF)). It follows that the losses of user applications are minimal, and since transmission control protocol (TCP)

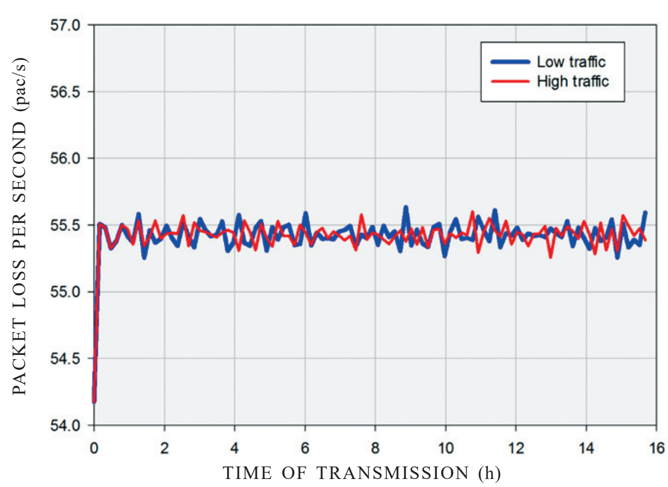


**Figure 7. Packet loss per second.**

based applications are concerned, the losses did not affect the performance of e-mail and WEB (http) services.

## 6. CONCLUSIONS

In order to successfully command and control the forces in military operations, it is necessary to connect all the engaged forces in the operation zone to the communication and information system. This enables the merger, transmission, delivery and display of relevant information and creates a unique information dimension of the operating environment. The model of the communication and information system must provide the necessary capacity of links and the transmission of appropriate services.

The aim of the research was to use the method of operational research and simulation to confirm whether a modelled communication information system with defined elements (nodes), the capacity of links (according to the specification of telecommunication devices) and defined traffic can respond to the requirements of command forces in the military operation in terms of telecommunication service. The capacity of the link for voice traffic is reserved by using Erlang-B formula for the collected intensity of telephone traffic between the command posts. The results of the simulation on the analysed service target parameters: link load, e-mail download response time, http page download response time and packet loss per unit time show that a modelled communication and information system provides an efficient flow of information and the transfer of voice and IP data for the needs of command and control (C2) in military operations.

It is characteristic that all links are not equally loaded in the network. The utilisation of the most downloaded link will reach up to 100 per cent of the capacity of the link during the preparation phase of the operation and transmission of 'high traffic' between different levels of command (submission of uncompressed operational orders by e-mail service). This is especially pronounced in the handover of operational orders from the battalion command posts, since the number of these nodes is greatest in the model of the communication information system. When transferring the remaining traffic, the capacity of the most downloaded link completely ensures uninterrupted transmission of all information. The results of the link load indicate that using the quality of the service can optimize the network in order to achieve the most efficient data transmission.

It can also be concluded that the average e-mail download response time, as well as the http page download response time, is small, except when the 'high traffic' transmission takes place. The number of packet loss is small and constant throughout the duration of the simulation. It is independent of the size of the transmitted information and the traffic capacity.

The simulation software proved to be a good software solution for simulating the telecommunications network in all its aspects: applications, user profiles, network elements, etc. It also provides a simpler, more efficient and more economical view of the capabilities of the system and the optimisation of the telecommunication network in operational use.

## REFERENCES


1. Loo, J.; Mauri, L.J. & Ortiz, H.J. Mobile ad hoc networks (Current status and future trends). CRC Press. New York. USA. 2011, pp. 3-17. ISBN-13:978-1-4398-5651-2.
2. Velasco L.; Castro A.; King D.; Gerstel O.; Casellas R. & Lopez V. In-operation network planning. *IEEE Communications Magazine*, 2014, **52**(1), 52-60. doi: 10.1109/MCOM.2014.6710064.
3. Wickboldt, J. A.; Paim, De Jesus. W. Isolani, H.P.; Both, C.B.; Rochol, J. & Granville, L.Z. Software-defined networking: Management requirements and challenges. *IEEE Commun. Magazine*, 2015, **53**(1), 278-285. doi: 10.1109/MCOM.2015.7010546.
4. Stanton, A.N. & Baber, C. Modelling command and control. CRC Press. New York. USA. 2017. eBook ISBN 9781317094876.
5. Patrick, H. Structured, graphical analysis of C2 teams and their technologies. *Int. C2 J.,* 2011, **5**(3), 1-38.
6. Viswanathan, S. Tactical military communication network of the future. *Def. Sci. J.*, 2013, **43**(1), 71-78. doi: 10.14429/dsj.43.4218.
7. Devetak, S. Model of telecommunication-information support forces of Army in the defense operation. University of Defence, Belgrade, Serbia, 2016. (PhD Dissertation)
8. Onvural, O.R. Asynchronous transfer mode networks: Performance. Artech House, Inc. Norwood, MA. USA. 1995. ISBN: 0890068046.
9. Elsayed, R.M.; Mostafa, M.M.; El-Moghazy, A. & Haggag, H.M. Enhancement of voice transmission over the intranet. *Sci. J. ECS*, 2012, **36**(1), 38-52.
10. Susa, V.; Bajcetic, J. & Pavlovic, B. MX One TSW Astra and MTIS Thales workstation interconnection possibility in mobile scenario usage. *In:* 20th Telecommunication Forum (TELFOR), Belgrade, Serbia, 2012, IEEE Xplore, 2013. doi: 10.1109/TELFOR.2012.6419194.
11. Devetak, S.; Bajčetić, J., & Perišić, Z. Modular tactical switching system. *In* 3rd Scientific Conference of Defense Technologies (OTEH 2009), Military Technical Institute, Belgrade, Serbia, 2009, pp. 55-62.
12. Talijan, M.; Jelić, M. & Slavković, R. Project management and modeling military operations. *In* Project Management and Operations of the Army of Serbia: Thematic collection of scientific papers, Military Academy, Belgrade, Serbia, 2012, pp. 61-81.
13. Doctrine operations of the Army of Serbia. Serbian Army General Staff. Media Center Defense. Belgrade. Serbia. 2012.
14. Joint operational planning, JP 5-0. US MOD. Joint Headquaters. Washington DC. USA. 2011.
15. Devetak, S. & Karović, S. Telecommunication-information support in military operations. *Vojno delo number 6/2016,* 2016, pp. 123-135, doi: 10.5937/vojnodelo1606123D.
16. Pavlović, B. & Karović, S. The application of Bass Diffusion Model in forecasting telecommunication services users in military assistance to civilian authorities. *Def. Sci. J.,* 2015, **65**(2), 144-149.

doi: 10.14429/dsj.65.6026.

17. Devetak, S.; Suša, V.; Dragović, R. & Trikoš, M. Application of the simulation program RIVERBED MODELER 17.5 in analyzing the performance data of functional telecommunication system. *In* YU INFO 2016: Collection of scientific papers, Association for Information Systems and Computer Networks, Belgrade, Serbia, 2016, pp. 431-434.
18. Ristić, V.; Pavlović, B. & Devetak, S. An implementation of MANET networks on command post during military operations. *In* 7th International Scientific Conference of Defansive Technologies (OTEH 2016), Military Technical Institute, Belgrade, Serbia, 2016, pp. 481-485.
19. Zheng, L. & Hongji, Y. Unlocking the power of OPNET Modeler. Cambridge University Press. New York. USA. 2012.
20. Bolch, G.; Greiner, S.; de Meer, H. & Trivedi, K. Queueing Networks and Markov: Chains Modeling and Performance Evaluation with Computer Science Applications. John Wiley & Sons. Edn 2nd. New Jersey. 2006.
21. Goyal, A.; Lavenberg, S. & Trivedi, K. Probabilistic modeling of computer system availability. *Annals Operations Res.*, 1987, **8**(1), 285–306.

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