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The use of modern ICT solutions in freight transport telematics

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ABSTRACT

Along with the evolution of our civilization is increasing demand for faster and cheaper transport, both from the point of view of trade and normal movement of people. In the case of trade most often we are dealing with the transport of the freight traffic, where the goods are not carrying by one type of transport. In this type of carriage time between transhipments on exchange stations plays an important role. The correct use of modern ICT (information and communication technologies), both wired and wireless for control loads, vehicles and carriers can significantly reduce total transport time and costs. Additional monitoring of the status of land units' drivers allows increasing the security and the reliability to wirelessly check the content and status of the load increases the reliability of the correct transport. Therefore, this article presents the use of modern wireless technologies (LTE-A, 802.11ac) and backbones of public networks (1…100 GbE) on the exchange stations.

KEYWORDS: transport telematics, modern technologies, reliability and security

1. Introduction

Network environment includes commonly operated information and communication technologies (ICT) which are part of a transport telematics. ICT, has no universal definition but authors propose, is an integration of telecommunications (smart phones, tablets) and information networks (computers, routers, servers, printers) using different subsystems of cabling and wireless signal distribution. It constitutes a framework for a platform generally used for provision of various multimedia services. Increase in computing power of processors implemented in network stations stimulates the increase in a set of different points of access to generally accessible wide area network resources.

At the same time, the network environment ICT opens for evolutionary changes in the process of telecommunication services performance. Today, the representative of the modern society uses in its everyday life more and more technical "innovations" such as technology advanced phones, pockets, smartphones and tablets. As part of the network operator service package, they offer numerous services. Except for the possibility of access to web sides, e-mail and transfer of files, the telephone services ICT covering image and sound transfer gain increasingly more interest. Thus, there is an economically justified need to asses (evaluate) the functionality of the environment that provides media services that are the result of numerous network properties. Progress introduces a society addicted to highly distributed systems ICT that operate in the unrestricted network environment. Important features characterize modern technical facilities constructed systemic, are among others [1]: the complexity of the architecture and the hardware and software as a participant in a system defined relationship and variety of functions and tasks and relatively large expenditures (financial, time, etc.) adsorbed at the design stage. These characteristics forcing a specific approach to the design process, methods of research and the organization of the operating system objects. Particularly noteworthy here the issue of measurement and criteria for suitability as object and the system and the relativity of the concept of "state of fitness." The provision of safety, reliability and quality of network services in relation to the network and application layer with control mechanisms. Each network, has limited parameters: average delay, bandwidth and capacity network [Fig. 1.].

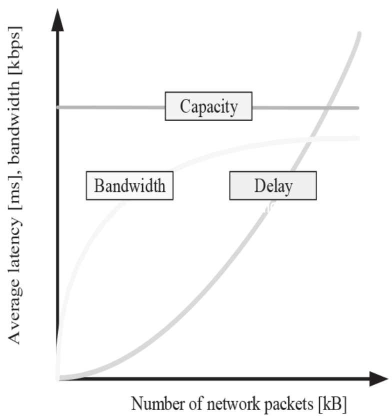

Fig. 1. Network parameters [own study]

The number of events that may cause network performance changes such as excessive demand for services, overloads, edge and backbone elements, and damage and destructor behaviour [Fig. 2].

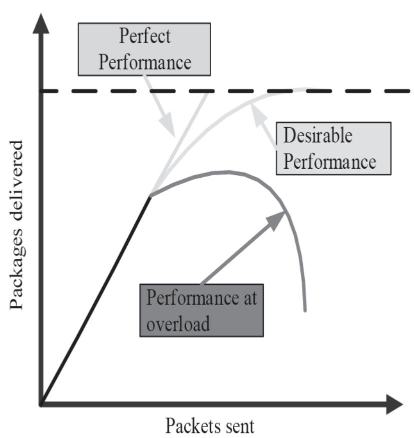

Fig. 2. Network Performance [own study]

Therefore, the authors decided to analyse the valuable features of several future information and communication technologies important for transport telematics. Also, proposed modifying the queuing methods for handling data stream. Expert method (IT staff: administrator, service technician, etc.) was used to evaluate the effects of proposed solutions. The research was aimed at measuring system efficiency as a comprehensive assessment based on three areas: safety [2], reliability [3,4] and quality [5] of network services. This article is a continuation of work from these research areas.

2. Network with future mechanism

Functionality of services may be presented from different perspectives. One of them is focused on practical use and depends on such components as availability, accessibility and continuity. Additionally, the functionality of services may be affected by several other properties such as intuitive use, quick operation etc. Considering the conclusions drawn from both the experience related to operation of real network environments and the analysis of published scientific materials (presented in the form of different elaborations made available on the web sides) and information contained in standardization documents (standards, recommendations, directives etc.) [2]. It is very important to ensure appropriate quality at the network level (reliability, security and quality of service), as it allows prediction of the size of available bandwidth and level of losses in the network layer. However, it does not reflect user requirements relating to various quality level of service performance [6-9].

Thus, in the case of audio and video, it is important to take into consideration the quality level in the application layer is defined by recommendation ITU-T G.1010 [7] which determines service availability, probability of locking, connection and disconnection time. These features define the capabilities of real-time ICT services. Adequate to the evaluation of network techniques and technologies, the demand of users for effective networks grows over time. So ever service provider and network owner introduces new network solutions in modern society ICT. Let us assume, that Telematics Enterprise Architecture (TEA) will use modern solutions in the form of [Fig. 3.]:

- wireless technologies (LTE-A, IEEE 802.11ac/ad standards) with fixed microwave communication systems based on quadrature amplitude modulation (QAM) and orthogonal frequency-division multiplexing (OFDM) [12],
- backbones of public networks (1…100 GbE, IEEE 802.3bj standards) with different optical and electrical interfaces [13],
- advanced signalling techniques used to mitigate multipath in licensed or unlicensed spectrum,
- Point-to-Point (P2P) or multipoint (P2MP) connections type with Bring Your Own Device technology (BYOD) and Cloud computing (CC),
- Ethernet Operations, Administration and Maintenance (EOAM) are the protocols for troubleshooting local (LANs) and wide (WANs) area network [14].

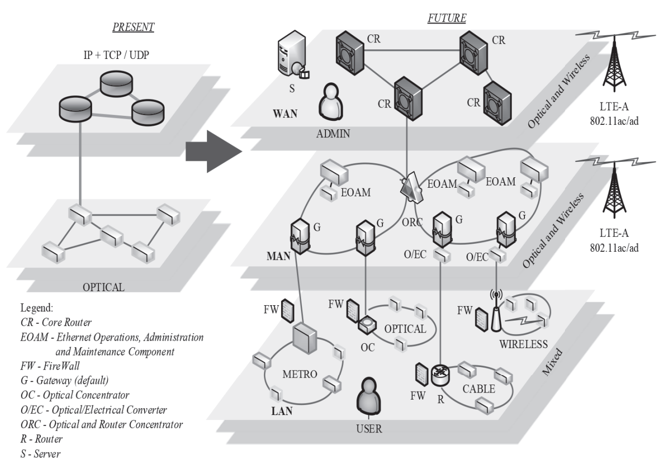

Fig. 3. Telematics Enterprise Architecture [own study]

The next changes are:

1. A modified traditional data queuing method: data stream is routed to the decision tree. Classification of data has been developed in relation to the importance of the service. The

traffic prioritization algorithm has been changed (the rules for traffic prioritization have been changed). Thus, delays have been minimized with increasing priority [Fig. 4.].

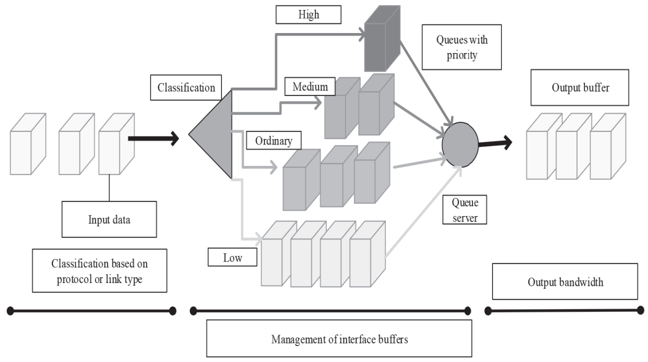

Fig. 4. Data queuing method [own study]

2. Application of dynamic protocol selection corresponding to the number of data (AMR G.723 protocol) and video (MPEG4, H.264, RTP protocol) with control (H.245, SIP, RTP, H.223 protocol). An example of a telephone service is shown on figures [Fig. 5].

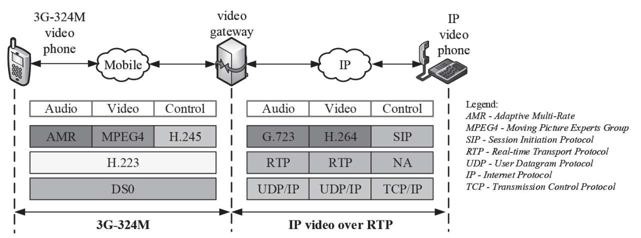

Fig. 5. Video protocol [own study]

3. Modifying Ethernet Operations, Administration and Maintenance (EOAM) software in the Default Gateway. Gateways are negotiating network parameters with the use of traffic policies. Support is provided by the ORC. During negotiation, parameters such as routing metric, throughput, delay, and the number of concurrent services are set [Fig. 6].

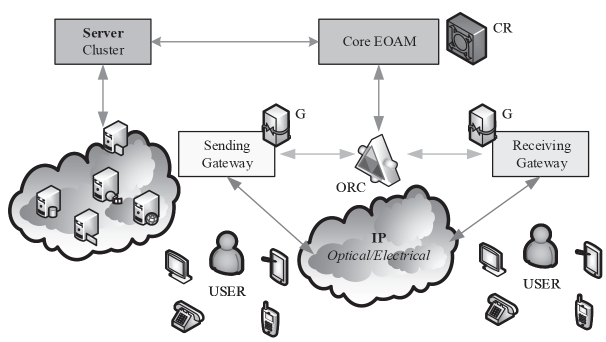

Fig. 6. EOAM software in the Default Gateway [own study]

3. Measures and criteria for the state of Telematics Enterprise Architecture

An important feature of the Telematics Enterprise Architecture with Information and Communication Technologies (TEA ICT) is that its properties are not a simple sum of the properties of its elements, but defined by the properties of the elements and coupling between components during operation of the algorithm, considering external circumstances (environmental influences). These coupling and interactions affect the overall properties of the system that determine its operating status. A model of such an object and its relationships with the environment are, in terms of electrically-effects module, presented in [11]. Users of such a system as TEA ICT generally assess its condition in the context of:

- integrity and readiness of structural elements of the TEA ICT;
- the reliability and robustness of system components (devices and software);
- the impact of natural random events - e.g. the interference of communication radio waves, floods, earthquakes, wind, lightning and power failure;
- deliberate or involuntary negative impact of the human factor on the TEA ICT.

In this aspect, the TEA ICT is a fully operational or operational only to a certain extent to carry out the required functions. Based on the conclusions and suggestions contained in [15], you can take the following measurable indicators characterizing the state of a system including a telecommunication network:

1. *Potentiality required* $E_{TEA\,ICT\,p\text{-}wym}(t)$ is determined by the number of services that start and/or continuation of accomplishment is require by users TEA ICT - at a specific time or in a certain elementary unit of time.
2. *Potentiality disposed* $E_{TEA\ ICT\ p\text{-}dys}(t)$ is determined by the number of services possible to start and/or continuation of accomplishment TEA ICT - at a specific time or in a certain elementary unit of time. In general, the potentiality disposed is a functional of the following arguments:

$$E_{TEA\,ICT_{p-dys}}(t)=f_p\left(W_i(t),P_s(t),O_s(t),O_n(t),S_{zs}(t)\right) \qquad \textbf{(1)}$$

where:
W_i – properties internal data communications network;
P_s – boost control;
O_s – favourable impact of the environment;
O_n – the unfavourable impact of the environment;
S_{zs} – feedback on the impact of network operator.

Using the literature [15] we get:

3. The criterion for the classification of up states and fault states:

The TEA ICT is capable of suitability only in those moments, in which the potentiality disposed is' smaller than the required potentiality.

This can be written as follows [11,15]:

$$E_{TEA\,ICT}(t)=E^{Z}(t) \quad when \quad E_{p-dys}(t)\geq E_{p-wym}(t) \qquad \textbf{(2)}$$

and

$$E_{TEA\ ICT}(t) \equiv E^N(t) \quad when \quad E_{p-dys}(t) < E_{p-wym}(t) \qquad (3)$$

where:

t – time, the current moment;
$E_{TEA\ ICT}$ – state of TEA ICT;
$E^Z(t)$ – up state;
$E^N(t)$ – fault state.

4. Mathematical formula:

$$E_{TEA\ ICT_{p-dys}} = f\left(P_{ir}(t,e_i), P_{in}(t,n,\pi,e_i), P_{Ps}(t)\right) \qquad (4)$$

where:

$P_{PS}(t)$ - the probability of the up state of the functional of the operator; in other words: the probability of generating the operator correct beats of control at time t;

$P_{ir}(t,e_i)$ - the probability of up state TEA ICT components e_i occurring at time t in traffic (with parameters a-intensity single stream and l-number service stations):

- for node (P_{lr}):

$$P_{lr}(w_l) \cong K_{gl}(1-P_{bl}) \qquad (5)$$

$$P_{lrn}(t,w_l) = \frac{\mu_l}{\lambda_l+\mu_l} + \frac{\lambda_l}{\lambda_l+\mu_l} e^{-(\lambda_l+\mu_l)t} \left[1 - \frac{a_l^{\,l}}{l!}\left(\sum_{i=0}^{l} \frac{a_l^{\,i}}{l!}\right)^{-1}\right] \qquad (6)$$

- for transmission line (P_{mr}):

$$P_{mr}(t_m) \cong K_{gm}(1-P_{bm})(1-P_{sm}) \qquad (7)$$

$$P_{mrn}(t,t_m) = \frac{\mu_m}{\lambda_m+\mu_m} + \frac{\lambda_m}{\lambda_m+\mu_m} e^{-(\lambda_m+\mu_m)t} \left[1 - \frac{a_m^{\,m}}{m!}\left(\sum_{i=0}^{m} \frac{a_m^{\,i}}{i!}\right)^{-1} - P_{sm}\right] \qquad (8)$$

where:

P_{bl} – the probability of a blockage in the l-node;
P_{bm} – the probability of a blockage in the m-th link;
P_{sm} – the probability of loss in the m-th link of the error signal[1];
K_g – non-stationary readiness ratio:

$$K_{gi}(t,e_i) = \frac{\mu_i}{\lambda_i+\mu_i} + \frac{\lambda_i}{\lambda_i+\mu_i} e^{-(\lambda_i+\mu_i)t} \qquad (9)$$

where:

λ_i – the failure intensity of the i-th network element;
μ_i – the repair intensity of the i-th network element;

$P_{in}(t,n,\pi,e_i)$ - the probability the state of fitness of TEA ICT components occurring at the time t the interaction of n-th exposure (n-th failure process initiation factor) of the π-type set of exposures; in other words: the probability "survival" of network components occurring at exposures:

$$P_{l/mnbw}(n,\pi,e_i) = 1 - P_{wn}P_{de}\left\{1 - exp\left[-\delta\left(\frac{r_i}{P_{ue}}\right)^2\right]\right\} \qquad (10)$$

The suitability of TEA ICT in terms of utility one can say when you have a value of potentiality required (expressed e.g. the number of requests for services in a elementary unit of time), and permissible - from the point of view of the user - the value of delay in the execution of the service requested.

4. Methods for maintaining and/or restoring of up state

The most important information for both the customer and the service provider network is the information about the up state of TEA ICT to provide network services. Supervision of the state of TEA ICT carried out by the tester (analyzer), allow precise monitoring selected elements (PC, router, switch, server. i.e.). It follows need for methods and tools for supervision TEA ICT [15] for so early detection of a state of emergency to allow for effective implementation of mechanisms to maintain and/or restore the up state of system:

- shielding subsystem (SSS) - i.e. set of activities and measures to prevent activation of the triggers failure processes leading to fault conditions (shielding subsystem deactivates triggers failure processes);
- intervention subsystem (ISS) - i.e. set of measures and activation measures intervention factors which inhibiting failure processes (subsystem intervention stops or at least inhibits the failure process);
- emergency subsystem (ESS) - i.e. a combination of activities and means of activating emergency factors limiting the impact of extensive damage (subsystem emergency weakens and reduces the consequences of failure).

To perform the functions listed above can be accept the following methods to increase the potentiality of dispose system (Fig. 7), reflecting the selected properties of these subsystems:

- method Single Passive Distribution Booking (SPDB); it is the introduction of one element backup for the selected component of core TEA ICT;
- method Double Passive Distribution Booking (DPDB); it is the introduction of two element backups for the selected component of core TEA ICT;
- method Increase Readiness Ratio (IRR); it is to introduce a component of core TEA ICT characterized by lower intensity of damage and shorter restoring up state.

The implemented tests include accurate capture - in millisecond intervals - all events affecting such basic network parameters like bandwidth, transmission delay, the number of transmitted frames, and the number of collisions and the availability of network hosts. After extracting, analyzing and classifying problems tester-analyzer shows (in the form of a graphic or text) collected and systematized information based on which may explain the cause of unfitness TEA ICT and recommend a set of therapeutic activities. In most

[1] The value of this probability is determined based on technical parameters of the signaling network (system).

currently available products on the market, this process is done automatically in real time.

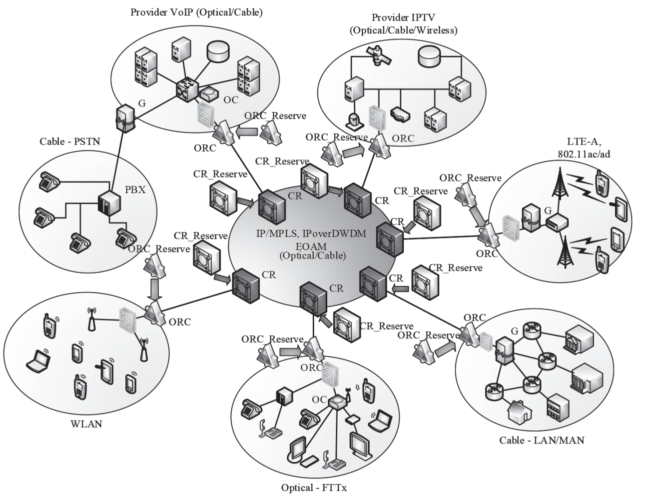

Fig. 7. TEA ICT containing elements of the method SPDB and DPDB [own study]

5. Simulation research of TEA ICT

To verify the hypothesis that potentially measures and criteria (2 and 3) assess the state allowing relatively easy supervision of changes of the up state of TEA ICT and inferences regarding the level of suitability and impact of actions taken therapeutic tests were carried out simulation of actual data communications network. The simulation model object a diagnostic test has been prepared in such a way that first these elements play of the implementation of network services that are necessary to determine.

The general architecture of TEA ICT is shown below. The user accesses the services in the cloud computing locally: a wired connection by using standard 1…100 GbE and radio by LTE-A and 802.11ac/ad standard; remotely via the Internet, including the mobile Internet. The connections between the scattered clouds are tunneled and encrypted IPsec. Cloud computing is supported by Apache CloudStack open source software that dynamically adapts to the changing conditions of use of cloud computing resources, providing the best conditions for running the service. CloudStack also allows combining multiple clouds with each other. The research methodology includes:

1. Develop a mathematical model of the network topology data communications.
2. Gather a set of information about both the technical parameters of all network elements as well as on indicators of reliability (failure rate) and the susceptibility of the repair (the intensity of repair) and information about the operating conditions of all network components.
3. Selection of the simulation computer program for the calculation of the potential-potentiality indicators describing the up state of TEA ICT.
4. The calculation of selected indicators of reliability and maintainability of components TEA ICT.
5. Adoption of the criterion of unfitness TEA ICT.
6. The choice of method of reserving structural segments.
7. Conducting research test-bed and develop the results.

These elements of the research program have enabled it to draw inferences about the state of the suitability of the network using the characteristics of potential-potentiality by determining the values of the following values:

- likelihood that services (e-mail, browsing the web, download files ftp);
- potentiality of dispose and required for network services;
- the potential of dispose and required for network services;
- allowable and acceptable value of time delay carry out service on the network;
- temporary suitability of the network;
- load selected network components.

The nominal volume of network traffic in a test-bed TEA ICT (Fig. 7.) was established based on measurements on the real network. The basis for these measurements was the recommendations and standards of the ITU -T (*International Telecommunication Union - Telecommunication*) and the recommendations of the IETF (*Internet Engineering Task Force*). The study also covered the local cases of fault of the structural network consisting of fault of a specific node and links (transport resource). This is an important aspect of the study because it was obtained in this way, information about the state of the network in case of unplanned and at the same time reducing the potentiality of the network. The figure (Fig. 8.) indicated the most sensitive points of the whole structure ("the network bottleneck"). These data were obtained because of work-introduction of and presented them for the first time in [16]. And in this article, will be used for further consideration aim to continue the analysis of the suitability of complex technical objects, i.e. TEA ICT. Tests were also carried out in the real environment test. This made it possible to check the efficiency and environmental safety test bed. The effectiveness of TEA ICT tested using a traffic generator LanForge ICE and Spirent Test Center C1, thereby simulating an increasing number of users in a moment of time, and the program IxChariot used to test applications under real conditions. Safety data was analyzed using Wireshark network traffic analyzer.

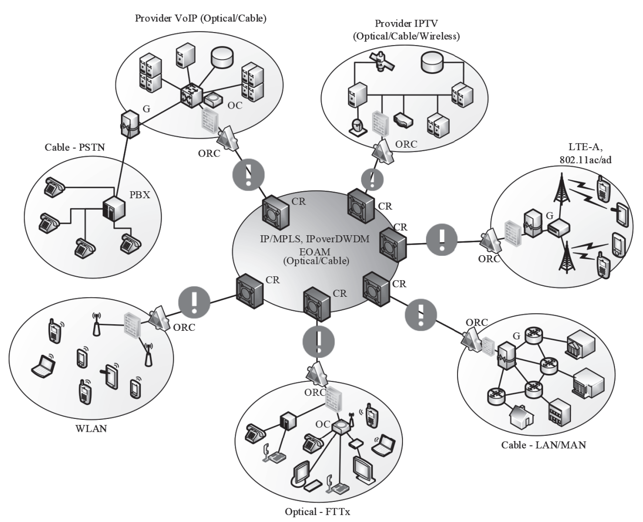

Fig. 8. Example of test services in the test-bed [own study]

6. Analysis of the results simulation research

According to the assumptions, reported by users demand for services are described in the corresponding mathematical distributions (for e-mail - normal distribution N(4E + 5; 3,5E + 5), web browsing (WWW) - uniform distribution Unif(4E + 5; 3 , 5E + 5), downloads FTP - uniform distribution Unif(1E + 5; 3,5E + 6) database - the normal distribution N(5E + 3; 7E + 5)).

Potentiality required for a service (indicating the forecasted demand for this type of service) was expressed in the number of requisitions, which is a random variable with a predefined schedule. The simulation results showed that the use of the proposed method (SPDB, DPDB, IRR) increasing the potentiality of disposed increases the number realizable service. The result is a reduction in the number of lost requests for services in relation to the nominal capacity of the network. Selected simulation results show graphs (Fig. 9-11). Based on the analysis of the received waveform can be concluded how often and to what extent there is a lack of immediate implementation services. It should be noted in this aspect that the refusal to join the immediate implementation of the services and/or its implementation in the wrong time to the user's needs is unfit TEA ICT (periodic or permanent).

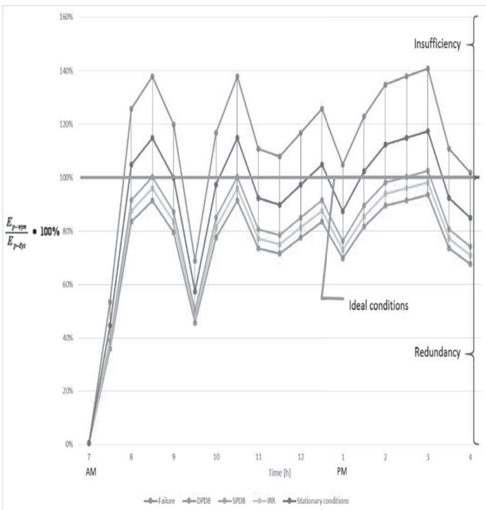

Fig. 9. The trajectories of potentiality of dispose for service Web browsing (WWW) [own study]

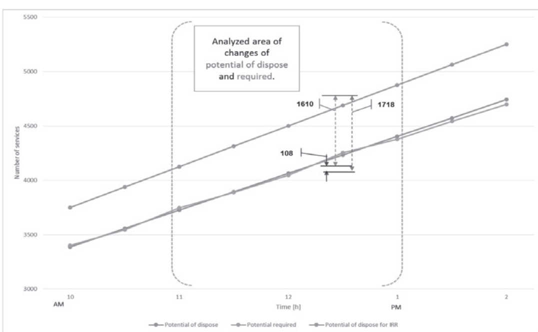

Fig. 10. Graphic interpretation of criterion interval (from 10.00 am to 2.00 pm) the up state of the network for e-mail services [own study]

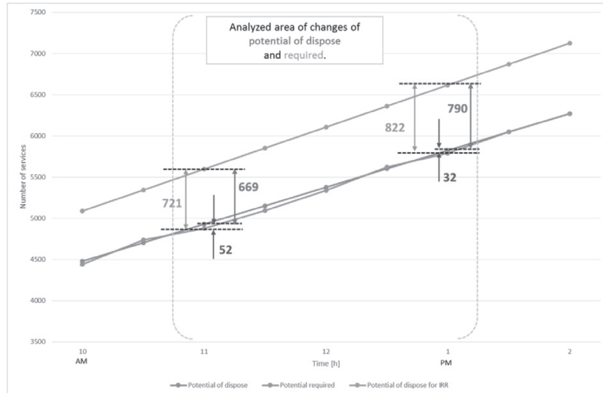

Fig. 11. The potential of dispose for the service to download files FTP between 11.00 am and 1.00 pm [own study]

The main conclusion from the presented graphs is that the resources of current TEA ICT oscillate at the border realizability of services desired by users of times. The use of the simplest methods SPDB allows for growth potentiality of dispose network, respectively: 10% for e-mail; 15% for Web browsing (WWW); 13% for downloading files (FTP). In turn, the most expensive solution, which method DPDB, ensures the highest potentialities of dispose - which is synonymous with the highest throughput TEA ICT Table 1).

Table 1. The increase in the value of potentiality of dispose network [own study]

No.	Service	Probability		
		E-mail	WWW	FTP
		[%]	[%]	[%]
1.	IRR	11	20	16
2.	SPDB	10	15	13
3.	DPDB	15	26	19
4.	Failure	-36	-17	-19

5. Conclusion

Knowledge of the shape and position of the trajectory of potentiality, designated for the daily life of the network, can significantly affect the process management operating TEA ICT. Total impact is possible mainly thanks to the results of the synthesis of these trajectories in the process of formulating prognostic applications and operating decisions. These applications can be divided into two sets of correlated. The first set may include requests shall be addressed to the supplier of services (on e.g. the management of network resources, the required properties of the operator, the desired effect under certain conditions, investments and financial resources) and the second set of conclusions identifying user satisfaction-customer (due to e.g. the number of available network services required and acceptable until the completion of the requested service, billing for services rendered).

Summarizing the results of the simulation can be drawn the following conclusions:

1. Network load during the day assumes variable values depend, among others, the number of users, their working hours and

the possible use of the potentialities of dispose network. This leads to periodic fault network in the mind of the number of users who, because of congestion or environmental exposures occurring cannot fulfill their needs in a timely manner.

2. The delay in the delivery of services subject to similar fluctuations as network load, and is different for different services (for e-mail and FTP has a level acceptable during the whole day, and for services web browsing are periods of time in which to implement this service is not possible).
3. Preventing unfavorable relation between potentiality and the desired Disposing is possible at least two ways. First, it is possible to establish priorities in access to services ordered by a specific user. This way you can prevent - at least partially - denials of immediate commencement of, or untimely delivery of services of considerable importance from the point of view of decision-maker system. Second, can enter the supervises-therapeutic system, upon detection of an unfavorable relationship between potentiality of dispose and the potentiality required result in a temporary increase of potentiality of dispose. This can be done by periodically attaching reserve com-shapes network (method SPDB or DPDB).

The proposed methods of increasing the potentiality of dispose, thus, the probability realization of the demand for services, have a positive impact on the satisfaction of users. These methods allow for more efficient use of network resources currently operated and handle more users in less time. In your opinion, it is equivalent to increasing the reliability of TEA ICT.

Bibliography

[1] BAJDA A., et al: Diagnostics the quality of data transfer in the management of crisis situation, Electrical Review 87(9A), pp. 72-78, 2011

[2] LASKOWSKI D., et al: Confidential transportation of data on the technical state of facilities, Advances in Intelligent Systems and Computing, Springer International Publishing AG, Switzerland, Volume 286, 2014, pp 313-324

[3] LUBKOWSKI, P., et al: Provision of the reliable video surveillance services in heterogeneous networks, Safety and Reliability: Methodology and Applications - Proceedings of the European Safety and Reliability Conference, ESREL 2014, CRT Press, A Balkema BOOK, 2015, pp. 883-888

[4] ŁUBKOWSKI P., LASKOWSKI D.: Selected Issues of Reliable Identification of Object in Transport Systems Using Video Monitoring Services, in Mikulski J. (ed) Telematics - Support for Transport, Springer Verlag, Berlin Heidelberg, CCIS 471 (2014), pp 59-68,

[5] LUBKOWSKI P., LASKOWSKI D., MASLANKA K.: On supporting a reliable performance of monitoring services with a guaranteed quality level in a heterogeneous environment, Theory and Engineering of Complex Systems and Dependability, Springer International Publishing AG, Switzerland, Volume 365, 2015, pp. 275-284

[6] SIERGIEJCZYK, M., KRZYKOWSKA, K., ROSIŃSKI, A.: Reliability assessment of cooperation and replacement of surveillance systems in air traffic, Advances in Intelligent Systems and Computing, Springer International Publishing AG, Switzerland, vol. 286, Springer, 2014.

[7] SIERGIEJCZYK, M., ROSIŃSKI, A., KRZYKOWSKA K.: Reliability assessment of supporting satellite system EGNOS, Advances in Intelligent Systems and Computing, Springer International Publishing AG, Switzerland, vol. 224, 2013.

[8] NOWAKOWSKI, T.: Problems of reliability modelling of multiple-phased systems, Maintenance and reliability, issue: 4, 2011, pp. 79-84

[9] WERBINSKA-WOJCIECHOWSKA S., ZAJAC P.: Use of delay-time concept in modelling process of technical and logistics systems maintenance performance. Case study, Maintenance and reliability, vol. 17, issue: 2, 2015, pp. 174-185

[10] LUBKOWSKI, P., et al: Provision of the reliable video surveillance services in heterogeneous networks, Safety and Reliability: Methodology and Applications - Proceedings of the European Safety and Reliability Conference, ESREL 2014, CRT Press, A Balkema BOOK, 2015, pp. 883-888

[11] LUBKOWSKI P., LASKOWSKI D.: Test of the multimedia services implementation in information and communication networks, Advances in Intelligent Systems and Computing, Springer International Publishing AG, Switzerland, Volume 286, 2014, pp 325-332,

[12] OFFICIAL IEEE 802.11 WORKING GROUP PROJECT TIMELINES. Available: http://grouper.ieee.org/groups/802/11/Reports/802.11_Timelines.htm [date of access: 03.02.2017].

[13] IEEE P802.3bj 100 Gb/s Backplane and Copper Cable. Available: http://www.ieee802.org/3/bm/ [date of access: 03.02.2017]

[14] Y.1731: OAM functions and mechanisms for Ethernet based networks. Available: http://www.itu.int/rec/T-REC-Y.1731/en [date of access: 03.02.2017]

[15] DĄBROWSKI T.M.: Diagnosis of anthropotechnical systems in a potential-effect perspective. Habilitation dissertation, MUT, Warsaw 2001.