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POPRAWA NIEZAWODNOŚCI SIECI SDN

Streszczenie: W niniejszy artykule, analizuje się parametry niezawodności sieci SND (czyli software-oriented network, czyli sieci dostarczających oprogramowanie). Dokonano porównania scentralizowanego oraz zdecentralizowanego typu sterowania, przy czym wykryto iż sieci SDN wymagają optymalizacji oraz zwiększenia ich niezawodności zgodnie ze współczesnymi standardami 3GPP. Zaproponowano model obliczania niezawodności dla scentralizowanych oraz zdecentralizowanych sieci. Model ten może służyć do identyfikacji słabych stron lub lokalizacji/miejsc o mniejszym bezpieczeństwie w sieciach komunikacji komórkowej (mobilnej). Ponadto opracowano metodę estymacji oraz poprawy charakterystyk niezawodności w systemach informatycznych oraz do zarządzania (dla sieci komunikacji mobilnej). Metodę oparto na hierarchicznym modelu oceny (assessment) niezawodności w odniesieniu do hardware'u oraz software'u. Wzięto pod uwagę zależność urządzeń od programów czy aplikacji. Ulepszony system umożliwia optymalizację procesu budowy sieci, modernizację oraz zwiększenie niezawodności usług dla klientów sieci mobilnych (komórkowych). Proponowane podejście znacząco usprawnia proces planowania sieci oraz modelowania infrastruktury sieci. Zwiększa to efektywność uzytkowania oraz redukuje koszty wyposażenia. Zaproponowano także zastosowanie modelu matematycznego do rozwoju software'u (oprogramowanie) oraz użycia huperwizorów (super nadzorców) w sieciach scentralizowanych. To także zwiększa efektywność użytkowania infrastruktury, redukuje czas odpowiedzi w systemach komunikacji mobilnej. Przyprowadzono ponadto modelowanie technologii zarządzania dla trzech typy współczesnych sieci mobilnych – mianowicie: IP, OpenFlov oraz Overlay. Uzyskano ocenę, że dla tych sieci bardziej korzystnym jest użycie sieci typu SDN, które mają zaawansowane modele zarządzania ale mniej niezawodną strukturę. Zatem konieczna jest optymalizacja, aby wygodniej je użytkować.

Słowa kluczowe: ISP (Dostarczyciel Usług Internetowych), OTS (open transport switch, przełącznik), SDN(software-defined networking), SDR(software-defined radio)

SDN NETWORK RELIABILITY IMPROVING

Abstract: in this paper, reliability parameters of a software-oriented network are analyzed, a comparison of centralized and decentralized types of control is made and it is revealed that the software-defined networks require optimization and increase of reliability with modern 3GPP standards. A model for calculating reliability of a centralized and decentralized network is proposed to identify weaknesses or less secured locations in mobile communication system.

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Method of estimating and improving reliability characteristics of information and management system of mobile communication network, based on a hierarchical model of reliability assessment of the hardware and software, had been developed. Dependence of equipment on programs or applications is taken into account. Reviewed system allows to optimize network deployment process, modernize and increase service reliability for mobile networks users. This greatly improves process of planning and modeling network infrastructure, which increases efficiency of usage and reduces cost of equipment. It is also proposed to use this mathematical model for software development and to deploy it on a hypervisors as an application for centralized network, which will help to increase infrastructure usage efficiency, reduce response time to the mobile communication systems performance restoration. Three types of modern mobile network infrastructure management technologies are modeled, namely IP, OpenFlov and Overlay. It is determined that for networks of future it is more expedient to use software-defined networks that have more advanced management model but less reliable structure, so its optimization is a necessary factor in usage of these types of networks.

Keywords: ISP (Internet Service Provider), OTS (open transport switch), SDN(software-defined networking), SDR(software-defined radio)

1. Introduction

The main task of reliability theory is to improve system performance by enhancing the reliability of the object, by calculating the optimum number of system maintenance to improve its performance

The object of the study is the 3 GPP mobile network, which is by far the most up-to-date heterogeneous network or smoll-sell network to complement the infrastructure of today's mobile network. All these standards greatly extend the spectrum of vulnerability of networks as physical infrastructure.

The purpose of the work is to increase the reliability of the computer network.

To achieve this goal it is necessary to solve the following main tasks:

Develop a method for evaluating the robust performance of computer networks.

Develop a method for enhancing the reliability of computer networks.

Therefore, for such network structures it is necessary to have some statistics of reliability, vulnerability of the system, not only in cyberspace, but also physical infrastructure.

Because, with the help of software, physical equipment fails. Therefore, it is necessary to understand where the vulnerabilities of the system are and keep this in mind. And to help to investigate this information through mathematical justification of the process, the indicators of which will be analyzed and taken into account.

You can also use a deeper analysis to develop a mathematical model that will process statistics to calculate the reliability of each selected segment, which in turn has a personal figure of the whole system, shows dependency.

For the future development of the system

designing monitoring programs for any object, in our case, is 3.5G (HSPA +) 4G, 5G, etc. The reliability of these standards should be equal to the reliability of the standard.

2. Analysis of the recent researches and publications

In article [1], the author focuses on a complex managing system of mobile infrastructure, which consists of many tools and capabilities of a program-controlled network, but the low reliability of the SDN network is not focused at all.
An analysis of the literature showed that a large role is devoted to studying the reliability of the SDN system, it is also shown the level of vulnerability of the system, for example, in article [2], it was proposed to compensate the low reliability by switching from the OpenFlow network to a classical network, which will help maintain the network's operability and increase its reliability. It should be understood that the technical performance of the network will significantly decrease, since the IP network is inferior to the technical performance, that can be seen in [3]. When switching to a more modern network, there is chance of overload which leads to reduce of quality of the services at some sites, but it must be emphasized that OpenFlow reliability is really much higher than the Owerlay network.
In [4], the network operation method in overloaded mode is considered, which in a complex solves the problem of switching from SDN to IP, but the low reliability of the Owerlay network remains, which makes using the network almost impossible for the operator of a mobile or stationary network of large objects.
In GPP models 3, when a network is being built, its reliability is analyzed, for example, remote control of objects or manipulators [5, 6].
And for the 4G and 5G standard, reliability is of certain importance and cannot be provided by the SDN controller and equipment of other levels [6, 7].
It is worth noting that work on network reliability is very important and for centralized networks it is a vital cycle, so you need to use additional tools.
Note that the cost of centralized networks is also very important, as noted in [8].
Many problems can be solved with the help of software; it is installed on the application level of a program-controlled network or PCN [9].
With it, it is possible to control processes and automate many network processes, in particular, combine existing models and functions. It is in the complex that these models will be able to reduce the cost and increase performance of the network, remove precisely those shortcomings that are not mentioned in the works on centralized PCN topics.
Given the above, it should be noted that the key problems of the software network are the cost and reliability of the system, they have lower performance than the existing, classical IP network, which in time has received both standards and industrial recognition
Its is already announced a standard with great technical characteristics, but it is almost impossible to implement it in a decentralized architecture, so the solution of the reliability problem is very important. Also, the problem of infrastructure cost makes the use of SDN technology unprofitable, therefore, reducing the cost of infrastructure is an equally important network problem.
Since the computer network has a dynamic structure, this can be solved using software to automate the functional tasks of network management, analysis and evaluation of the effectiveness of automated information processing and control systems.
Therefore, this topic is relevant and has a modern problem.

3.Statement of the main material

Calculation of the reliability of the SDN network

A software-controlled system has disadvantages such as high cost and low reliability, which is obtained by the client-server architecture itself or from its centralized form. In addition, it must be taken into account that the main type of industrial networks looks like a heterogeneous network, but with the help of SDN it's possible to control the network and increase the dynamics of the introduction of new equipment, which may differ not only in such criteria as: bandwidth, delay and reuse of the resource, but a variety of interface and adaptive capabilities of the equipment. It complicates the work and makes the possibility of network maintenance very difficult and costly.

The network is programmatically oriented - this is the main technology with which it is possible to improve the performance of the mobile network, but the network structure, as it is said, has a number of significant drawbacks that need to be fixed in order to introduce this technology to the industrial level.

The first and main drawback is the reliability of the network, because of the control center, the controller that manages the network and how it breaks down the network which becomes incapacitated. Reliability of the network and other shortcomings (for example, the cost of infrastructure) can be solved with the help of building information technologies for automating functional management tasks, analyzing and evaluating the effectiveness of automated information processing and management systems.

Therefore, firstly, it is necessary to determine the network calculation model.

In fig. 1, 2, 3 depict the architecture of the transport segment of the LTE mobile network

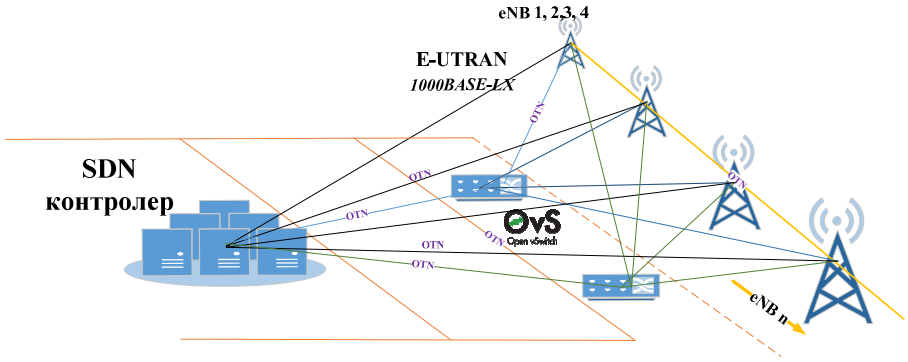

Figure 1. Architecture software-defined networking

The architecture of the program-oriented network is a hierarchically dependent, complex, multi-ancient system of transmitting traffic flows using the processes of managing the SDN controller, which manages the OvS candles, where the forwarding table is located.

The disadvantages of this architecture are that the performance of each level depends on the other and therefore the connection of such bands is not reliable, but this network has more effective indicators, and the main task is to increase reliability and develop a model for the distribution, redundancy and diversity of weak parts of the system.

and Fig. 5 shows the architecture of a mobile network built on the basis of the protocol of the classical IP technology for addressing nodes. Here, each element of the system operates an autonomous structure of such a network is considered decentralized therefore the reliability is greater.
But it should be noted that the IP network is less efficient and has a less dynamic management structure which can restrict its usage in the network of the future FN.
It should be noted that building a software-controlled network from scratch is very expensive and an invoice because it is impossible to stop the work of an existing infrastructure.

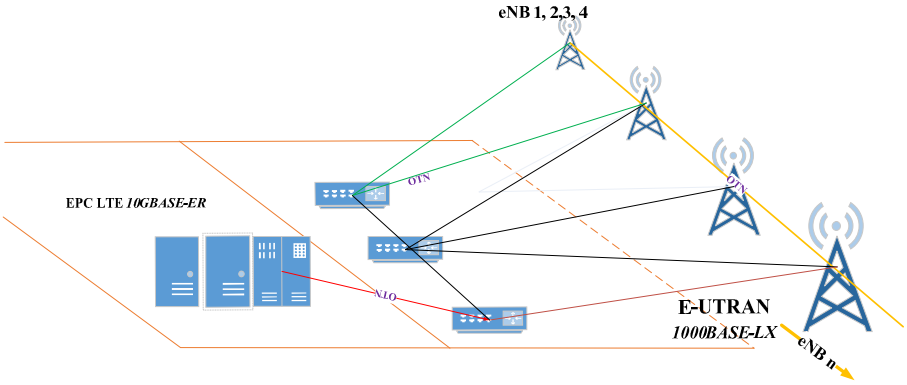

Figure 2. Architecture System Architecture Evolution

Therefore, the third most popular network is OpenFlow, where it is possible to place the SDN network on top of the existing infrastructure and subsequently develop the Overlay network. The OpenFlow network architecture is depicted in Fig. 6.

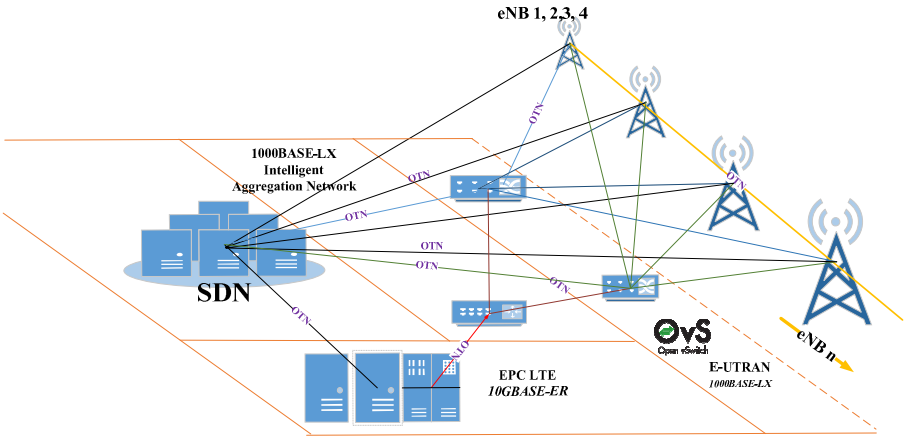

Figure 3.The work of the software part of the SDN network

Program-configuring network (Software-defined Networking, also program-enumerated network) – a data network in which the level of network management is separated from the data devices and implemented programmatically, is one form of virtualization of computing resources.

Reliability and control of devices in the mobile transport segment

Despite the high reliability of modern computer systems, the occurrence of failures are quite possible events. Reliability indicators of a software-controlled network is a collection of software and hardware that depend on each other and the performance of the object depends on their functioning and failure stability. A computer system is a complex entity that runs on a sequence of execution of algorithms and commands that manipulate physical equipment, which in turn performs the functions of transporting information flows.

The command line interface output format is performed using the CLI, and the embedded Web server API is installed on the hypervisor.

Namely, such violations of the software part of the controller may occur during operation:

• incorrect modification or update of the system software or application,
• the presence of IRSLKBDB programs in the system or in the download files,
• Mismatch of hardware configuration parameters to the data stored in memory.
• improper expansion of the SDN controller hardware power,
• Failure of buffer ICs serving power current ICs or peripherals.
• mismatch of API applications,

Due to possible failures and failures after completing the task, the controller raises the question of the accuracy of the information received. In this regard, all modern systems have the means to control the correct functioning of both individual devices and the kernel as a whole. These tools were called the SDN control system (in our case). The main requirements for the control system are: automatic detection of the fact of malfunction of the application system; elimination of consequences of accidental failures in the calculation process; localization of the failure site to the nearest block.

The period of operation of any complex system can be described by a curve which according to the theory of reliability is called the typical line. This line is divided by the object's work cycle into periods where for each period the system passes a certain cycle through which it is possible to see the state of system reliability (Fig. 5)

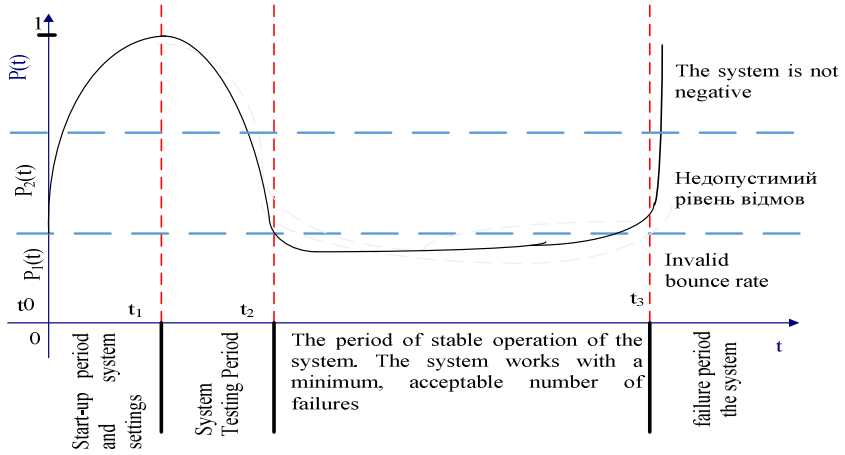

Figure 4. Typical direct start SDN controller.

Typical line shows.

1. Stages of launching the mobile network infrastructure, which includes:
   • system setup period;
   • system testing period;
   • period of stable operation of the system;
   • system failure period.
2. Object status:
   • system inoperative condition;
   • unacceptable level of refusals;
   • the permissible level of refusals;

1. Network operational status - the network meets all documentation requirements.

2. Network outage - the network does not meet at least one of the documentation requirements for it (the network may provide services)

3. Working state of the network - the network can perform all the functions assigned to it. (however, a viable entity may not meet the documentation requirements).

4. Invalid network status - when the value of at least one network parameter that characterizes the performance of the specified object functions does not meet the requirements of the documentation.

It may be a partial inoperative condition in which the network is capable of performing the desired functions with reduced performance (for example, one of the candles failed), or is capable of performing only part of the required functions.

5. Network boundary condition - when further operation of the facility is unacceptable or not logical or economically unprofitable further operation of the equipment.

The criteria for the limit state of each object are defined in the documentation for it. You need to understand that objects can be in a state of limitation and at the same time be able to work. In this case, the operation must be discontinued.

When receiving practical data, the system can monitor the status of the network and keep metrics within the user or standard set. Integrated software will help reduce the hour of network limit state, reduce network reconfiguration times, calculate the cost of equipment repair or maintenance.

Using first-rate models (the models in question, namely the model of reliability and cost of computer networks), we can deduce additional functions that will calculate the cost of repair and the period of prolongation of operation after repair or maintenance.

Using first-rate models: the reliability and cost of computer networks (discussed below), we can deduce additional features that will calculate the cost of repair and the period of service life after repair or maintenance.

Application testing can be done with an algorithm that can also analyze a more optimal algorithm for a particular scenario.

It is possible to implement this algorithm at the application level, on the NFV hypervisor

The abstract scheme is based on the principle of location of the object according to its functional characteristics.

That is, if the object refuses, the state of the entire scheme will not be affected, the parallel objects are shown in Figure 1a.

If the system fails when the unit fails, this is the flowchart shown in Figure 1B.

Since we use centralized systems, it should be noted that such a system is actually a sequential block diagram shown in Figure 1D.

And system backup Figure 1 C

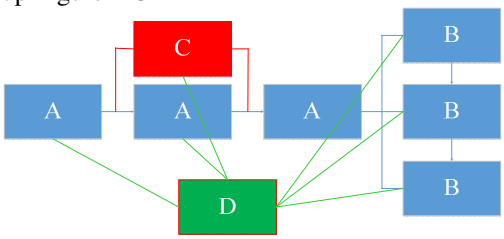

Figure 5. Butt rostasuvannya last block diagram

The main drawbacks to improving reliability through the redundancy method are the increase in cost and the increase in latency by increasing the number of nodes, each giving 0.022 ms latency, in software configured networks and (0.068 according to simulation modeling, and 0.088.

Figure 6 shows the results of network modeling, up to 99%, in this case the cost of the network increases to 2 times

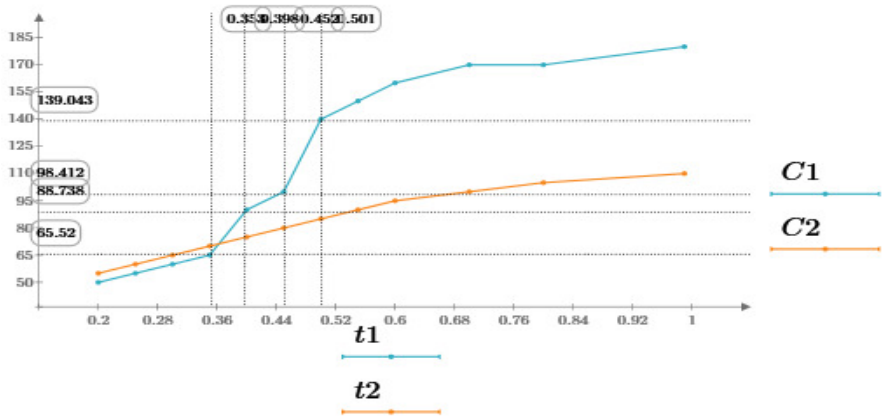

Figure 6. The result of the model is the reserve of the system, and the actual one is higher.

To reserve a controller you must pay 30% of the network cost. To reserve each block, you need to use a chart and a table.

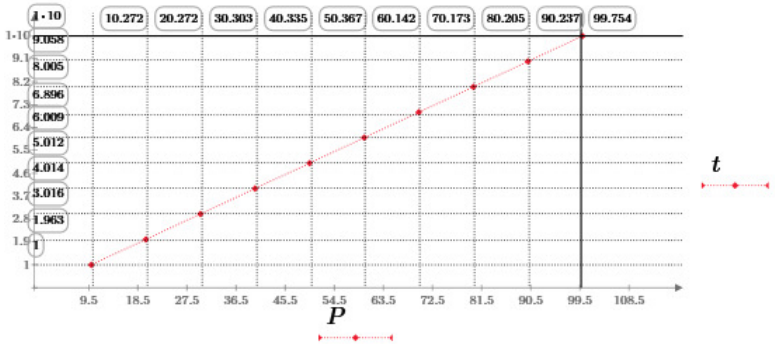

Figure 7 Dependence on high-speed system

Table 1 Calculating the cost of booking an SDN system

	Cost of equipment	Cost of service	The cost of the software
Controller redundancy	$(n+1)\cdot C_{con}$	$(E+1)\cdot C_{con}$	$+E$
OvS redundancy	$(n+1)\cdot C_{con}$	$(E+1)\cdot C_{con}$	$+E$
Other	…	…	…
General	$C_{dev}+E_{dev}=C_{cn}$		

Where n - number of operations, C_{dev} - variety of operations, E_{dev} - number of operations, E - cost of maintenance

The dependence of each additional block on the delay is shown in (Fig. 8). Each OvS switch adds a delay of up to 0.022-0.026ms. and reduces efficiency. SDN efficiency with the number of switches up to 3 times higher than IP, so for efficient use of the system, we can duplicate each switch only 2 times.

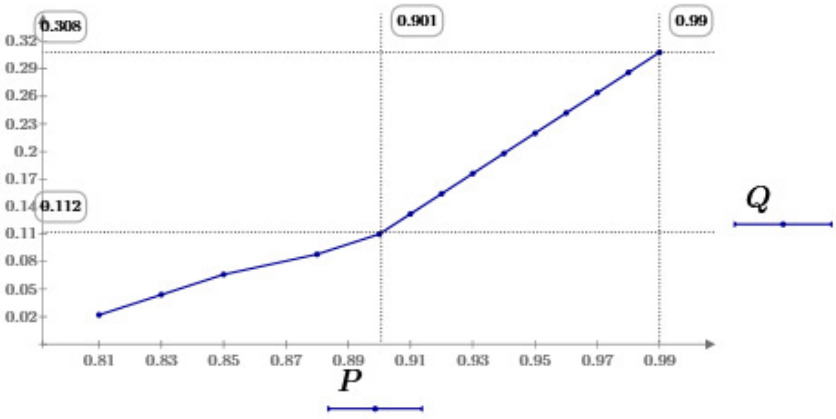

Figure 8 Dependence of the number of switches (delay of each switch) on the delay

CONCLUSIONS

Reliability, dynamic, variable, object characteristics decrease over time, just for reliability.

The longer the object runs, the more negative it has, such as: failure, partial failure, failures in both hardware and software part, or level; and, as a last resort, failure.

I must say that over time, the equipment gets old, both in hardware and software, or as they say in the "moral" sense. That is, this equipment should not work, not because it has failed, but because many standards and technologies have changed over time.

But at the facility, we saw that the process can be managed using methods such as redundancy and load concentration. It is clear that it is much better to control the SDN software mode. Which one we looked at, and built the architecture of a so-called heterogeneous network that overlaps one another, creating a redundant decentralized network. This technology is called OpenFlow. What is the efficiency In the second place [5].

The tasks of calculating the reliability of LTE measures by managing centralized and decentralized management methods for this network have been accomplished.

However, the reliability of the three-way network is analyzed, namely the network IP and the SDN, which in turn are divided into OpenFlow and Overlay.

Further, it is possible to develop a system for managing the service processes of this system, which can control the reliable characteristics of the object, and take into account the failures, such as throughput, service delay times (0.08 sec, on a router for example.), hours worked.

It should be noted that the most failure-proof is the OpenFlow network itself, since a decentralized model can be used when a controller's SDN fails, until the network is restored.

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