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Research of parameters of reliability of the management level of info communication networks with use of the equipment of the software defined networks

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Abstract—In this article deals the management level of infocommunication network, examines the parameters of reliability of each equipment. The statistical data MTBF and average recovery time of each component failures. Calculated the parameters of the coefficient of readiness (K_r) to upgrade the network and after the modernization of the network management level.
Keywords—the management level of next generation networks, infocommunication network, software switches, controllers, routers of transport level, switches of transport layer, redundant communication channels, uptime, reliability.

I. INTRODUCTION

In [1,3] introduced the model, that allows from system position to research reliability parameters of infocommunication network (ICN) with distribution structure, the core of that presentation components of the infocommunication network as subsystem, that they presentation as independently levels and accomplishing specific function in packet regime with preassigned quality of service.

The model substantiates the notion that the availability of the K_G, describing the probability of the system in an arbitrarily chosen time performance (i.e, characterizing the degree of reliability ICN), defined as the multiplication of the coefficients of readiness of its component parts (layers), i.e,

$$K_G^{ICN} = \prod_{i=1}^{n} K_G^{n} ,$$

where n– the number of components of info-communication network.

In turn, each level ICN includes a plurality of elements, which also have the final reliability values of parameters, that is, for each i -level fair expression

$$K_G^{i} = \prod_{j=1}^{m_i} K_G^{j} , \qquad (1)$$

m_i– the number of component of i-th level of ICN.

The following are the results of a study of reliability parameters of its equipment level ICN, which directly affect the quality of services ICN as a whole.

II. FORMULATION OF THE PROBLEM

Network management layer is responsible for organizing the NGN network management system (Next Generation Network). The tasks include monitoring the level and appropriate management of the network infrastructure, network maintenance at the specified quality parameters, as well as a number of parameters that characterize the work of the network principle in general (safety and security). The management system should ensure: control procedures to eliminate errors and failures; configuration management procedures; management billing system; manage network performance; security management.

The main task of the network management level is to provide flexible wiring to be used for call control and manage the installation of the compounds in real time. Softswitch is the main device implementing functions of the control level switching and transmission of information. All calls in the network are managed by modern softswitch that provides intelligent routing and traffic distribution, resulting from regional segments. Softswitch is coordinating the exchange of signaling messages between networks, maintaining and transforming the existing signaling protocols.

At its core softswitch - a computing device with the appropriate software and a high degree of availability. Call control in NGN network typically includes call routing, user authentication, establishment and disconnection signaling and other tasks. As an intermediary flexible switch must "understand" both signaling protocols in telephone networks, and protocols of information transmission control in packet-based networks. Flexible switch is the main device implementing control plane functions switched architecture NGN network.

The flexible hardware switch must be implemented the following main functions: - basic call control function, providing the reception and processing of signal information, and the implementation of actions for the establishment of a packet network; - Function of the authentication and authorization of subscribers connected to the packet network, both directly and using the PSTN access equipment - a function call routing in a packet network - function billing, collection of statistical information; - control function equipment transportation gateways - the function of the additional species service (FEB) - implemented in hardware or flexible switch in conjunction with an application server; - Function operation, management (administration), maintenance and provision of OAM & P (Operation, Administration, Maintenance and Provisioning) information. Additionally the following features may be implemented in hardware flexible switch: - Function terminal/transit SP/STP signaling point (Signaling Point/ Signaling Transfer Point) network SS7 - function interaction with application servers - site service switching function SSP (Service Switching Point) and other intelligent network.

All flexible switch (softswitch), depending on your network functions are divided into two classes: Class 4 and Class 5 switch Flexible class 4 is intended for the organization of the transit call control node in carrier networks with packet switching. It performs the routing and distribution of calls to IP-based networks on the main (long-distance / international / local) level, thereby ensuring transit traffic for network segments to the subscriber connection. The fundamental difference flexible switches grade 5 is the ability to work directly with the customer's terminal network and providing them with a basic telephone and multimedia services, as well as additional services (FEB) such as intelligent call routing depending on the subscriber's availability, call waiting, call hold, transfer calls, the tripartite conference, parking and pick up a call, multiline subscriber group, etc.

Softswitch main task - to coordinate the various signaling protocols. He is able to coordinate the work of networks of the same type and establish cooperation networks with circuit-switched IP-networks. Softswitch provides access to various networks and applications, thereby simplifying the process of organizing additional services. It enables a full range of advanced telephony services (intelligent call routing, call transfer, conference, control and limitation, etc.). Softswitch provides great opportunities for service specific telephone line.

IR seems performance equipment (gateways, switches, routers), algorithms, flexible operation switches (of Softswitch) and reliability characteristics, determined by the given network structure, communication protocol and communication channel characteristics.

At the level of the network vector control function $Y(T) = [y_1(t), \ldots, y_r(t)]$, describes the change in the reliability of the state of the flexible switch (Softswitch) network, that is, change the network performance in relation to its functions. Where $y_i(t)$- the process of defining the reliability of the state i- change of input, that is, change the network performance in relation to its i- th function. As above, we see that the network management level reliability of the state change process inputs $y_1(t),..,y_r(t)$-switching processes. Call them reliability process in flexible switches (of Softswitch) at the inputs of the network management level. Reliability situation IN at an arbitrary time t is completely described by the four vectors [1]:

$$Z = (X, B, A, Y, V),$$

where X- the reliability of the state inputs (gateways of access level); B- the reliability of the state channels of communication; A- the reliability of the state blocks (routers and switches transport layer); Y- the reliability of the state inputs (flexible switch-Softswitch), V- the reliability of the state NGN network outputs at time t (service control layer).

This static description relating to the selected point in time. In reality, all four vectors are time-dependent change and reliability change of IN described vector function:

$$Z(T)=[X(T),B(T),A(T),Y(T),V(T)].$$

This description is dynamic, it covers the desired time interval operation info-communication network as a whole.

The approach, called software-configurable network (Software Defined Network, SDN) - the separation of network management level and the data transfer by transferring control functions (Plan route-absorbers, switches, etc...) In the applications running on a separate server (controller). The approach of SDN is the ability to dynamically control the forwarding of data to the network using an open protocol OpenFlow. All active network devices together under the control of a network operating system that provides applications access to network management. Network controllers can be centralized, use common abstraction to forward packets.

By controlling the forwarding of data on the network to use the SDN allows for simultaneous multi-path circuit data, flow control on the basis of priorities, network virtualization, to provide the QoS, effectively distribute the load on the network. OpenFlow open standards and the imposition of control logic in a single controller simplifies hardware and software active network equipment.

SDN technology is aimed at: improving the efficiency of the use of channel capacity, load balancing in the network; simplify network management, increase network scalability; increasing network security; efficient routing; lower capital costs.

The controller is a server, which manages the operation of the network operating system (NOS). Like the traditional operating system, the NOS manages all network resources. In the terminology of the SDN -controller is called NOS. Over the controller operates a variety of applications that implement network services, such as routing, load balancing, a variety of protocols, gateways, firewalls (Firewall), encryption, DPI, NAT, and so on. An application on the basis of information on the network managed by the controller and the resulting application from the controller generates a set of rules, in which the controller loads the appropriate switches.

The controller always has current information about the structure and topology of the network switches to which it operates (programs). This makes it possible to optimize the promotion of data packets and dynamically manage data flows rather than individual packets, load balancing, rapid control of the implementation of the information security requirements of the network.

SDN controller in the network is a key element, since it carries the elements of network infrastructure control and data flows in the network. Features SDN network reliability depends directly from the respective controller reliability characteristics.

Controller software-configurable network allocates packet transmission quality parameters: the priority of the package, the required delay for packet transmission, the required bandwidth in the transmission packet and the required reliability of the transmission packet.

III.THE DECISION OF THE PROBLEM

The integrated scheme of transmission of packet on the control layer shown in Fig. 1.

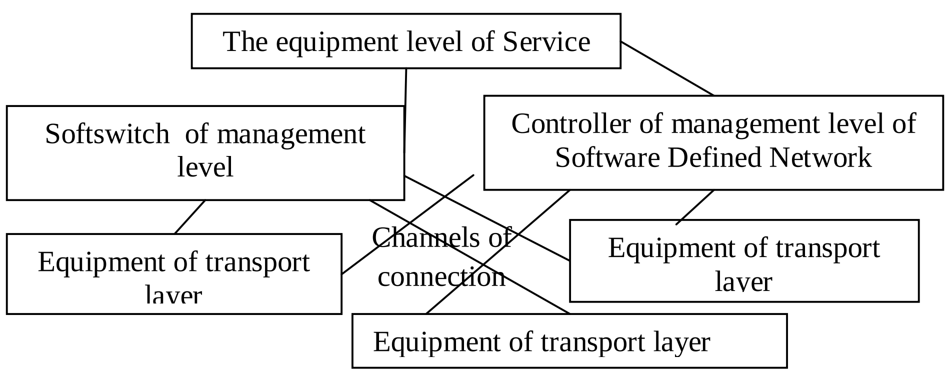

Fig.1. The integrated scheme of transmission line of streams at the management level ICN network.

According to expression 1, the reliability of the management layer is characterized by a work readiness coefficients of its components, ie,

$$K_G^{manag.} = \prod_{j=1}^{3} K_G^{j} .$$

Readiness coefficients usually determined from the statistical data using the following formula:

$$K_G = T_0/(T_0+T_в) , \qquad (2)$$

where T_o- MTBF (for all types of failures), which is calculated by the formula:

$$T_o = \sum_{i=1}^{N} t_i / N , \qquad (3)$$

$T_в$ – mean time to repair of system failures,

$$T_в = \sum_{i=1}^{N} t_{ipr} / N , \qquad (4)$$

t_i – i-period of continuous time of system working;

t_{ipr} – down time of system, caused i-malfunction of considered equipment;
N – amount of malfunction.

The reliability of management layer is considered as part of the network stability in general and, in general, includes a property a) reliability b) durability, c) adaptability and d) persistence. Trouble-free and long-lasting operation of the management layer is achieved with reliable and smooth operation of the whole complex of the level of equipment. Here we consider the problem of resource allocation allocated to improve the reliability of the management layer between its components. So, let there be given: - initial topological structure of the management layer, that is: the number of Softswitch, their types and characteristics, the number, types and characteristics of conrollers; coordinates equipment deployment; the number of channels and their capacities; - Statistical parameters for reliable operation of each equipment for a certain period (eg, one year); overall uptime, total downtime due to a malfunction of each equipment, the degree of congestion of communication channels, the total number of served and unserved orders for each message type and for each area, etc .; - The value of the allocated funds to improve vehicle reliability and so on.
The algorithm for solving the problem can be described as follows:

1. On the basis of statistical data by the expression 3 and 4 are determined by the average uptime and the average downtime for each type of hardware Softswitch and conrollers; 2. Based on the calculated value formula 2 availability factor for each of the management -level equipment; 3. According to the formula 1 is determined by the current value of the coefficient of readiness $K_G^{manag.}$ management layer as a whole; 4. Checking compliance with the current value $K_G^{manag.}$ management layer required standards. In the case of this condition proceeds to operator 7; 5. Determine the equipment (or more equipments) and the number of communication channels that do not have the condition in terms of reliability, that is, $\{K_G^j\} \leq$ required $\{K_G^j\}$, and in relation to them being taken to implement this provision.

Some detail on this operator. It should be noted that failure of communication channels connecting the routers equipment with equipment Softswitch and controllers leads to failure of access to the equipment management level, regardless of the status of communication channels connecting equipment Softswitch of management level equipment and, conversely, the failure of the link between the router and facilities level control results in failure of the output level control of all equipment connected to this router.
A complete refusal to consider the transport IN is considered the failure of all the channels of communication between all hardware routers and equipment management level, switches and management level, as well as the transport network equipment. Evaluation of reliability of the software (software) that implements the interaction between the components of the transport on the basis of the relevant protocols, different from the assessment of the reliability of the hardware (HW).
The reliability of the software can be reduced when you make mistakes in their debugging and change. Software to access the network level are based on the approved protocol standards, so they can be considered to satisfy the reliability requirements.
After determining the weak points of the management -level measures are taken, increasing the value of K_G. They may include: reservations, "obgreyt" specific hardware areas, within the allocated funds replacement of old with new equipment, the connection gateway equipment to a nearby identical router or to an adjacent equipment management level, etc. As a result of the implementation of specific measures, control is passed to the operator 8.

A. Definition of a loaded sections of the management layer, as well as areas with the lowest values of K_G and the transfer of control to the operator 6;
B. Determining the value of availability factor after operations 6 operator and check the condition of the operator 5. In case of non fulfillment of the condition the transfer of control to the operator 5, otherwise the fixing of a new management -layer structure and stop the algorithm.

Work algorithm was tested on a concrete example. The original data were derived from a company which is engaged in the maintenance of modern networks. The topological scheme of research management layer is shown in Figure 2.

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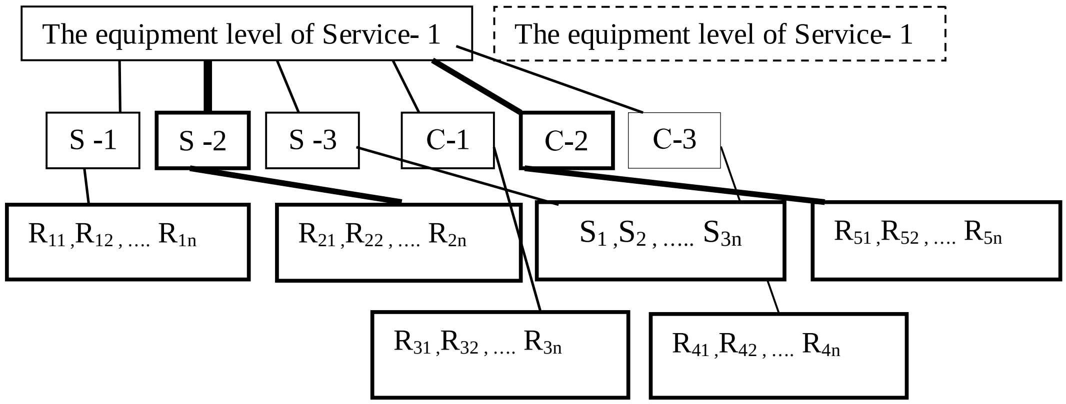

Fig.2. The topology of research management layer

According to figure 2 the considered topology management level contains the Softswitch equipment Softswitch, controller (Controller software defined networking), which is connected to the appropriate equipment routers, switches. Softswitch and controllers are connected to the appropriate hardware level (servers IN providing certain types of services) of the infocommunication networks with distributed structure. Equipment management level are connected via communication channels with different bandwidth. In table are summarized the average values of the smooth operation of communication channels sites the router Softswitch Softswitch Softswitch Softswitch controller, and the main channels between softswitches Softswitch (and controllers) and equipment level of service. Statistical parameters characterizing the reliability parameters listed in the table. As a parameter of reliability used availability factor K_G. The value of K_G was determined on the basis of the above formulas. For example, K_G of the software switch will be equal to:

$K_G^S=T_0^S/(T_0^S+T_в^S)=8753/(8753+8)=0{,}999087.$

TABLE I

THE STATISTICAL PARAMETERS OF THE RELIABILITY OF THE EQUIPMENT PARAMETERS OF MANAGEMENT LAYER

№	Name of equipment of management layer	T_0	$T_в$	K_G	$T_0^м$	$T_в^м$	$K_G^м$
1.	Softswitch - 1	8753	8	0,999087	8755	6	0,999315
2.	Softswitch - 2	8542	12	0,9986	8544	10	0,99883
3.	Softswitch - 3	9015	7	0,999224	9016	6	0,999334
4.	Controller- 1	8750	10	0,99886	8755	5	0,999429
5.	Controller - 2	8930	7	0,999217	8932	5	0,99944
6.	Controller - 3	8454	6	0,99929	8456	4	0,999527
7.	Channels of connection: Softswitch (controller) router (switch)	8754	14	0,9984	8759	9	0,99897
8.	Channels of connection: Softswitch (controller)-equipment level of service	9023	11	0,99878	9029	5	0,99945

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The reliability control level is defined as the product of the coefficients of readiness of all of its components, that is,

$$K_G^{manag.} = \prod_{j=1}^{8} K_G^{j} = 0{,}9989$$

As you can see, the current value of $K_G^{manag.}$ of the level of managment is located in the "two nines." This is the average result. To determine vulnerable points of control level IN and the adoption of certain measures increasing values of the coefficient of readiness, a program, which is administered by the source data determines what areas need to "enhance" from the point of view of increasing the value of K_G. These areas were mostly backbone links, as well as some routers. The program data have been entered, what measures should be taken to improve the K_G of each land management level. For the considered case such areas are circled with bold lines.

Thus, at the expense of the allocated funds (as defined in relative units)" and the available opportunities (in terms of "obgreyt" technical equipment) K_G control level can be raised to the value shown below:

$$K_G^{manag.} = \prod_{j=1}^{8} K_G^{j} = 0{,}9993$$

Reliability of the management level provide: - redundant channels and paths of communication; - redundancy of the routing information; - redundant equipment performing the functions of switching control and services, and also equipment, performing the switching function; - procedures for overload protection; - development of the infocommunication network-based fault-tolerant architectural solutions. The redundancy scheme depending on the network structure of communication and are developing in relation to its features.

As well as timely testing of control functions: audit of the administration at various levels – as the data tier and the application tier. For each of these levels, check the following possibilities: - error management; - configuration management of the equipment; - management of billing system; - services management; - security management. The testing process included two main levels responsible for testing of NGN equipment (test equipment EUT) and test comprehensive NGN solutions and implemented them using the communication services (testing of network solutions – NUT). Level 1: testing of NGN technical means (functionality Testing, load Testing, compliance Testing). Level 2: the NUT Testing (functional Testing, interconnect Testing, services Testing, Testing "end-to-end" Testing of the quality of service, Testing of mobility and roaming). Each level test contains a set of checks of the equipment (EUT) and implemented on its basis the networking (NUT).

During testing of system-network solutions Softswitch (Softswitch) the greatest number of comments was found in the following three types of checks: - check the functionality of the equipment; - checking communication equipment various system-network decisions; - check compatibility of equipment part of the system-network solutions Softswitch different manufacturers. To test the functionality of your equipment is confirmation that the functionality of the equipment included in the system-network solutions Softswitch one manufacturer meets the requirements of international and national regulatory documents. To verify the interaction of equipment is the confirmation that the equipment, part of system-network solutions Softswitch the same manufacturer, correctly interacts with the hardware included in the system-network solutions Softswitch from another manufacturer. To verify compatibility of the equipment is confirmation that equipment from different manufacturers to ensure compatibility within a single system-network solutions Softswitch.

IV. CONCLUSIONS

In conclusion we note that the trend of modern info-communication networks, software configuration task (SDN) is to transfer the main burden to improve the reliability of the physical to the higher levels, up to the application. This corresponds to a transition from a hardware method of redundancy in a programmatic way. To combat the loss of packets on the network and find the backup route is used rerouting mechanism. In all cases the decision of the routing problem reduces to the problem CSP (Constrained Shortest Path) the problem of constructing the shortest paths with the restrictions. In this method of solving the linear programming problem seek out a minimum cost function value of all paths, defined as the sum of the values of all network paths formed when the restriction on the total delay. The developed program when entering the corresponding initial data allows to determine the vulnerable points of the level of management and modernization which needs to be done to raise the value of the coefficient of readiness of the site and the level of management in general.

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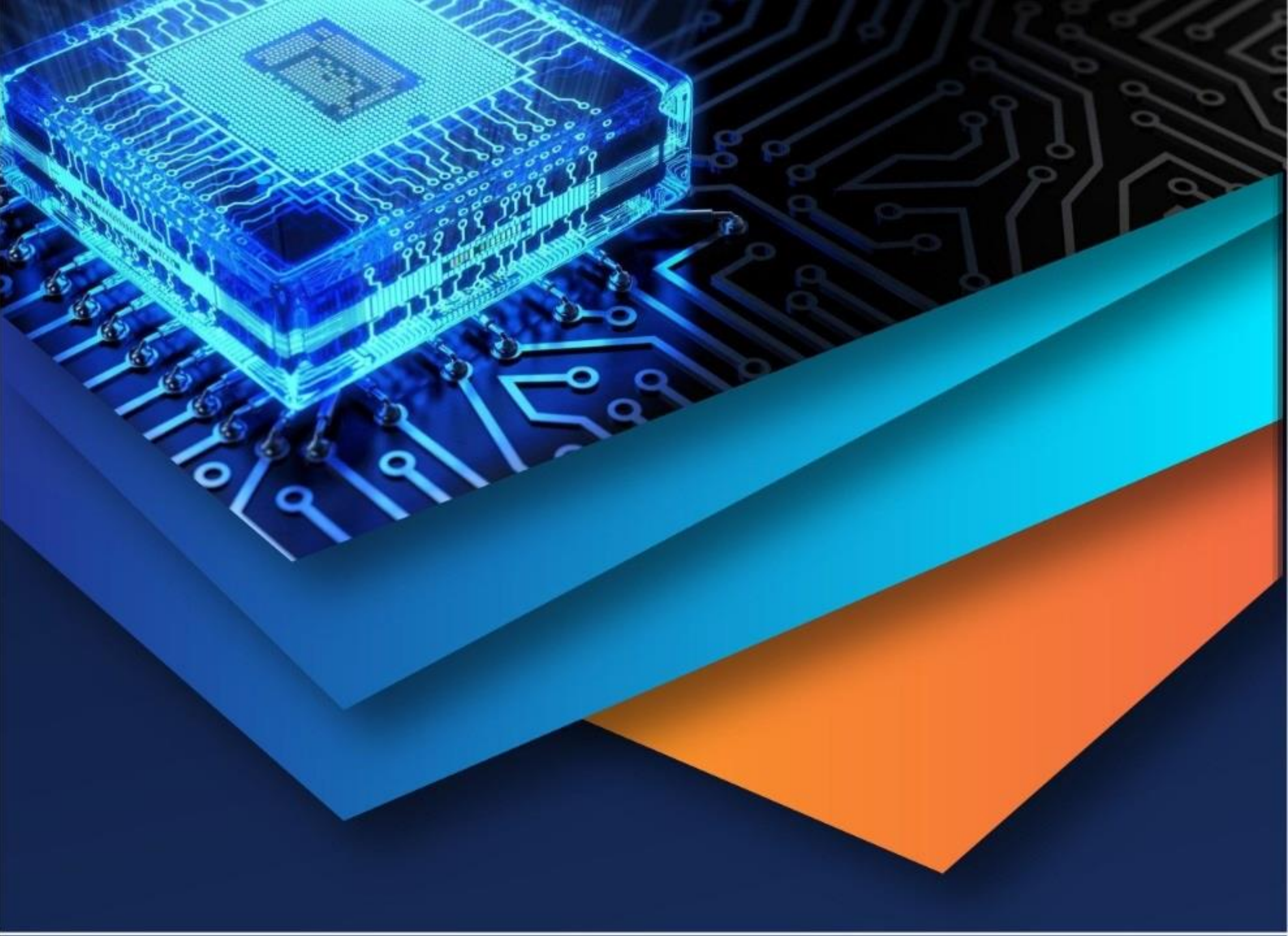

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