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INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY
DEVELOPMENT OF FOUR-LEVEL MODEL SYSTEM OF SDH / SONET NETWORK MANAGEMENT

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ABSTRACT
It has been conducted the analysis of performance process of optical communication systems of synchronous SDH / SONET network, which is connected to the system control, its testing and collection of statistical data on the passage of the signal in the event of ordinary, extraordinary or emergency situations, as well as the management or administrative management of the system. The implementation of management tasks at the physical, logical, informational and administrative levels is associated with the development of SDH / SONET mathematical model of the network management system.

In this regard, the problem of development system of SDH / SONET 4-level network management model has been posed and solved in this work. In connection with this, it has been carried out a structural analysis of building management systems and developed a structural model of the control system based on the model of collective control units, a mathematical model of functioning with seepage theory, the reliability model of functioning over time.

The developed system of four-level SDH / SONET network management model provides a fundamental limitation on the performance of structural reliability based on critical probabilities, the value of which is determined by the principles of building the control systems of optical data transmission systems.

KEYWORDS: control module, administration, service, management, seepage, structural reliability, critical probability.

INTRODUCTION
The operation of the optical communication systems (OCS-OSP) of SDH / SONET synchronous network is impossible without its services at various levels.

In this case, maintenance is reduced to an automatic, semi-automatic or manual control system, its testing and collection of statistical data on the passage of the signal in the event of ordinary, extraordinary or emergency situations, as well as the management or administrative management of the system.

In its turn, these functions can not be implemented without various types of alarm states of the system, connecting control subsystem and controlled systems or network components, that are specially built-in or reserved for this channel [1,10]. To implement control problems at the physical, logical, informational and administrative levels, of which the last two belong to a special category of management - management, it is necessary to develop a network model and describe the communications necessary to implement control functions in different parts of the network.

FORMULATION OF THE PROBLEM
In contrast to existing transmission systems with PDH hierarchy, having no standard description of the model and interfaces and special control of communication channels, the SDH systems have their management systems - SMN, based on a fairly elaborate system of standards that describe the model, interfaces, interaction scheme function of blocks and channels management. Telecommunications management system (TMN) can be imagined as a 4-level management model [1], where each level has a specific function, representing the top level successively generalizing picture of network performance by the lower levels (Figure 1).
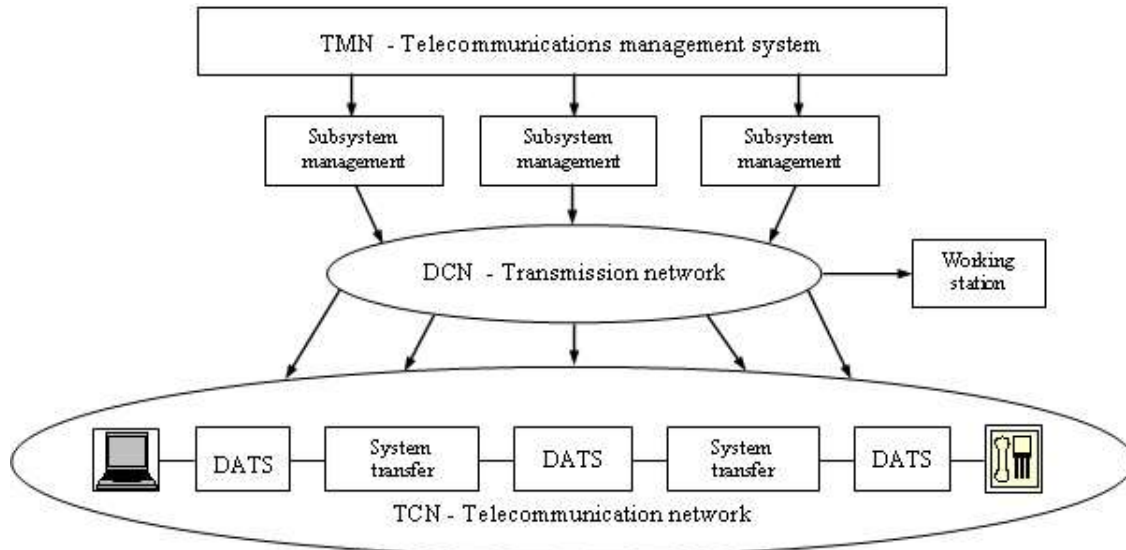
Figure 1. System Diagram of 4-level telecommunications management model (TMN)

In this case, the optimal implementation of the management model of operation, administration and maintenance of OCS synchronous network SDH / SONET is an urgent research priority. In this connection, the service process of high-speed digital channel on the physical layer is closely related to the development of 4-level management model systems (SMN) of synchronous network SDH / SONET, and including the individual components of such networks, i.e. control system (CS) OCS.

In this regard, it has been posed and solved the problem of system development of design 4-level model network SDH / SONET. To achieve this goal in the work it has been carried out structural analysis of constructing CS and OCS and developed the structural model of construction of CS on the basis of the collective model of control modules (CM).
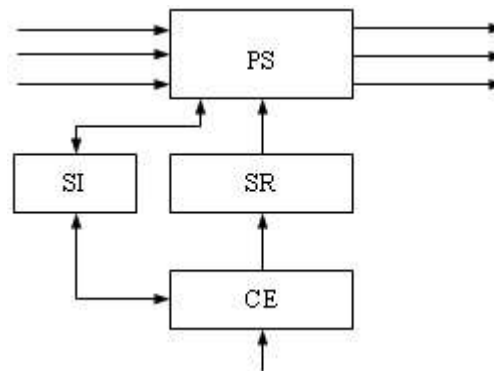
TEAM MODEL OF CONTROL MODULE

Conceptually, the system development of 4-level model of SDH / SONET networks are one of specification of the ideas of homogeneous computing systems, structures, and environments, proposed by E.V.Evreinov [2,7-9]. Implementation of CS based on the model of collective of calculators allows you to expand the scope of its application, to determine optimal ways of implementing a number of complex functioning of the management tasks, administration and maintenance of OCS of SDH / SONET synchronous network. This is ensured by the fact that any logical model structures of widest variety of specialized systems and control devices can be set in them without time-consuming.

It has been conducted the analysis of the structural construction of the individual components, such as control units of OCS of SDH / SONET synchronous network in order to specify the practical application. The use of this system allows the expansion of the scope and type of services, improve maintenance of existing transmission systems and the gradual transition to a purely optical transmission systems. It is possible to add increased reliability provided by high survivability of systems of homogeneous control modules, the relatively low cost of the CS and the possibility of determining the optimal number of channels served by management decentralization and increasing the number of CM [2.9]. Construction of SMN based on the collective model of calculators is the complement of the existing transmission systems, as CS of such systems is not anything else, as some staff of CM (Figure 2).
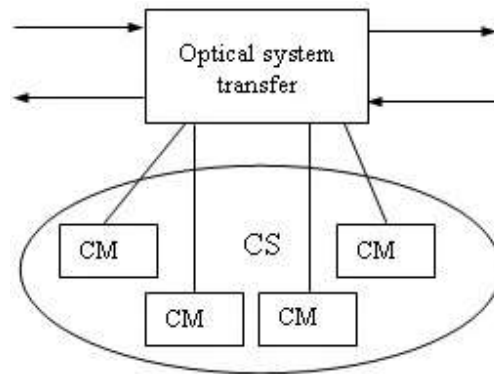
Figure 2. Diagram of building SMN-based on the collective model of control modules

To ensure the collective (parallel) operation, each CM is entered the control element (CE), system interface (SI), a programmable switch (PS) and the setting register (SR) (Figure 3) [3,11-17].

Figure 3. Control Scheme of Control System Module

MATHEMATICAL MODEL OF CONTROL SYSTEMS FUNCTIONING

The process of channels service, organized by OCS is made by CS, consisting of CM collective, which should ensure the adopted procedure of services and channels provision [5]. The management of operation process, administration and maintenance of SDH / SONET synchronous network can be conditionally divided into the following levels:

- Business Management (top level management of the network of economic and practical efficiency);
- Service management (control level of network service);
- Network management (systems level of network management);
- An element of management (lower level element - of managers or B control system of network elements).

Let us assume that each CM is in order with the probability of P, and the relationship between them is in order with the probability if R. Let us portion maximum cluster with the size of $n = n_1^2$. in CS. Operation of CS can be considered as passing control information (data and commands) via serviceable CM and the relations between them. CS is considered to be serviceable, if such a passage is possible, and moreover, that the serviceable part forms a cohesive cluster (subsystem) comprising $n_k \geq n_0$ control modules, where n_0 - is the minimal number of CM, needed to select and present a particular channel.

Building redundancy of CS has the growth of size n and in $n \rightarrow \infty$, endless defective cluster must exist in CS. Otherwise CS is divided into disconnected parts and cannot function in any number of serviceable CM. Then, there is a task, under which probability of P and R is there an infinite defective cluster in CS?

The answer to this question is the main content of seepage theory [8,9]. Let us consider the problem of seepage on CS when $P<1$, a $R=1$. Seepage on relations $(P=1, R<1)$ is reduced to seepage on CS, as everywhere below, the term "control unit" can be replaced by the term "communication", and the symbol P with symbol R. Therefore it is necessary to carry out a study of the structural reliability of CS, considering the link between CM absolutely reliable.

With regard to the established task, the result of seepage theory required by us can be formulated as follows [8].

Proposition 1. For any periodic control of graph G of channel service process displayed in the collective control modules K^2, there is a critical probability P_C such that if $P<P_C$, then there is only one infinite serviceable cluster in G existing with a probability of 1.

Let us assume that $P(n, p)$ - is seepage probability through the serviceable cluster of controlling device of G size of $n=n_1^2$ at a given time. This value is called the coefficient of readiness. Then the following statement is obvious.

Proposition 2. On the set of serviceable clusters of local CS of the same type displayed in

$$\lim_{n\to\infty} P(n, p) = \begin{cases} 0 & at \ P < P_C, \\ 1 & at \ P \ge P_C. \end{cases}$$

In other words, with increasing redundancy CS becomes arbitrarily reliable if $P \ge P_C$, and arbitrarily unreliable if $P < P_C$.

Figure 4. dramatically demonstrates the typical behavior of the function $P(n, p)$. It is evident that with the growth of n_1 the function $P(n, p)$ tends to speed and, in addition, the inflection point $P(n, p)$ tends to seepage threshold P_C.
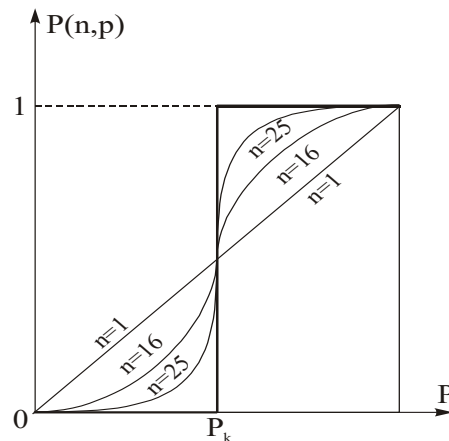
Figure 4. Dependence of seepage probability through the serviceable cluster CS on the probability of each serviceable control module

Thus, in the interval (0,1) the root of equation $P_p''(n, p) = 0$ is the estimation of threshold leakage, even at quite acceptable $n=16$. In this case the problem of obtaining the polynomial coefficients $P(n, p)$ has time complexity constraint $T(n) \ge O(2^n)$, that gives further complication to the established the problem.

MODEL OF RELIABILITY OF CS FUNCTIONING IN DYNAMICS

Analysis of structural reliability of SU in the dynamics is clear from Proposition 1. We consider an ensemble of independent and identical CM and always demand the satisfaction of the condition

$$P \ge P_C. \tag{1}$$

Let us assume that the trouble-free operation time of CM is exponentially distributed with the parameter α and the mean working time till failure for such CM is equal to $\tau = \alpha^{-1}$. The value α - is the intensity of CM failures, and τ - is the life -time of module. The failed module is found and restored with the intensity β, and the average recovery time is β^{-1}. Now for the probability of P, working order of CM at the moment of $t+\Delta t$ time can be

recorded

$$P(t + \Delta t) = P(t) - \alpha \cdot P(t)\Delta t + \beta \left[1 - P(t)\right]\Delta t$$

hence, when $\Delta t \to 0$ we have

$$dP(t) = \{\beta \cdot [1 - P(t)] - \alpha \cdot P(t)\}dt \tag{2}$$

Let $P_0(t) = P(0)$ and $P = P(t)$. The probability P_0 characterizes the failure of CM and if faulty modules can be restored, then $P_0 = 1$. Solution of the equation (1) has the following form at the specified initial conditions:

$$P = P_\infty + (P_0 - P_\infty)e^{-(\alpha+\beta)t}, \tag{3}$$

Where $P_\infty = \lim_{t \to \infty} P = \beta/(\alpha + \beta)$ -is the final probability of serviceable condition of control modules.

Equation (3) describes the process of death-restoration in an infinite ensemble of CM, which is represented in Figure 5.
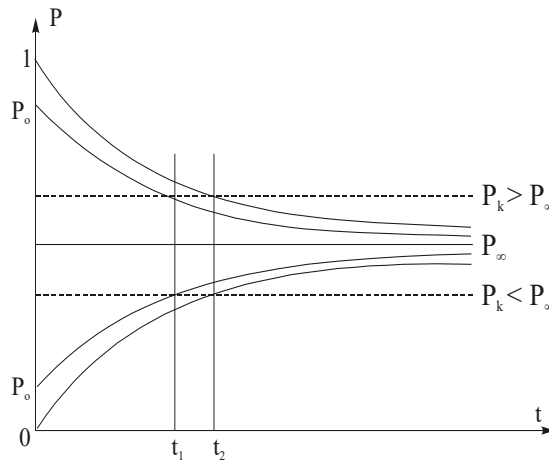
Figure 5. The process scheme of death-restoration of control modules sets

Given the requirement (1) as a condition of control elements cohesion, we can formulate the following assertion.
Proposition 3. The lifetime of endless serviceable cluster in local CS is equal to:

$$t = \begin{cases} 0, & if \quad P_0 < P_\infty < P_C, \\ \dfrac{1}{\alpha + \beta} \cdot ln\dfrac{P_0 - P_\infty}{P_C - P_\infty}, & if \quad P_\infty < P_C < P_0, \\ \infty, & if \quad P_C < P_\infty. \end{cases} \tag{4}$$

In particular, in a system with no recovery at $\beta = 0$

$$t = \tau \cdot ln\frac{P_0}{P_C} \le -\tau \cdot ln P_C, \tag{5}$$

where $\tau = \alpha^{-1}$ - is the lifetime of a single control element.
So, CS with an infinite number of control modules can function indefinitely if $\beta/(\alpha + \beta) \ge P_C$. Otherwise redundancy does not increase the operating hours of CS.
However, redundancy should guarantee not only the serviceability of the control unit, but also the presence of $n_c > n_0$ serviceable CM in good cluster. In the final set containing a sufficiently large number of n control units, the size of the serviceable cluster is

$$n_k = n \cdot P_p,$$

here P_p -is the probability of getting a specific control module into serviceable cluster.

From here $n \ge n_0 \cdot P_p^{-1}$. It is clear that $P_p(P_C) < P_\kappa$, where

$$n \ge n_0 \cdot P_p^{-1}. \tag{6}$$

There is a suspicion that in high redundancy, the control device fails before the critical number n_0 of management modules of the serviceable cluster is reached.

Let us consider the control unit with a limited recovery. For our purposes it is sufficient to use an approximate method for dynamics of averages and consider only stationary state. Let us assume n - is the number of CM, m - is the number of regenerative organs, α and β - are the intensity of failures and recoveries respectively.

When $m > n(1-P)$, the controlling devices behave as self-repairing. When $m < n(1-P)$, there is a limited recovery, and the condition of equality of failures and recoveries flows is as follows:
$$n \cdot \alpha \cdot P = m \cdot \beta. \tag{7}$$

We also know that at the fully loading of limited recovery system, mathematical expectation of the healthy controls number is equal to $m\beta\alpha^{-1}$. Let us require that this number exceeds n_0, and in addition, $P > P_c$ is satisfied. Using (7) we have.

Proposition 4. Control unit with a limited recovery is serviceable, if the condition $n_0 < m \cdot \beta \cdot \alpha^{-1} \le n \le m \cdot \beta (\alpha \cdot P_c)^{-1}$. is met or stationary state of the system is a state of denial.

These obtained results allow making such conclusion that it is important for practical applications to preserve not only serviceable cluster, but also similar structure, for which the algorithms of channels service have been developed. In [3,5] the specific algorithms of reconfiguration in faulty structure have been considered to ensure the restoration of the original matrix size n_1^2. This is achieved by placement of reserve line and column in the matrix.

Saving the structure is possible if the number of failures is n_1. Adopting the value of $(n-n_1) \cdot n^{-1}$ for the estimate of the probability of P_k, we have $\lim P_k = 1$ for $n \to \infty$. Increasing the size of the matrix reduces the time of its life. Apparently, the provision should be placed evenly throughout the structure and its reconfiguration should not disrupt the work of entire system of automatic switching. Global reconfiguration is equivalent to a restriction on the number of devices $m = 1$, which is undesirable in the effect of Proposition 4.

CONCLUSION
Thus, the developed system of four-level management model of SDH / SONET network provides a fundamental limitation on the performance of structural reliability based on the critical probability, the value of which is determined by the principles of building control systems of optical data transmission systems.

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