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ENHANCED OPERATIONAL PROCESS OF SECURE NETWORK MANAGEMENT

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ABSTRACT

Available server management in network environments is considered. The local backup servers are hooked up by LAN and replace broken main server immediately and another types of backup servers so called remote backup servers are also introduced. The remote backup servers are hooked up with high-speed optical network with the virtual private network that is applied to use a long distance public network infrastructure within a single network domain. The operational workflow in the paper gives the guidelines for the actual implementations.

Index Terms -- Operational process, workflow, network management, N-policy,

1. INTRODUCTION

In light of the recent acts of terrorism and cyberterrorism, it becomes imperative not only to provide a network security, but to offer a paradigm of a network security which can be applied to networking for the business continuity such as stock market, postal offices, nuclear power plants, and government offices. Availability [9] of networked servers is a major issue in security respects because of rapid growth of Internet. The paper is focused on enhancement of network availability to support more reliable services. Two types of backup servers are considered. Local backup servers are located in same area and hooked up via LAN (Local Area Network) and he remote backup servers are geometrically separated with main servers but remote backups are hooked up by a Virtual Private Network (VPN) with high-speed optical network. A VPN is networking between remote servers and clients via using a public telecommunication infrastructure with secure access to their organization's network. Unlike an expensive system of owned or leased lines, a VPN can provide the organization with the same capabilities, but at a much lower cost. The m main working servers with the $w+1$ local backups and S remote backup servers are geometrically separated with main servers.

The remote servers are hooked up by a Virtual Private Network (VPN) and can be used during the maintenance of internal backup servers or absence of the repair facility (see Figure 1). The number of the remote backups has the control level N within the total number (S) of remote backups. Unlike previous research from author [5], N-policy is applied to restrict the quantity of external resources. A VPN is networking between remote servers and client via using either a public telecommunication infrastructure such as Internet with secure access to private network and secured network such as military system.

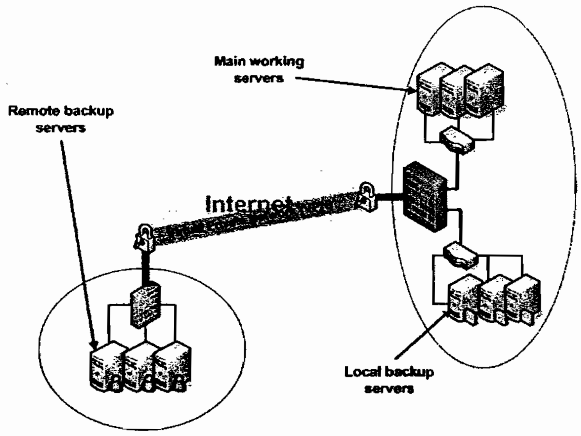

Figure 1. Mixture of the local and the remote backups

In this article we study a class of closed queueing systems with the initial quantity of m main unreliable machines, $w+1$ reserve machines and S auxiliary reserve machines, also called "super-reserve" machines [7]. The behaviors of the network system have been analyzed by author [8] and the analysis of the system determine the values of the initial conditions. As mentioned on the previous research [8], the system tries not exhaust this quantity and sets up a smaller control number N. During this period of time, the system is observed only upon some random epochs of time, while dropped machines line up in the "waiting room."

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If at one of these observation epochs, the number of defective machines reaches or exceeds N (after some delay), the repairman returns to his duties, a busy period begins, and thereby the busy cycle continues. The operational workflow that is solved on the following session gives the implementation guidelines for network management based on the mathematical results. The mathematical values are the initial conditions for network management operations.

2. MATHEMATICAL MODEL

2.1. Analysis of the enhanced network system

The mathematical model of the network system is basically stochastic network management system that has been revealed by author [5, 7-8]. The analytic solution of the system have been explored [8]. This section provides the concepts of the several mathematical tools such as first exceed level theory from fluctuation theory [6], duality principle [2], renewal theory, regenerative techniques are applied for the solution of the system. The system is controlled by the so-called "first excess level process." This is a marked three-variate point renewal process with all dependent components. The process by itself can be applied the practical applications such as router design [6]. The process will be "terminated" at some of the random observation times when one of its "active" components crosses N, and because its value can be of any magnitude with positive probability, the first excess level will be curtailed to its maximal number S should it formally exceed S. The Duality Principle [2] we would like to begin with includes another reliability model, which is more simple than the main one (Model 1) and to which we will refer as to Model 2. Model 2 is similar to Model 1, except that it does not have the super-reserve facility and idle periods. Besides, the total number of reserve machines is w (i.e. less by one than in Model 1. We rather associate it with repairman's vacations, which are distributed as regular repairs. However, upon his return, the repairman brings a brand new machine, which replaces any one that breaks down during his vacation trip if any such available. Otherwise, the new machine he brings in substitutes any other machine and in both cases the old machine is disposed. Model 2 is directly connected with yet another model, which we will call Model 3. Model 3 is a multi-channel queueing system, with buffer of capacity w, and state dependent arrival process, in notation, $(G_1,G_2)/M/m/w$. The related functions of these models are have been defined on the previous research [7].

Model 3 describes the number of customers in a $(G_1, G_2)/M/m/w$ queueing system with state dependent arrival stream. More specifically, it is like a multichannel queue $GI/M/m/w$ (of Takacs [10]), except for the input is not a "general independent," but it "varies" dependent on the queue length. If upon any arrival, the total number of customers (including those in service) are less than $m+w$, the PDF of the next inter-arrival time is $A_0(x)$. While Models 2 and 3 seem to be identical, we call them *stochastically congruent*.

Let $\pi_k^1 := \lim_{t\to\infty} P^x\{Z_t^1 = k\}$, $k = 0, 1, \ldots, m+w$, be the limiting probabilities of the process Z_t^1. These probabilities exist under the same conditions as those for the embedded process [5].

$$\pi_{m+w+1}^1 = \frac{\xi P_{m+w}}{a_0 + (\xi + \epsilon)P_{m+w}}$$

and

$$\pi_k^1 = (1 - \pi_{m+w+1}^1)\pi_k,\ k = 0, 1, \ldots, m+w$$

where

$$\xi = \frac{1}{m\mu} + \widetilde{\delta} + \frac{N}{m\mu},$$

and

$$\epsilon = \widetilde{\rho}\,\widetilde{\delta}\,\lambda\Big(1 + \frac{N}{\widetilde{\delta}\,\lambda} - \Delta^{S-N}\Big)$$

where $\widetilde{\rho}$ is the average repair time for single machine and definition of other factors are found on the previous research [7]. The stationary probabilities $P = (P_0, P_1, \ldots, P_{m+w})$ for the embedded process are known to satisfy the following formulas [8] :

$$A^{-1}P_k = \begin{cases} \sum_{r=k}^{m-1}(-1)^{r-k}\binom{r}{k}U_k, & k = 0, \ldots, m-1, \\ Q_{m+w-k}, & k = m, \ldots, m+w, \end{cases}$$

where

$$A^{-1} = U_0 + \sum_{j=0}^{w} Q_j,$$

$$Q(z) = Q_0 \cdot \frac{\alpha^0(m\mu(1-z)) - \alpha(m\mu(1-z))z}{\alpha^0(m\mu(1-z)) - z},$$

$$U_r = a_n^0 \sum_{r=n+1}^{m} \frac{W_r}{a_r(1 - \frac{1}{a\mu r})}$$

where $Q(z)$ is the generating function, convergent in the open disc centered at zero. All of other related factors are defined in [8]. By using the Kolmogorov differential equation and the semi-regenerative techniques [4-8], this system has been solved by Dshalalow [3]. The limiting distribution $\pi = \{\pi_0, \pi_1, \ldots, \pi_{m+w}\}$ is:

$$\begin{cases} \pi_0 = 1 - \sum_{n=1}^{m+w} \pi_n & , k = 0, \\ \pi_k = \frac{P_{k-1}}{k\mu PA} & , k = 1, \ldots, m-1, \\ \pi_k = \frac{P_{k-1}}{m\mu PA} & , k = m, \ldots, m+w \end{cases} \quad (2.1)$$

where

$$PA = a_0(P_0 + \ldots + P_{m+w-1}) + aP_{m+w}$$

For the process Z_t^1, the corresponding formulas yield

$$\pi_k^1 = \frac{a_0 + \epsilon P_{m+w}}{a_0 + (\xi + \epsilon)P_{m+w}} \pi_k, \; k = 0, \ldots, m+w, \quad (2.2)$$

$$\pi_{m+w+1}^1 = \frac{\xi P_{m+w}}{a_0 + (\xi + \epsilon)P_{m+w}}, \quad (2.3)$$

along with (2.1).

2.2. Optimization of networked backup servers

The stochastic optimization techniques are used for the sample illustration of the optimization and the stochastic optimization techniques by itself can be applied to real-world problems such as computer-networking, human resources and manufacturing process. Let a strategy, say Σ, specify, ahead of the time, a set of acts we impose on the system and the system can be subject to a set C of cost functions. The general formula of stochastic optimization is [5, 7, 8]:

$$\phi(\Sigma, C) := \lim_{t\to\infty} \frac{1}{t} \phi(\Sigma, C, t) \quad (2.4)$$

Now we turn to convergence theorems for semi-regenerative, semi-Markov, and Markov renewal processes [1],

$$\text{(i)} \quad \lim_{t\to\infty} \frac{1}{t} R^i(t) = \frac{1}{PM}$$

$$\text{(ii)} \quad \lim_{t\to\infty} \frac{1}{t} \int_0^t P^i\{Z_s^1 = k\} ds = \pi_k^1$$

$$\text{(iii)} \quad \lim_{t\to\infty} \frac{1}{t} \int_0^t P^i\{Y_u^1 = k\} du = \frac{P_k M_k}{PM}$$

to arrive at the objective function $\phi(\Sigma, C)$, which gives the total expected rate of all processes over an infinite horizon. As a reasonable performance measure, let us consider the reliability factor ϱ, which represents the probability of the number of intact machines at any moment of time in equilibrium:

$$\varrho = \sum_{k=m}^{m+w+1} \pi_k^1. \quad (2.5)$$

This is not only a reliability measure of the system, but it can also serve as a constraint to an optimally functioning the system. We arrive at the following expression for the sample objective function [5]:

$$\begin{aligned} \phi(\Sigma(N), C) = c \cdot \pi_{m+w+1}^1 + (G - B)\overline{Z}_\infty^1 \\ + (H - G)\sum_{k=m+1}^{m+w+1} (k - m)\pi_k^1 \\ + B(m + w + 1) + r \cdot \frac{1}{PM} \end{aligned}$$

The control level N_0 stands for the excess level of remote backup which minimizes the total cost of this system. Based on the typical simulation, the minimal cost equals 15.6445 with optimal value $N_0 = 9$. It means that we allocate our internal resources to 2 main (m) and 4 internal $(w+1)$ networked servers and obtain the threshold value $N_0 = 9$ which gives us the decision point that is the number of remote backups which we need from external resources to minimize the cost of the backup system.

3. OPERATION WORKFLOW OF THE NETWORK MANAGEMENT

The network architecture that has mentioned in the previous is the mathematical and theoretical approach to analyze the stochastic model. The operational method is the guideline for actual implementation. The workflow of operating the enhance network management can be easily adapted for software programming and simulation. All of the mathematical results from the previous sections are applied into the operational method as the initial conditions. The variables need to be defined for using the results from the mathematical model. Number of iteration, number of main and backup servers, the status of the repair facility are some of key factors for implementation. The variables for operations of enhanced network management are as follow:

n : *number of iterations*
m_n : *number of main servers at iteration n*
w_n : *number of local backups at iteration n*
S_n : *number of remote backups at iteration n*
$Q_n := m_n + w_n$
L_0 : *control level of remote backups*
c : *counting number of remote backup usage*
G : *number of servers that have been fixed within iterations*

$$Repaireman := \begin{cases} ON, & \textit{repairman is available}, \\ OFF, & \textit{repairman is on vacation} \end{cases}$$

The values in the mathematical model are applied as the initial conditions in the operational workflow but the notations are different. The delta of notations between mathematical model and operational method is shown in Table 1.

Operational	Mathematical	Descriptions
m_0	m	number of main servers
w_0	$w+1$	number of local backups
S_0	S	number of remote backups
L_0	N_0	Control of remote backups

Table 1. Delta list of the initial condition

The operational workflow can be presented after defining the initial condition (see Figure 2.) The workflow is the depiction of a sequence of operations for enhanced network management that is focused on service availability. If the operations is applied in the example case in section 2, the actual values of the initial condition are given:

$$m_0 = 2,\ w_0 = 4,\ S_0 = 15,\ L_0 = 9$$

based on the delta list (see Table 1.) The network management based on above operation workflow gives the optimal performance in server availability perspective.

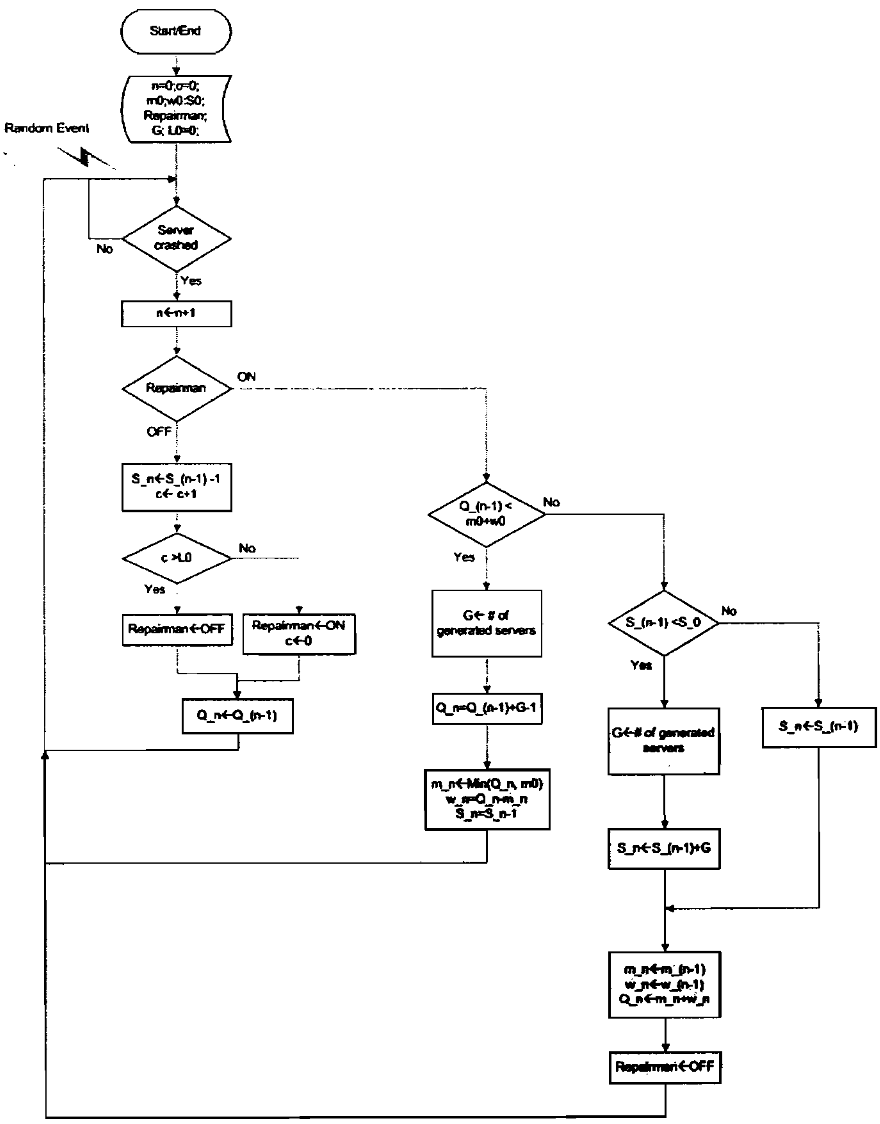

Figure 2. Operations Workflow of Enhanced Network

4. CONCLUSIONS

In this article theoretical approaches of the network defense model is presented. The explicit formulas give the key elements of the complex model of the complex model and the operational workflow has been designed for guidelines of the actual impelementions for design the network architecture.

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