2001년 한국정보처리학회 추계 학술발표논문집 제8권 제2호

An Analysis of Effects of TMN Functions on Performance of ATM Switches Using Jackson's Network

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Abstract

This paper considers the TMN system for management of public ATM switching network which has the four-level hierarchical structure consisting of one network management system, a few element management system and several agent-ATM switch pairs, respectively. The effects of one TMN command on the local call processing performance of the component ATM switch are analyzed using Jackson's queueing model. The TMN command considered is the permanent virtual call connection, and the performance measures of ATM switch are the utilization, mean queue length and mean waiting time for the processor interfacing the subscriber lines and trunks directly, and the call setup delay of the ATM switch.

I. Introduction

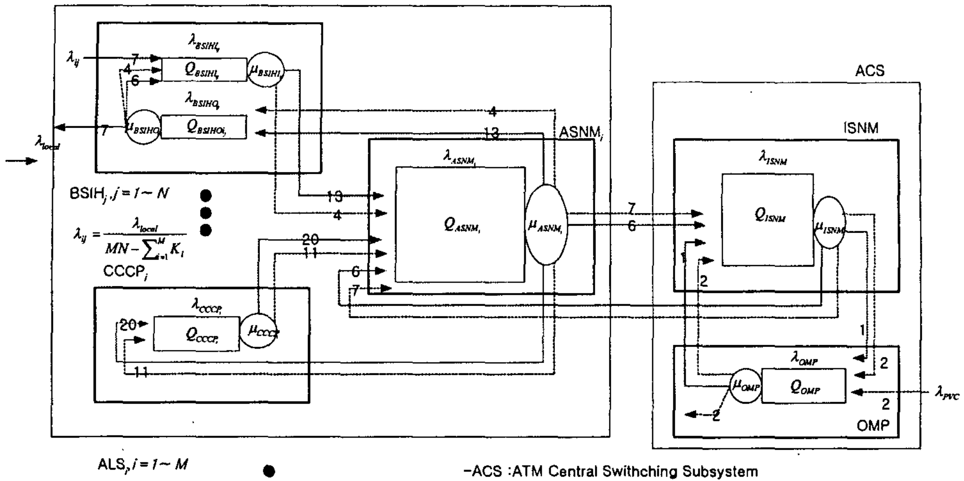
With ATM there seems to be a convergence of paradigms of the data communications and telecommunications. The efficient operation of the ATM networks requires the management and control of ATM switches [4]. The TMN is capable of managing all types of telecommunication networks and equipments as well as services. The TMN system for management and control of ATM switch networks is composed of managers and agents which are connected to each other by Q3 interface. A control module of ATM switch performs the functions related to call processing, charging and maintenance. These functions are usually carried out by exchanging the messages among the processors.

Five models between an EMS (element management system) and subordinate agents have been proposed [7] and each has been evaluated with respect to the time from agent to ATM switch. The local call processing capability of ATM switch has been analyzed with respect to the performances of the processors concerning call processing, and charging and maintenance [8]. The above papers have analyzed the local call processing performances of ATM switch without considering the effect of the TMN system which sends the management and control commands to ATM switch.

In this paper we analyze the effects of TMN functions on the local call processing capability of ATM switch using Jackson's network model. The TMN system and the ATM switches considered in this paper are developed by ETRI (electronics and telecommunications research institute)[7][14]. The TMN command considered is the PVC (permanent virtual call connection), and the performance measures of ATM switch are the utilization, mean queue length and mean waiting time for the processor interfacing to the subscriber lines directly, and the call setup delay of the ATM switch.

II. The Queueing Network Model

The Jackson's theorem is widely used for analyzing the open networks. It says that even large networks of M/M/m queues could be solved simply by multiplying the results for each queue together [2][5][11][12]. Figure II-1 shows the Jackson's queueing network for the TMN-based ATM switches developed by ETRI. The dotted lines represent the flow of messages generated by a PVC command from the TMN system, and the solid lines the flow of messages by a local call from a subscriber line. The figures on the lines are the number of messages generated per one PVC command or local call. The CCCPs (call connection control processor) perform the call–connection and control functions by exchanging messages from and to N BSIHs (basic-rate subscriber interface hardware blocks). Messages are exchanged among M CCCPs and OMP (operation and maintenance processor) via ISNM (interconnected switching network module)



-ACS :ATM Central Swithching Subsystem
-ISNM:Interconnected Switching Network Module
-OMP:Operation and Maintenane Processor
-ALS:ATM Local Switching Subsystem
BSIH:Basic-rate Subscriber Interface Hardware block
CCCP:Call Connection and Control Processor
ASNM:Access Switching Network Module
λ_i, μ_i : arrival and service rates of queue Q_i ,respectively

—M_L—→ number of messages generated per one local call
------M_{PVC}—→ number of messages generated per one PVC

K_i : number of BSIHs allocated to PVC

Figure II-1 Queueing Network Model

The first column of table II-1 shows the arrival rates of queues when an ATM switch is used for processing local calls only.

	Processing local calls only	Processing both local and PVC calls
$\lambda_{BSIHI_{ij}}$	$7\lambda_{ij} + \frac{6}{13}\lambda_{BSIHO_{ij}} = \frac{13}{MN}\lambda_{local}$	$\frac{13}{MN - \sum_{i=1}^{M} K_i}\lambda_{local} + \frac{4}{\sum_{i=1}^{M} K_i}\lambda_{PVC}$
$\lambda_{BSIHO_{ij}}$	$\frac{1}{3N}\lambda_{ASNM_i} = \frac{13}{MN}\lambda_{local}$	$\frac{13}{MN - \sum_{i=1}^{M} K_i}\lambda_{local} + \frac{4}{\sum_{i=1}^{M} K_i}\lambda_{PVC}$
λ_{ASNM_i}	$\sum_{j=1}^{N}\lambda_{BSIHI_{ij}} + \lambda_{CCCP_i} + \frac{6}{7M}\lambda_{ISNM} = \frac{39}{M}\lambda_{local}$	$\frac{39}{M}\lambda_{lcoal} + \frac{176}{8M}\lambda_{PVC}$
λ_{CCCP_i}	$\frac{20}{39}\lambda_{ASNM_i} = \frac{20}{M}\lambda_{local}$	$\frac{20}{M}\lambda_{local} + \frac{11}{M}\lambda_{PVC}$
λ_{ISNM}	$\frac{6}{39}\sum_{i=1}^{M}\lambda_{ASNM_i} + \lambda_{OMP} = 7\lambda_{local}$	$7\lambda_{local} + 9\lambda_{PVC}$
λ_{OMP}	$\frac{1}{7}\lambda_{ISNM} = \lambda_{local}$	$\lambda_{local} + 4\lambda_{PVC}$

Table II-1. Arrival Rates of Queues

III. A Numerical Analysis

Here we make a numerical analysis of the effects of λ_{PVC} on CCCP$_i$'s utilization, mean queue length and mean waiting time, and call setup delay. We assume that i) K_i BSIHs for each ALS$_i$ are allocated to processing the PVC calls, and ii) the local calls from the basic-rate subscribers are distributed uniformly among the remaining BSIHs. When an ATM switch is used for processing both the local and PVC calls, the arrival rates of queues are listed on the last column of table II-1.

We also assume that iii) the mean processing time of each of the queues of BSIHI$_{ij}$, BSIHO$_{ij}$, ASNM$_i$, and ISNM is linearly proportional to the length of a message to be processed, iv) the probability that a message is composed of n cells is p_n and v) d represents the processing time per cell. The last two columns of table III-1 show the service rates calculated under the assumed distributions of p_n and values of d [8][14]. The service rates of queues of CCCP$_i$ and OMP are assumed to be 1000 messages per second, respectively [8].

	p_n		d (sec)	Service rates	
	local calls only	both local and PVC calls		local calls only	both local and PVC calls
$\mu_{BSIHIij}$ or $\mu_{BSIHOij}$	$\begin{cases} 11/13 & n=1 \\ 1/13 & n=2 \\ 1/13 & n=6 \\ 0 & o/w \end{cases}$	$\begin{cases} 15/17 & n=1 \\ 1/17 & n=2 \\ 1/17 & n=6 \\ 0 & o/w \end{cases}$	$2.12 \times E(-6)$	$\frac{13 \times 2.12E(6)}{19}$	$\frac{221 \times 2.12E(6)}{331}$
μ_{ASNMi}	$\begin{cases} 26/39 & n=1 \\ 7/39 & n=2 \\ 2/39 & n=4 \\ 2/39 & n=6 \\ 2/39 & n=9 \\ 0 & o/w \end{cases}$	$\begin{cases} 42/61 & n=1 \\ 9/61 & n=2 \\ 4/61 & n=4 \\ 2/61 & n=6 \\ 4/61 & n=9 \\ 0 & o/w \end{cases}$	$1 \times E(-6)$	$\frac{1 \times E(6)}{2}$	$\frac{61 \times E(6)}{124}$
μ_{ISNM}	$\begin{cases} 2/7 & n=1 \\ 2/7 & n=2 \\ 2/7 & n=4 \\ 1/7 & n=9 \\ 0 & o/w \end{cases}$	$\begin{cases} 6/15 & n=1 \\ 4/15 & n=2 \\ 3/15 & n=4 \\ 2/15 & n=9 \\ 0 & o/w \end{cases}$	$1 \times E(-6)$	$\frac{7 \times E(6)}{23}$	$\frac{15 \times E(6)}{44}$

Table III-1. Service Rates of $Q_{BSIHI_{ij}}$, $Q_{BSIHO_{ij}}$, Q_{ASNM_i}, and Q_{ISNM}

Under the above assumptions formulas for the utilization, mean queue length and mean waiting time of CCCP$_i$ and call setup delay can be easily calculated using the Jackson's results [2][5] as follows:

- The utilization of CCCP$_i$

$$\rho_{CCCP_i} = \frac{\lambda_{CCCP_i}}{\mu_{CCCP_i}}$$

- The mean queue length of CCCP$_i$

$$L_{CCCP_i} = \frac{\rho_{CCCP_i}}{1 - \rho_{CCCP_i}}$$

- The mean waiting time of CCCP$_i$

$$W_{CCCP_i} = \frac{1}{\mu_{CCCPi} - \lambda_{CCCP_i}}$$

- The call setup delay

Eleven (11) and one (1) messages are processed at the CCCP$_i$ and OMP, respectively, during the call setup [8][13].

$D = 11 \cdot W_{CCCP_i} + W_{OMP}$, where W_k is the mean waiting time of queue k

Assuming that an ATM switch processes both local and PVC calls, and that fourteen (14) and one (1) BSIHs of one ALS are allocated to local calls and PVC, respectively, figures III-1 to III-4 show the ratios of $\rho_{CCCP_i}, L_{CCCP_i}, W_{CCCPi}$, and D when processing both local and PVC calls to $\rho_{CCCP_i}, L_{CCCP_i}, W_{CCCPi}$, and D when processing local calls only in a function of λ_{local} for the cases where $\lambda_{PVC}/\lambda_{local}$ are 0.2 and 0.1, respectively.

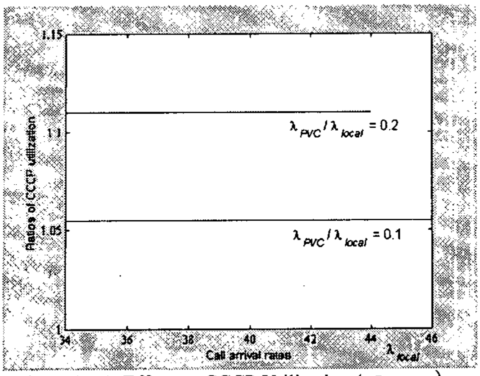


Figure III-1. Effect on CCCP Utilization (ρ_{CCCP_i})

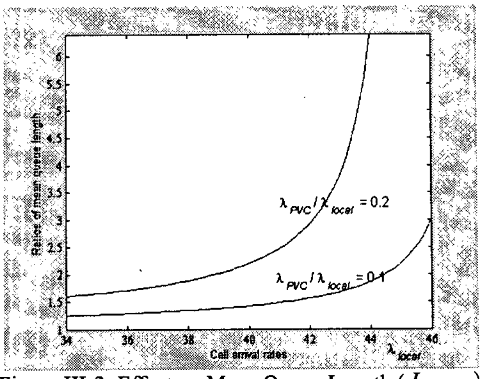


Figure III-2. Effect on Mean Queue Length (L_{CCCP_i})

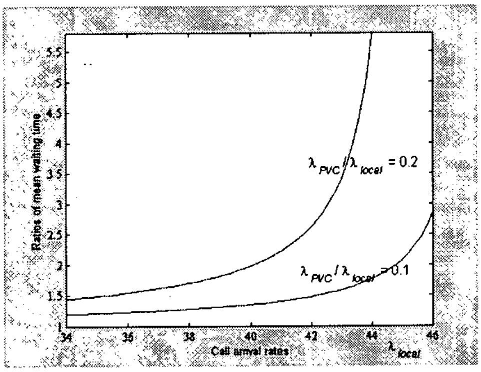


Figure III-3. Effect on Mean Waiting Time (W_{CCCP_i})

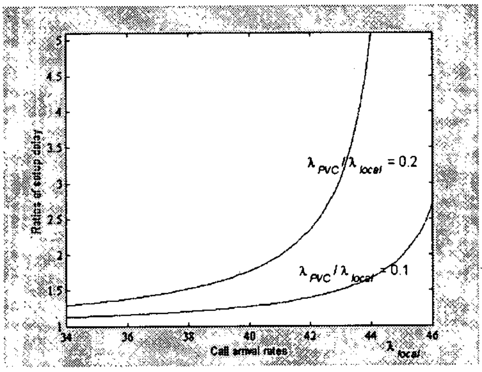


Figure III-4. Effect on Call Setup Delay (D)

It can be said from the figures that the effect of PVC from the TMN deserves much consideration into the design of the TMN network.

IV. Conclusion

In this paper we analyzed the effects of TMN functions on local call processing performances of ATM switches developed by ETRI using the Jackson's method for the open queueing networks. The analysis of the effects of λ_{PVC} on CCCP's utilization, mean queue length and mean waiting time, and call setup delay has been made. We can see that the effects of the PVC calls on the performance of ATM's local call processing deserves to be taken into consideration.

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