マルチメディア通信と分散処理　57－5
(1992. 9. 24)

ネットワークフロー制御支援エキスパートシステム

イマド　ハッサン　ラシッド　　小林広明　　中村維男

東北大学工学部

あらまし　本論文では、スイッチングシステムにおける呼のフロー制御支援のためのエキスパートシステムを提案する。本エキスパートシステムは、直接接続されたノード間の呼の流れを変え、トラフィック量の多いリンクにチャネルを追加することにより、多くの呼が迂回経路を通ることなく、直接リンクにより目的ノードに到達するようにフロー制御を行なう。本エキスパートシステムでの意志決定に必要なトラフィックの定量化のための理論モデルについて議論する。

和文キーワード

Expert System Aid in Networks' Flow Control

Emad Rashid　Hiroaki Kobayashi　Tadao Nakamura

TOHOKU UNIVERSITY
Dept. of Machine Intelligence
and Systems Engineering
Tohoku University
Sendai 980.

Tel: (022)-222-1800 Ext: 4137　Fax: (022)-268-3695

Abstract　This paper introduces an expert system's decision making process into telecommunication to assist in flow control of calls in switching systems. The decision can be made to change flow of calls direction from output to input or vice versa in direct routes. The strategy uses temporary modifying data for low traffic trunks between source and destination. The new modified trunks are added to high traffic links under uncertain load traffic measure with given hardware systems. Our propose is to utilize the trunks that have low traffic measure, in order to add them to higher traffic links. Moreover, we can use network resources more efficiently in view of economics enhancement. Therefore, more calls will be allowed to pass through a direct rout before attempting to take an alternative route by providing new resources. The theoretical model for the traffic and its traffic measurement where the decision can be made to re configure trunks' scheme are discussed in this paper.

英文 key words　Switching System, Flow Control, Expert System, Heuristic Algorithm

I. INTRODUCTION

Electronic switching systems become a fully electronic stored program control. They provide more flexibility in traffic network flow control and maintains more grade of service to customers. Flow control has intensively been used in telecommunication network algorithms to reduce network blocking, and to avoid congestion in the networks under heavy traffic load.

The flow control algorithms are implemented in the stored program control for switching systems to let the calls be served by direct link resources or alternative link resources. These algorithms may exhibit weakness for the calls to allocate resources in the present of network overload due to the constraints in the number of resources. From economic point of view, we need better utilization of the network resources if the network resources hardware is limited or difficult to expand.

The calls' connections in switching systems are passing through direct routes in a normal traffic fashion. Otherwise, the calls will carry by an alternative route in case of a heavy traffic on direct route.

The existence of alternative route choices may make the network more flexible for the calls to get destination under low traffic conditions. Occasionally, in the presence of networks under heavy load conditions the calls choosing an alternative route has a major impact on the overall network performance.

The traffic rate leads to the network's instability due to increasing in blocking rate. Besides, the call will pass through intermediate switching systems which effect on their equipment operation. Overload stabilization can be improved by utilizing low traffic trunks in specific busy hour period. This can be made by changing trunk's category from outgoing to incoming and vice versa to create new trunks. These new trunks can be adding to a certain group of trunks that have excessive blocking during a busy hour period or uncertain heavy load. Switching system's software require to be dynamic data structure and more flexibility in modification its office data when the system face uncertain overload periods. A control strategy for such modification is modeling in the context of expert system.

Many researchers investigated to enhance traffic performance and minimize blocking level in networks. An approach based on trunks' reservation was discussed in [1] where alternative roue will be blocked if there are less than a certain number of free trunks in the alternate paths. External blocking is another strategy to stabilize routing algorithms. This strategy was discussed in [2] where the calls are allowed to attempt alternate paths only if certain conditions are satisfied. An adaptive control strategy was discussed in [3] in which the calls are allowed to wait for valuable resources in a limited time before attempting a standard alternate routing policy.

Switching systems' software required to be dynamic data structure and more flexibility in modification of their office data when the system faces uncertain overload periods.

The network that use dynamic reconfiguration of its flow calls direction provides a significant opportunity to reduce network blocking. A control strategy for such reconfiguration imposes by aid decision making software, which is a model of the context of expert system.

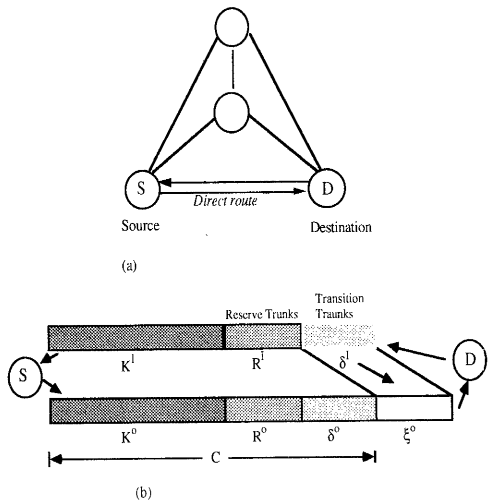

Fig. 1. (a) Routing in a telecommunication Network. (b) Outgoing and incoming trunks in the direct route.

II. OUTGOING AND INCOMING LINKS

Each path or route has two types of links in opposite direction. One is incoming call to the source the other is outgoing call from the source (see figure 1). Each outgonig or incoming link consists of groups of trunks (channels). In full electronic switching systems, the physical electronic board connections for outgoing and incoming are identical, but the difference is in the software package assignment for outgoing and incoming in the source and destination, respectively. Trunk's reconfiguration is the process of changing flow calls direction. To reconfigure the outgoing and incoming trunks requires to change in system office data assignment (ODA) facility. ODA is the procedure of identifying which trunk is incoming or outgoing between two systems connections. This can be done by sending the sequence of commands to each system that is required for reconfiguration. In figure 1 (a) and (b) is depicted the network connection and the total number of the trunks in the incoming /outgoing link, respectively.

Let the total number of incoming or outgoing link be C. The link C is partitioned into three groups fixed trunk; reserve trunk, and transition trunk K, R, δ, respectively. In the fig.(1), the symbol with I or O accent mean the trunk is used for incoming and outgoing, respectively.

III. MODEL DESCRIPTION

In the following we describe the theoretical model for traffic and traffic measurement in which the decision can be made to reconfigure trunks' category. We assume that the calls will be arrived according to Poisson process with a mean arrival rate of λ. The average call holding time is exponentially distributed with parameter μ. When all trunks are busy, the call will choose an alternative path. We suppose R is similar to reserve trunk strategy (see [2]), but the goal is different. In case of reverse trunk in [2], when there are no more free trunks, all alternative route calls will be banned on that route. In our strategy we choose reserve trunks as control trunks to support the expert system's decisionmaking process by adding and removing new temporary trunks. We will call these trunks transitory trunks (ξ). Meanwhile, the calls can pass through these trunks under heavy traffic condition. When the traffic becomes normal condition, all modify transitory trunks return to ordinary condition. We suppose the number of outgoing trunks and incoming trunks are equal. Let m, j, and k be the total number of trunks K, R, and δ, respectively.

$$K_i^o = \{ K_1^o, K_2^o, \ldots\ldots, K_m^o \}$$
$$R_i^o = (R_1^o , R_2^o , \ldots\ldots, R_j^o)$$
$$\delta_i^o = (\delta_1^o , \delta_2^o , \ldots\ldots, \delta_k^o)$$

Where m, j, and k are outgoing trunks' capacity for K_i^o, R_i^o, and δ_i^o respectively. Then, the total number of outgoing trunks C^o is obtained as follows:

$$C = \sum_{i=0}^{m-1} K_i^o + \sum_{i=0}^{j-1} R_i^o + \sum_{i=0}^{k-1} \delta_i^o \qquad \ldots\ldots\ldots\ldots (1)$$

We assume the traffic rates to be independent at each link.

We have Markov chain that flows arrival process can be controlled by specific resource in direct route. The blocking probability of the direct link and alternative link is B_d, B_a respectively. The blocking probability of the direct calls is given by Erlang formula A=(λ/μ). where A is traffic offered load. Calls are served immediately if at least one trunk (resource) is free. Otherwise, the calls will choose alternative path when all trunks are busy. The calls arrival may found in one of these three cases.

Case 1:

The calls will be served immediately when the busy server or trunk n is less than the total number of trunks. By using Erlang formula

$$B_d = \frac{A_d^n}{n!} P_0 \qquad n \le C^o \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where A_d in equation (2) is traffic offered load in direct route.

Case 2:

When the calls are served by first reserve trunk (i.e., first trunk on R becomes busy), the switching system will send a message to expert system. It means the system is toward heavy load. In this time a new trunk will prepare to be added to outgoing trunks. If more R trunks become busy, then it will more new trunks to the outgoing link until all R become busy. Modifying trunks for transition ones must satisfy a given set of constraints in which the new trunk must be created within limits at busy / idle status.

Assumption 1: $R_i^o \prec \delta_i^I$

This means that the transition trunks for incoming δ^I cannot be start modifying until all constraints are satisfied. These constraints are satisfied when at least one of the reserve trunks for outgoing trunks (R_1^o, R_2^o, ..., R_i^o) becomes busy and should all reserve trunks for incomig (R_1^I, R_2^I, ..., R_i^I) should become idle.

Assumption 2: The number of transition trunks δ should be greater than the number of reserve trunks (R) in the same link.

$$\sum_{i=1}^{k} \delta_i^I > \sum_{i=1}^{j} R_i^I$$

The time elapses by expert system to realize the problem and make modification more calls will burst to the link. These calls will occupy more resources in the link. Therefore, the expert system requires early alerting when reserve trunks R's are busy or the system is towards overload to make early trunks' modification. Then, the calls will be able to obtain more resources before congestion occures in the network.

We suppose the number of reserve trunk R's for incoming and outgoing are equal.

t_z= time elapseing by expert system to complete modifiy one trunk.

Z= the number of calls arrived during a modification process.
$= \lambda t_z$

$$B_d = \frac{A_d^n}{n!} P_0 \quad (1 \le n \le K+Z-1) \ldots\ldots\ldots\ldots\ldots (3)$$

$$B_d = \frac{A_d^{n+\xi}}{(n+\xi)!} P_0 \quad (K+Z \le n \le C) \ldots\ldots\ldots\ldots\ldots (4)$$

where the normaliztion is as follows

$$P_0 = \left[\sum_{i=0}^{K+Z-1} \frac{A_d^i}{i!} + \sum_{i=K+Z}^{C} \frac{A_d^{i+\xi}}{(i+\xi)} \right]^{-1} \qquad \text{....................(5)}$$

Here j is a total number of transitory trunks ξ that are added to the outgoing link.

Case 3

The new trunks ξ will allow more traffic passes through. The calls will utilize the new trunks. If arrival calls time is more than release or holding time, the system will exhibit blocking condition. It means the percentage of the calls unable to obtain network resources. In these circumstances, we need to stabilize network blocking by letting the calls to be carried on alternative path A_a .

$$B_t = \frac{A_d^{C^o+\xi} \, A_a^{n-C^o-\xi+1}}{n!} P_0 \qquad \text{.................... (6)}$$

Where the normaliztion

$$P_0 = \left[\sum_{i=0}^{C^o+\xi-1} \frac{A_d^i}{i!} + \sum_{i=C^o+\xi+1}^{n} \frac{A_d^{C^o+\xi} \, A_a^i}{i!} \right]^{-1} \qquad \text{........... (7)}$$

(For more details on the derivation of these equations, see [5] and[6]).

IV. EXPERT SYSTEM

An expert system represents an appropriate set of tools for capturing the knowledge needed to define requirements for its decision making processes to reconfigure trunks' direction. It aimes at expanding the range of resources in direct routes that could exploit reduction in the network's blocking. Figure (2) shows that expert system is connected to each switching system through control links. The link uses for receiving update traffic information such busy-idle trunks' status from each system. Traffic information store in the expert system's database and can use it in a reasoning process. It's conceivable to use a self control node (switching system) instead of the expert system. This may be done by connecting each node with adjacent nodes through control links. The disadvantage of the self control node is, firstly: we may face on an unavoidable deadlock problem, if one of the adjacent nodes is failure. Second, each swiching system should have exiplict information such commands, office data related to adjacent nodes, and control data. All of these need enough memory space in main memory of the system extermly costly. Third, we need to expand the control structure of the system that may effect on the system operation and system preformance. For these reasons, we use the expert system in such an environment. We can consider several tasks that perform: diagnosis, monitoring, prediction to forcast the busy peroid to be taken into acount. the expert system has ability to lean from dealy traffic measure and equire new knowledge to take prematurely action before

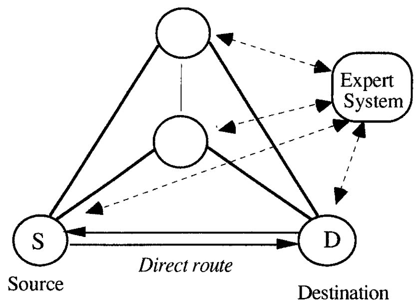

Fig. 2. Network Controlled Routing

A. KNOWLEDGE BASE

A Knowledge base is used to store the representation of the domain problems. For example, it stores the necessary knowledge about traffic problems, and consists of facts and heuristic rules.

B. DATABASE

A Database contains explicit commands related to office data. Therefore, the expert system will send the sequence of commands to a system that is required changing in its office data.

The office data change is related to trunk classes, routing and trunk assignment. The modification can be specified by sequence commands to be sent to the source and destination.

The database consists of a dynamic database and a static database. The dynamic database contains temporary information about daily traffic measure and busy/idle trunks' status record. The letter contains static information such commands that need to modify switching system's software. It contains explicit office data for trunks and subscribers for each system connected.

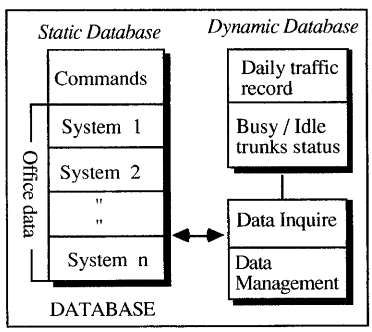

Fig. 3. Database

C. INFERENCE ENGINE

The inference engine is a control structure using rules and facts in the knowledge base. The reasoning processes are associated with information from database and knowledge base to take suitable decision to dispatch commands to switching systems. To reduce congestion probability in the network, it is necessary to reduce time elapse during the reasoning process. Therefore, the reasoning process must be designed for efficiency and speed. See [7], [8]. The control structure for inference engine needs to be real time system to face certain requirements. First, it must dispatch commands to switching systems within limit times to make repaid modifying trunks. Second, the modification process's elapse time needs to be at minimum time before the calls accumulate on the link. The result in aggregation of calls' arrival in the link without created new resources leads to network congestion.

V. HEURISTIC ALGORITHM

Heuristic algorithms are a technique that improves the efficiency of problem solving process. The algorithm is based on the shortest processing used in inference structure of expert systems (see [4]).

We suppose two systems l, m are connected through a link containing outgoing trunks from l and incoming to m. We can write as l -----> m

When first's reverse trunk (R) is busy

CHANGE TRUNK'S IDENTITY FOR TRANSITION TRUNKS($\delta^{m\to l}$)

```
begin
  for i <-----1 to j
      while R^{l->m} (i) = 1 (busy)
      for S_(l,m) do
        OPEN_DATABASE
        TRAFFIC_OBSERVATION_ Link (for L_{m->l} and
                                        L_{l->m} )
        (Check last Traffic measure )
      ASSIGN free Transition trunks number δ^{m->l}
      endfor
  endfor
  (Changing office data for system m by sending sequence of
commands from expert system to system m )
  OFFICE DATA_CHANGE_ MODE_ S_(l,m)
  for all S_(l,m) , where R^{m->l} ≠ 1 (busy) do
    for i <----- j - 1 downto 0 do
      Make_Block δ^{m->l}(i)
      (Change link direction from incoming to outgoing for
        trunks δ^{m->l}(i))
      Change_Link_Identity δ^{m->l}(i)
      Change_Trunk_Clase δ^{m->l}(i)
      for n <----- 1 to j do
        δ^{m->l}(i) <----- ξ^{l->m}(n)
        Make_Ideal ξ^{l->m}(n)
        if R^{m->l}(i) = 1 (busy) AND ξ^{l->m}(n) = 0 (free)
         then
          for n <----- j-1 downto 0 do
           for all S_(l,m) do
              Make_block ξ^{l->m}(n)
              Change_Link_Identity ξ^{l->m}(n)
              Change_Trunk_Clase ξ^{l->m}(n)
               for k <----- 1 to j do
                  ξ^{l->m}(n) <----- δ^{m->l}(k)
                  δ^{m->l}(i) <----- δ^{m->l}(i)
                                  + δ^{m->l}(k)
                  Make_Ideal δ^{m->l}(i)
               endfor
            endfor
          endfor
        endif
      endfor
    endfor
  endfor
end
```

VI. SIMULATION RESULTS

In this section, we evaluate the performance of the reconfiguration trunks for outgoing and incoming in the same link through numerical examples. Using the analysis, we have investigated the effects of changing flow calls direction on the system performance in terms of the blocking probability, traffic offered, and accumulate arrivel calls during the modification process.

Fig. 4 illustrates the link blocking against the trunks' capacity for various offered traffic values. Fig. 4 (a), shows blocking probability in previouse model when there is no modification accure. In fig. 4 (b) the link is controlled by expert system when the link is towards a heavy load. We choose fixed trunk k=10, accumlate arrivals during modification Z=1, and rverse trunks R=5.

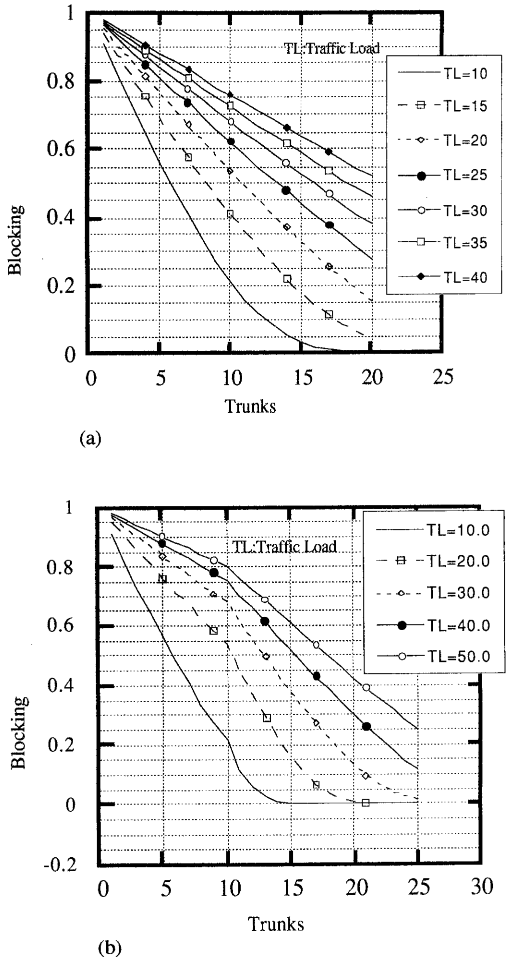

Fig. 4. Blocking versus trunks' capacity. (a) in previous model. (b) in a new model with different traffic offered.

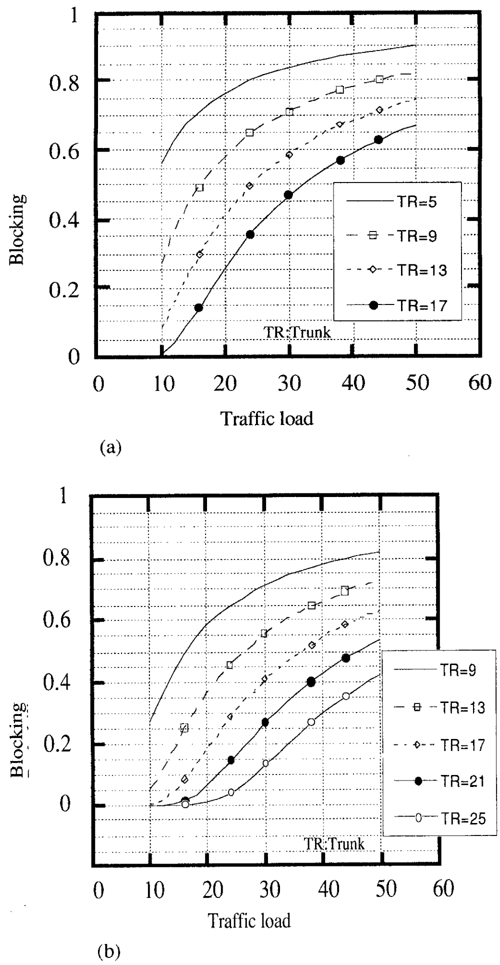

Fig. 5. Blocking versus traffic load with different capacity trunks in previous model. (a) in previous model. (b) in a new model

Fig. 5 shows blocking probability versus traffic offered with different trunks' capacity. Blocking with no modify trunks' strategy is plotted in fig. 5 (a), while fig. 5(b) shows the effectiveness of modifing trunks' strategy on blocking aganist traffic load with verious capacity of the trunks. This model can lead to larg reduction in network blocking to approximately 30%.

Fig. 6 shows blocking against the accumulate arrival calls during modification(Z). Fig. 6(a) is with different trunks' capacity. Fig.6(b) is with various traffic load. In fig. 6(a) the blocking has increased slightly about 10% for one arrival during modification process.

In fig. 6(b), we can see serious increasing in blocking when Z increases with various traffic offered. For this reason, we need to reconsider the desgin of reasoning process algorithms to be effective and speedy to enhance network proformance. Fig. 7, has the same results as thoseobtaind in fig. 6 (b). Fig. 8, shows blocking versus fix trunks (K) with different total trunks (C).The blocking is increasing with increase in fix trunks K. So, we can obtain signficant results if we choose less value offix trunk (K).

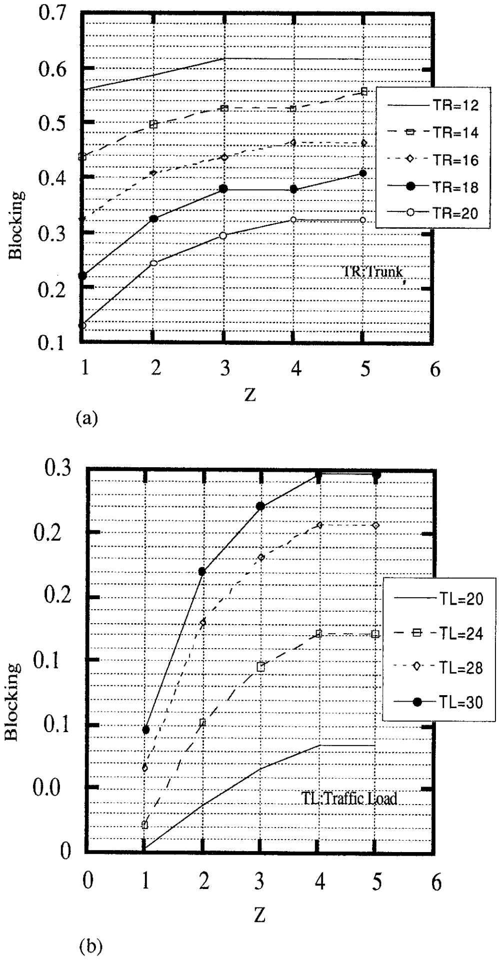

Fig. 6. Blocking versus (Z) with (a) virous capacity trunks. (b) virous traffic load.

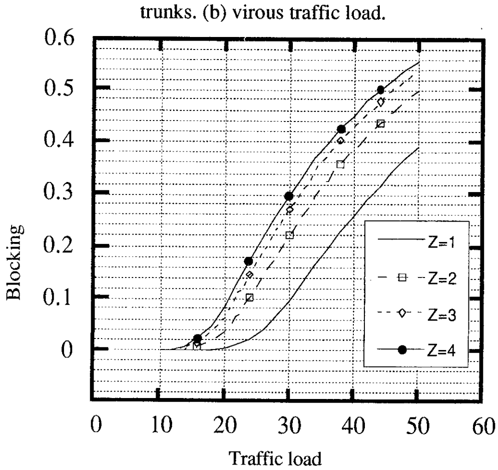

Fig. 7. Blocking versus traffic load with different (Z).

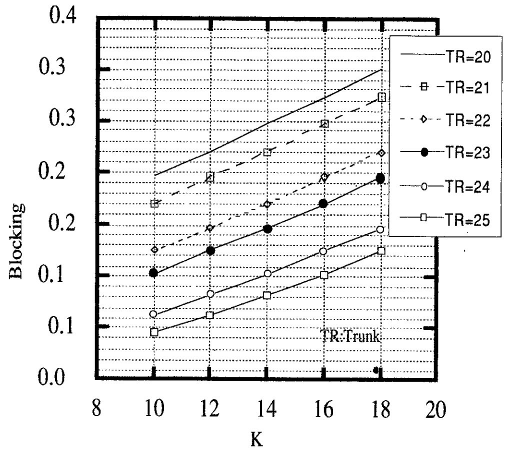

Fig. 8. Blocking versus fix trunks (K) with different total trunks (C).

VII. CONCLUSIONS

In this paper, we have presented economics prospect by modifying trunks category in the same link and changing flow call direction. This mechanism has been proposed to let more flow call serve by new trunks. The result is to relieve congestion in the network. Also, our propose is to utilize the maximum number of free trunks in specific direction, which have low traffic measure and add to a link with high traffic. Moreover, we can use network resources more efficiently in view of economics enhancement. Therefore, the calls will be allowed to pass through a direct rout before attempting to take an alternative route.

REFERENCES

(1) J. M. Akinpelu, " The overload performance of engineered networks with nonhierachical and hierarchical routing, " Bell Labs Tech. J., Vol. 63, pp. 1261-1284, 1984.

(2) T. K. G. Yum and Schwartz, " Comparison of routing procedures for circuit-switched traffic in nonhierarchical networks, " IEEE Trans. Commun., vol. COM. 35, no.5, pp. 535-544, May 1987.

(3) A. Weinrib and Gita Gopal., " Limited Waiting: An Adaptive Overload-Control Strategy for Circuit Switched Networks, " IEEE Jour. on Selec. Area in Comm., vol. 9, no. 2, pp. 157-164, Feb. 1991.

(4) D. B. Lenat, " The Nature of Heuristics," Artificial Intelligence vol. 19, pp.189-249, 1982.

(5) D. Gross and C. M. Harris, " Fundamentails of Queue ing Theory," John& Sons, Inc.USA, 1974.

(6) Ryszard Syski, " Introduction to Congestion Theory", Elsevier Science Publishers B. V. North-Holland-Amsterdam,1986.

(7) J. R. Fox, G. M. Slawsky, " The Role of Expert Systems in Switch Maintenance operations and the Generetion of Switch Analysis Requirements", IEEE Jour. on Selec. Areas in COMM., Vol. 6, No. 4, pp. 706-714, May 1988.

(8) M. T. Sutter, P. E. Zeldin, "Designing Expert Systems for Real-Time Diagnosis of Self -Correcting Networks," IEEE Network Magz., pp 43-51, September 1988.