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A Comparison of Methods for Internet Traffic Sharing in Computer Network

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ABSTRACT

Naldi presented a Markov chain model based analysis for the user's behaviour in a simple scenario of two competitors. The model is applied to predict influence of both parameters (blocking probability and initial preference) on the traffic distribution between the operators. It is also shown that smaller blocking competitors can be benefited from call-by-call basis assumption. In this paper this criteria of Call-by-call attempt is converted into two call attempts and new mathematical results are derived. A comparative study between call-attempts is made with Naldi [1] expressions. It is found that, by two-call attempt model, the operator gains more traffic than one-call attempt.

Keywords: Blocking probability, Call-by-call basis, Internet Service Provider [operators], Internet access, Internet traffic, Markov chain model, Network congestion, Quality of service (QoS), Transition probability matrix, Users behavior.

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I. INTRODUCTION

A user of internet services has a big proposition among all through out the world. These services are provided by operators (Internet Service Providers) by the help of wide area network in a region. A broad band connectivity is easier and few attempts one can achieve the call connection but dialup based connectivity often takes a large number of call attempts to be connected.

Markov Chain Model is a technique of exploring the transition behavior of a system. Naldi [1] has opened up the problem of internet traffic sharing evaluation. Shukla and Gadewal [2] have shown the application of Markov Chain model to the modelling of space division switches. In similar type of contribution Shukla and Gadewal et. al. [3] has provided the modelling approach for know-out switches. Shukla and Thakur [8] have predicated useful contribution for modelling of internet traffic sharing phenomena between two operators in competitive markets. Vern Paxson [16] has discussed the experiences with different measurement and analysis with Internet Traffic.

Shukla and Tiwari [15] have given a modelling approach for Internet Traffic in the presence of rest state. Medhi [11],[12] has discussed the foundational aspects of Markov chains in the context of stochastic processes. Dorea and Rajas [18] have shown the application of Markov chain models in data analysis. Aggarwal and Kaur [14] have on reliability analysis of fault-tolerant in a multistage interconnection on computer networks. Yuan and lygevers [6] obtained the stochastic differential equations and proved the criteria of stabilization for Mrakovian switching.

Newby and Dagg [13] presented a maintenance policy for stochastically deteriorating systems, with the average cost criteria. Shukla, Pathak and Thakur [9] have shown the use of this kind of model based approach to explain and specify the behavior of internet traffic users. Shukla and Sarabh et. al. [7] have a using a markov model for analysis on some problem. Babikur Mohd. et.al [4] has shown the flow ased internet traffic classification for bandwidth optimization. Some other useful similar contributions are due to Perzen[10] and Agarwal [5].

The model of Naldi [1] is based on dial-up setup in which the user behaviours are assumed as following systems:

II. SYSTEM-I

(a) Suppose two operators O_1 and O_2 are in competition in the market.

(b) The user initially chooses one of the two operators (indicated as O_1 and O_2) with probability *p* and *1-p* (initial shares) respectively.

(c) The probability *p* can take into account all the factors that may lead the user to choose one of the two operators as his first choice, including the range of services it offers and past experience.

(d) After each failed attempt the user has two choices: he can either abandon (with probability p_A) or switch to the other operator for a new attempt.

(e) Switching between the two operators is performed on a call-by-call basis and depends just on the latest attempts.

During the repeated call attempt process the blocking probability L_1 and L_2 (i.e. the probability that the call attempt through the operator O_1 and O_2 fails) and the probability of abandonment p_A stay constant.

The transition diagram of a behaviour system-I is in Fig. 1 is listed here

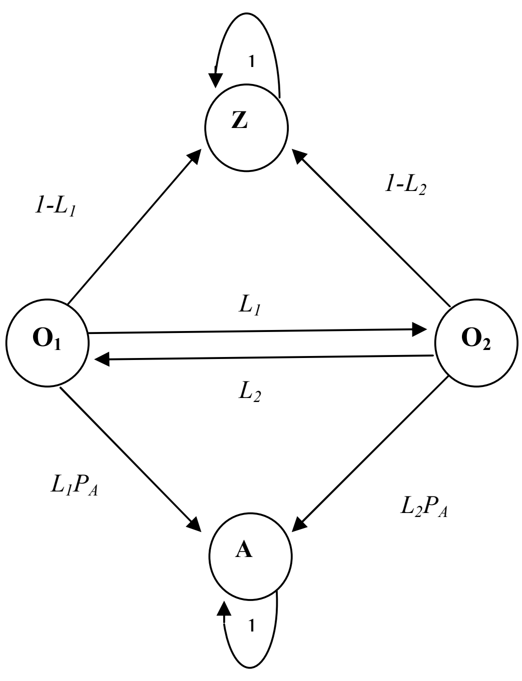

Fig 1 (Transition diagram for system-I)

The limitation of system-I by Naldi [1] is the assumption of connecting attempts on call-by-call basis. If this assumption released a bit then we have another system definition for user's behavior as described below.

III. SYSTEM-II

(a) The user initially chooses one of the two operators (indicated as O_1 and O_2) with probability *p* and *1-p* (Initial shares) respectively.

(b) The probability *p* can take into account all the factors that may lead the user to choose one of the two operators as his first choice, including the range of services it offers and past experience.

(c) After each failed attempt the user has two choices: he can either abandon (with probability p_A) or switch to the other operator for a new attempt.

(d) The switching between two operators is on two call basis, which means if call attempt on O_1 is failed then user is allowed to make one more call attempts with O_1, if this also fails them user is to move to O_2 for next attempts. Similar happens for operators O_2.

(e) During the repeated call attempt process the blocking probability L_1 and L_2 (i.e. the probability that the call attempt through the operator O_1 and O_2 fails) and the probability of abandonment p_A stay constant.

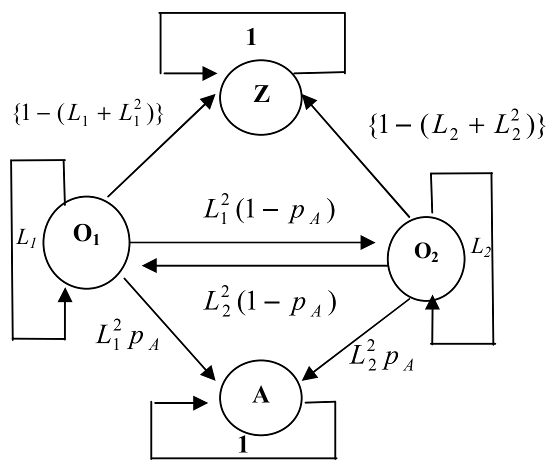

Fig 2 (Transition diagram for system-II)

IV. USER'S CATEGORIZATION

Based on position of system in n attempts, one gets:

(a) Faithful User (FU):

Who is faithful to ISP_1 otherwise prefer for the rest state (RS) or abandoned but does not attempt for ISP_2. The converse of same is for ISP_2. A group of this kind is defined as faithful users for ISP_1 {or ISP_2}.

(b) Partially Impatient User (PIU):

Who attempts between the two service providers only, ISP_1 and ISP_2, all the time until call completes or abandoned but never goes to RS.

(c) Completely Impatient User (CIU):

User who attempts to ISP_2 or goes to rest state RS in the $(n+1)^{th}$ attempt when was at ISP_1 in the n^{th}. Moreover, when was at ISP_2, moves to either ISP_1 or on RS in the next.

The transition diagram of a behaviour system-II is in Fig. 2.

V. TRANSITION PROBABILITY MATRIX:

SYSTEM-I

States $X^{(n)}$ (columns); States $X^{(n-1)}$ (rows)

	O_1	O_2	Z	A
O_1	0	$L_1(1-P_A)$	$1-L_1$	L_1P_A
O_2	$L_2(1-P_A)$	0	$1-L_2$	L_2P_A
Z	0	0	1	0
A	0	0	0	1

Fig 3 (Transition probability matrix for system-I)

SYSTEM-II

States $X^{(n)}$ (columns); States $X^{(n-1)}$ (rows)

	O_1	O_2	Z	A
O_1	L_1	$L_1^2(1-P_A)$	$\{1-(L_1+L_1^2)\}$	$L_1^2P_A$
O_2	$L_2^2(1-P_A)$	L_2	$\{1-(L_2+L_2^2)\}$	$L_2^2P_A$
Z	0	0	1	0
A	0	0	0	1

Fig 4 (Transition probability matrix for system-II)

Computation of probabilities under Markov chain model in system-I are the starting conditions (state distribution before the first call attempt) are

$$P[X^{(0)}=O_1]=P,$$
$$P[X^{(0)}=O_2]=1-P,$$
$$P[X^{(0)}=Z]=0,$$
$$P[X^{(0)}=A]=0,$$

The state probabilities after the first attempt can be obtained by simple relationships:

$$\left.\begin{aligned} &P[X^{(1)}=O_1]_{System-I} \\ &\quad = P[X^{(0)}=O_2]P[X^{(1)}=O_1 \mid X^{(0)}=O_2] \\ &\quad = (1-p)L_2(1-p_A), \\ &P[X^{(1)}=O_2]_{System-I} \\ &\quad = P[X^{(0)}=O_1]P[X^{(1)}=O_2 \mid X^{(0)}=O_1] \\ &\quad = pL_1(1-p_A), \end{aligned}\right\}$$

after unwrapping the recursions we obtain the general relationships,

for O_1

$$\begin{cases} P[X^{(n)}=O_1]_{System-I} = p\sqrt{(L_1L_2)^n}.(1-p_A)^n, & n\, even \\ P[X^{(n)}=O_1]_{System-I} = (1-p)L_2\sqrt{(L_1L_2)^{n-1}}.(1-p_A),^n & n\, odd \end{cases}$$

for O_2

$$\begin{cases} P[X^{(n)}=O_2]_{System-I} = (1-p)\sqrt{(L_1L_2)^n}.(1-p_A)^n, & n\, even \\ P[X^{(n)}=O_2]_{System-I} = pL_1\sqrt{(L_1L_2)^{n-1}}.(1-p_A)^n, & n\, odd \end{cases}$$

The details of transition probabilities, for n>0, are the system-II in attempts n=0,1,2,3,4,5,..., classified into four different categories A, B, C and D like :

The general expressions of probability of n^{th} attempts for O_1 are:

Type A : when t=4n+1, (e.g. t= 1,5,9,13,17,21,.......); (n≥0)

$$P\left[X^{(4n+1)}=O_1\right]_{A\ \ for\ system\ -II} = L_1\left[pL_1^{(3n)}L_2^{(3n)}(1-p_A)^{(2n)}\right]$$

Type B : when t=4n+3, (e.g. t= 3,7,11,15,19,23......); (n≥0)

$$P\left[X^{(4n+3)}=O_1\right]_{B\ \ for\ system\ -II} = \left[(1-p)L_1^{(3n+1)}L_2^{(3n+3)}(1-p_A)^{(2n+1)}\right]$$

Type C : when t=4n, (e.g. t= 0,4,8,12,16,20,...........); (n>0)

$$P\left[X^{(4n)}=O_1\right]_{C\ \ for\ system\ -II} = \left[pL_1^{(3n)}L_2^{(3n)}(1-p_A)^{(2n)}\right]$$

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Type D : when t=4n+2, (e.g. t= 2,6,10,14,18,22......); (n>0)

$$P\left[X^{(4n+2)} = O_1\right]_{D\ for\ system\ -II} = \left[(1-p)L_1^{(3n)}L_2^{3(n+1)}(1-p_A)^{(2n+1)}\right]$$

Same as for O_2.

VI. TRAFFIC SHARING

Traffic Sharing Difference between "Call-by-Call" and "Two-Call" basis contains following notations.

D_C = Difference due to Call-by-call basis Naldi [1].
D_T = Difference due to Two-call basis.

Using proposed model of both systems, the expressions for traffic sharing (when n→∞) under system-I are:

$$D_{C1} = \overline{P_1} = (1-L_1)\left\{\frac{\{P+(1-P)L_2(1-P_A)}{\left[1-L_1L_2(1-P_A)^2\right]}\right\}$$

for operator O_1

$$D_{C2} = \overline{P_2} = (1-L_2)\left\{\frac{(1-P)+PL_1(1-P_A)}{\left[1-L_1L_2(1-P_A)^2\right]}\right\}$$

for operator O_2

Similar expression of traffic share under system-II are :

$$D_{T1} = \overline{P_1} = \left\{\frac{\{1-(L_1+L_1^2)\}(1+L_1)}{\left[1-L_1^3L_2^3(1-P_A)^2\right]L_1^3(1-P_A)}\right\}\left[PL_1^3(1-P_A)+(1-P)L_1^3L_2^3(1-P_A)^2\right]$$

for operator O_1

$$D_{T2} = \overline{P_2} = \left\{\frac{\{1-(L_2+L_2^2)\}(1+L_2)}{\left[1-L_1^3L_2^3(1-P_A)^2\right]L_2^3(1-P_A)}\right\}\left[(1-P)L_2^3(1-P_A)+PL_1^3L_2^3(1-P_A)^2\right]$$

for operator O_2

While comparing both systems I and II for only first operator O1, the numerical difference between traffic sharing is:

$$D_{ifference} = D_{T1} - D_{C1}$$
$$= p\left[\left\{\frac{\{1-(L_1+L_1^2)\}(1+L_1)}{\left[1-L_1^3L_2^3(1-P_A)^2\right]}\right\} - \left\{\frac{(1-L_1)}{\left[1-L_1L_2(1-P_A)^2\right]}\right\}\right]$$
$$+(1-p)L_2(1-P_A)\left[\left\{\frac{\{1-(L_1+L_1^2)\}(1+L_1)L_2^2}{\left[1-L_1^3L_2^3(1-P_A)^2\right]}\right\} - \left\{\frac{\{(1-L_1)}{\left[1-L_1L_2(1-P_A)^2\right]}\right\}\right]$$

VII. SHARE LOSS

As per Naldi [1]and for system – I the share loss expression ΔP_{C1} , for O_1 is:

$$\Delta p_{C1} = \left(p-\overline{P_1}\right)$$
$$= \frac{p\left[1-L_1L_2(1-p_A)^2\right]-(1-L_1)\left[p+(1-p)(1-p_A)L_2\right]}{1-L_1L_2(1-p_A)^2}$$
$$= \frac{p\{L_1+L_2(1-p_A)[1-L_1(2-p_A)]\ \}-L_2(1-L_1)(1-p_A)}{1-L_1L_2(1-p_A)^2}$$

Under system – II (two – call basis) expression of share loss are:

$$\Delta p_{T1} = \left(p-\overline{P_1}\right)$$
$$= \frac{pL_1^2\left\{2+L_1-L_1L_2^3(1-p_A)^2\right\} - (1-p)L_2^3(1-p_A)\left\{1+L_1^3+2L_1^2\right\}}{\left[1-L_1^3L_2^3(1-p_A)^2\right]}$$

VIII. SIMULATION STUDY

Fig. 5 to Fig. 6 are showing the graphical pattern of traffic sharing $\overline{P_1}$ of operator O_1 when blocking probability L_1 of O_1 is very (keeping L_2, p, p_A is fixed) in shown in fig. 5. One can observe that in a system-II the traffic sharing goes down with a faster rate than system-I. After 50% call blocking the traffic share call blocking reaches to nearly at zero level.

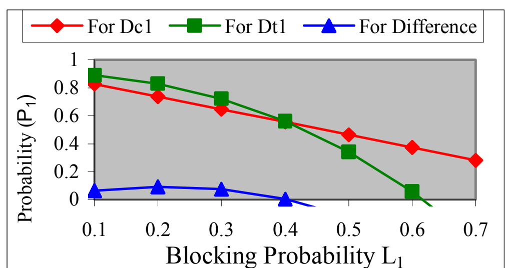

Fig. 5 (L_2=0.8, P=0.9, P_A=0.8)

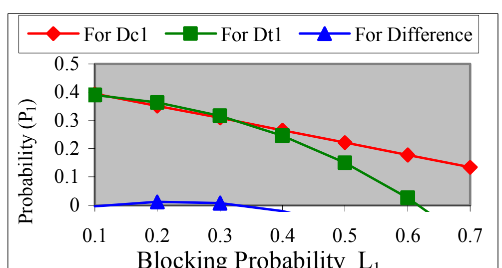

Fig. 6 (L_2=0.8, P=0.33, P_A=0.8)

Looking over Fig. 6 when p is low (0.33), the similar pattern is found.

While comparing the blocking of opponent, with the increase of L_2, the operator O_1 gains the traffic with relatively slower rate. With reference Fig. 8 if the blocking of opponent is high over then the traffic share doesn't change. In other way it is observed that the traffic share is independent of call variance with increasing value of L_2.

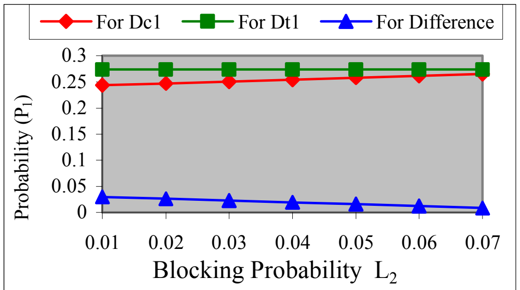

Fig. 7 (L_1=0.2, P=0.3, P_A=0.4)

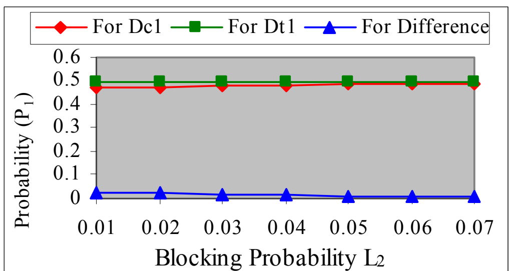

Fig. 8 (L_1=0.06, P=0.5, P_A=0.4)

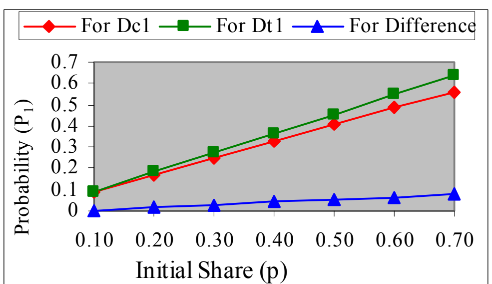

Fig. 9 (L_1=0.6, L_2=0.1, P_A=0.9)

The Fig. 9 shows the effect of initial market share *p* over both systems. If seems that system-II has little advantages over system-I when *p* is high.

IX. Concluding Remarks

Both the systems of user behavior have shown the little difference in traffic sharing because of call difference. The two call based system is not able to bear blocking more than 60 % for operator O_1. The operant blocking, is high provides better traffic share in system-II than system-I for operator O_1. Moreover if initial traffic share is high the system-II reveals more gain in internet traffic than system-I.

The quality of service (QoS) provided by an ISP is a function of blocking probabilities (L_1 and L_2) faced by internet service providers due to congestion in the network. Higher level of blocking probability leads to lesser quality received by users. As per assumptions of the system, a user is supposed to attempt for calls between ISP_1 and ISP_2 until connects or may take rest if fed-up due to attempt process.

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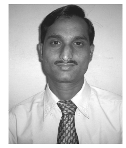
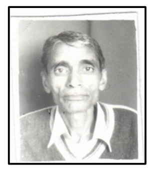


Dr. Sanjay Thakur has completed M.C.A. and Ph.D. (CS) degree from H.S. Gour University, Sagar in 2002 and 2009 respectively. He is presently working as a Lecturer in the Department of Computer Science & Applications in the same University since 2007. He did his doctoral work in the field of Computer Networking and Internet traffic sharing. He has authored and co-authored 10 research papers in National/International journals and conference proceedings. His current research interest is Stochastic Modeling of Switching System of Computer Network and Internet Traffic Sharing Analysis.



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