Analysis of Internet Traffic Distribution for User Behaviour based Probability in Two-Market Environment

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ABSTRACT
Consider two markets and two operators having different networks operators. Both operators are in competition for capturing more and more the internet traffic. The users have presumptive behaviour like faithful, impatient and completely impatient. This paper presented Markov chain model based analysis of user behaviour for selecting any one operator. It is found that blocking probability of network plays important role for determining the user's behaviour towards choosing an operator as internet service provider. Also it contains analysis of initial share over the blocking probability varying probability of the rest-state.

Keywords: Markov chain model, Blocking probability, Call-by-call basis, Internet traffic, Quality of Service (QoS), Users behavior.

1. INTRODUCTION

Markov Chain Model is a technique of exploring the transition behavior of a system. Naldi [13] has opened up the problem of internet traffic sharing evaluation. Shukla, Gadewal [6] have shown the application of Markov Chain model to the modelling of space division switches. Shukla, Pathak and Thakur [7] have predicated useful contribution for modelling of internet traffic sharing phenomena between two operators in competitive markets. Vern Paxson [17] has discussed the experiences with different measurement and analysis of the Internet Traffic. Hambali and Ramani [3] have proposes a new architecture of the switch for the demand of multicast service and cell loss with delay will decrease the performance of an ATM networks. Hemangi and Murali et. al. [2] has presenting a new protocol for probabilistic quality of service analysis for distributed control system. Al-Shargabi and Ismail [15] have proposes internet compressed traffic: a solution for the explosion of the internet.

Shukla, Tiwari, Thakur and Deshmukh [18] have given a share loss analysis of internet traffic distribution in computer networks. Andrikopoulos et al. [8] have providing rate guarantees for internet application traffic across ATM networks. Medhi [11],[12] contains the foundational aspects of Markov chains in the context of stochastic processes. Dorea and Rajas [5] have shown the application of Markov chain models in data analysis. Aggarwal and Kaur [16] have proposed reliability analysis of fault-tolerant in a multistage interconnection on computer networks. Shukla, Tiwari and Thakur [21] have shown the effects of disconnectivity analysis for congestion control in internet traffic sharing. Yuan and lygevers [4] obtained the stochastic differential equations and proved the criteria of stabilization for Mrakovian switching.

Shukla, Tiwari et. al. [19],[20] have discussed a comparison of methods for internet traffic sharing in computer network. Newby and Dagg [14] presented a maintenance policy for stochastically deteriorating systems, with the average cost criteria. Shukla and Thakur [9] have useful contribution on the use of crime based user analysis in Internet traffic sharing under cyber crime. Mohammed and Ramli et.al [1] has analyses of an authentication protocol for mobile cellular network. Some other useful similar contributions are due to Perzen[10].

2. USER'S BEHAVIOR AND MARKOV CHAIN MODEL

Let O_i and O_j $(i=1,3;\ j=2,4)$ be operators (or ISP) in two competitive locations Market-I and Market–II. Users choose first to a market and then enters into cyber cafe (or shop) situated in that market where computer terminals for specific operators are available to access the Internet. Let $\{X^{(n)}, n \geq 0\}$ be a Markov chain having transitions over the state space O_1, O_2, O_3, O_4, R_1, R_2, Z_1, Z_2, A, M_1 & M_2 where

State O_1: first operator in market-I

State O_2: second operator in market-I

State O_3: third operator in market-II

State O_4: fourth operator in market-II

State R_1: temporary short time rest in market-I

State R_2: temporary short time rest in market-II

State Z_1: success (in connectivity) in market-I

State Z_2: success (in connectivity) in market-II

State A: abandon to call attempt process

State M_1: market-I

State M_2: market-II

The $X^{(n)}$ stands for state of random variable X at n^{th} attempt $(n\geq 0)$ made by a user. Some underlying assumptions of the model are:

a) User first selects the Market-I with probability q and Market-II with probability $(1-q)$ as per ease.

b) After that user, in a shop, chooses the first operator O_i with probability p or to next O_j with $(1-p)$.

c) The blocking probability experienced by O_i is L_1 and by O_j is L_2.

d) Connectivity attempts of user between operators are on call-by-call basis, which means if the call for O_i is blocked in k^{th} attempt $(k>0)$ then in $(k+1)^{th}$ user shifts to O_j. If this also fails, user switches to O_i in $(k+2)^{th}$.

e) Whenever call connects through either O_i or O_j we say system reaches to the state of success (Z_1, Z_2).

f) The user can terminate call attempt process, marked as system to abandon state A with probability P_A (either from O_i or from O_j).

g) If user reaches to rest state R_k $(k=1,2)$ from O_i or O_j then in next attempt he may either with a call on O_i or O_j with probability r_k and $(1-r_k)$ respectively.

h) From state R_k user cannot move to states Z_k and A.

The transition diagram is in figure 1 to explain the details of assumptions and symbols. In further discussion, operator $O_1=O_3$ and $O_2=O_4$ is assumed with network blocking parameter $L_1=L_3$, $L_2=L_4$.

3. LOGIC FOR TRANSITION PROBABILITY IN MODEL

(a) The starting conditions (state distribution before the first call attempt) are

$$P[X^{(0)}=O_1]=0, \quad P[X^{(0)}=R_1]=0,$$
$$P[X^{(0)}=O_2]=0, \quad P[X^{(0)}=R_2]=0,$$
$$P[X^{(0)}=Z]=0, \quad P[X^{(0)}=M_1]=q,$$
$$P[X^{(0)}=A]=0, \quad P[X^{(0)}=M_2]=1-q$$

(b) If in $(n-1)^{th}$ attempt, call for O_i is blocked, the user may abandon the process in the n^{th} attempts.

$P[X^{(n)}=A\,/\,X^{(n-1)}=O_i]=P$ [blocked at O_i].P[abandon the process]$=L_i\,P_A$

Similar for O_j,

$P[X^{(n)}=A\,/\,X^{(n-1)}=O_j]=P$ [blocked at O_j].P[abandon the process]$=L_j\,P_A$

(c) At O_i in n^{th} attempts call may be made successfully and system reaches to state Z_k from O_i. This happens only when call does not block in $(n-1)^{th}$ attempt

$P[X^{(n)}=Z_k\,/X^{(n-1)}=O_i]=P$[does not blocked at O_i]$=(1-L_i)$

Similar for O_j,

$P[X^{(n)}=Z_k\,/X^{(n-1)}=O_j]=P$[does not blocked at O_j]$=(1-L_j)$

(d) If user is blocked at O_i in $(n-1)^{th}$ attempts, does not want to abandon, then in n^{th} he shifts to operator O_j.

$P[X^{(n)}=O_j\,/\,X^{(n-1)}=O_i]=P$[blocked at O_i].P[does not abandon]$=L_i\,(1-p_A)$.

Similar for O_j,

$P[X^{(n)}=O_i\,/\,X^{(n-1)}=O_j]=P$[blocked at O_j].P[does not abandon]$=L_j\,(1-p_A)$

(e) For operator O_i. $P[X^{(n)}=O_i\,/\,X^{(n-1)}=R_k]=r_k$.

Similar for O_j, $P[X^{(n)}=O_j\,/\,X^{(n-1)}=R_k]=1-r_k$.

(f) For M_k, $(k=1,2)$ for O_i, O_j

$P[X^{(n)}=O_i\,/\,X^{(n-1)}=M_k]=p$.

Similar for O_j,

$P[X^{(n)}=O_j\,/\,X^{(n-1)}=M_k]=1-p$.

4. CATEGORIES OF USERS

Define three types of users as

(i) Faithful User (FU).

(ii) Partially Impatient User (PIU).

(iii) Completely Impatient User (CIU).

5. SOME RESULTS FOR n^{th} ATTEMPTS

At n^{th} attempt, the probability of resulting state is derived in following theorems for all $n=0,1,2,3,4,5....$ for market-I.

$$A=\left[L_1(1-P_A)P_{R_1}r_1\right],\quad B=\left[L_2(1-P_A)P_{R_1}(1-r_1)\right],$$
$$C=\left[L_1L_2(1-P_A)^2(1-P_{R_1})^2\right],\quad D=\left[L_1^2L_2(1-P_A)^3(1-P_{R_1})^2P_{R_1}\right],$$
$$E=\left[L_2^2(1-P_A)^2(1-P_{R_1})P_{R_1}\right]$$

Theorem 5.1: If user is FU and restrict to only O_1 and R_1 in M_1 then n^{th} step transitions probability is

$$\left.\begin{aligned}P[X^{(2n)}=O_1]&=pA^n\\ P[X^{(2n+1)}=O_1]&=qpA^n\end{aligned}\right\}$$

Theorem 5.2: If user is FU and restrict to only O_2 and R_1 then n^{th} step transitions probability is

$$\left.\begin{aligned}P[X^{(2n)}=O_2]&=(1-p)B^n\\ P[X^{(2n+1)}=O_2]&=q(1-p)B^n\end{aligned}\right\}$$

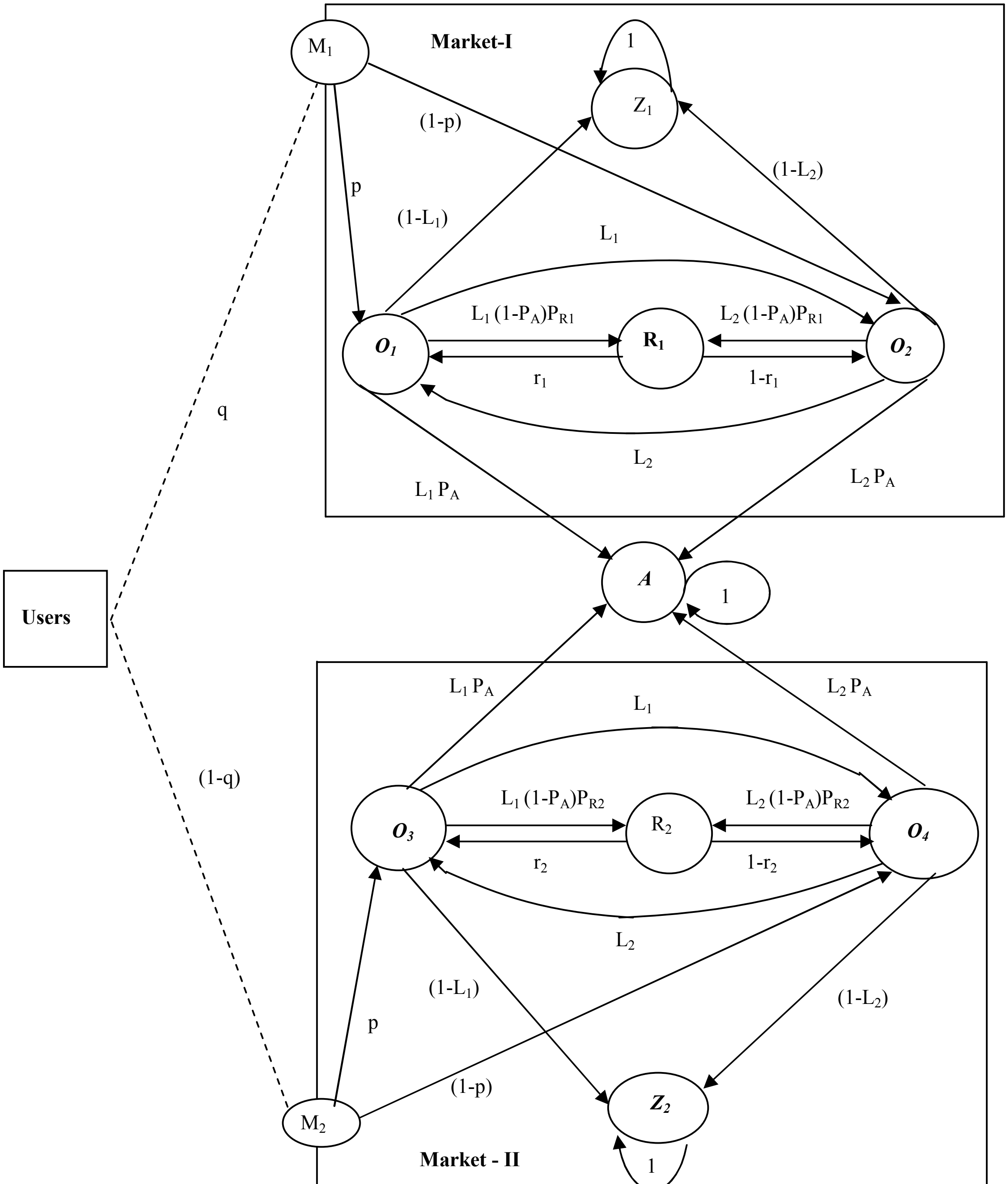

Fig 1: Transition Diagram of Model

6. THE TRANSITION PROBABILITY MATRIX

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

	O_1	O_2	O_3	O_4	Z_1	Z_2	R_1	R_2	A	M_1	M_2
O_1	0	$\begin{bmatrix} L_1(1-P_A) \\ (1-P_{R_1}) \end{bmatrix}$	0	0	$[1-L_1]$	0	$\begin{bmatrix} L_1(1-P_A) \\ P_{R_1} \end{bmatrix}$	0	$[L_1 P_A]$	0	0
O_2	$\begin{bmatrix} L_2(1-P_A) \\ (1-P_{R_1}) \end{bmatrix}$	0	0	0	$[1-L_2]$	0	$\begin{bmatrix} L_2(1-P_A) \\ P_{R_1} \end{bmatrix}$	0	$[L_2 P_A]$	0	0
O_3	0	0	0	$\begin{bmatrix} L_1(1-P_A) \\ (1-P_{R_2}) \end{bmatrix}$	0	$[1-L_1]$	0	$\begin{bmatrix} L_1(1-P_A) \\ P_{R_2} \end{bmatrix}$	$[L_1 P_A]$	0	0
O_4	0	0	$\begin{bmatrix} L_2(1-P_A) \\ (1-P_{R_2}) \end{bmatrix}$	0	0	$[1-L_2]$	0	$\begin{bmatrix} L_2(1-P_A) \\ P_{R_2} \end{bmatrix}$	$[L_2 P_A]$	0	0
Z_1	0	0	0	0	1	0	0	0	0	0	0
Z_2	0	0	0	0	0	1	0	0	0	0	0
R_1	r_1	$[1-r_1]$	0	0	0	0	0	0	0	0	0
R_2	0	0	r_2	$[1-r_2]$	0	0	0	0	0	0	0
A	0	0	0	0	0	0	0	0	1	0	0
M_1	p	$[1-p]$	0	0	0	0	0	0	0	0	0
M_2	0	0	p	$[1-p]$	0	0	0	0	0	0	0

Fig 2: Transition Probability Matrix.

Theorem 5.3: If user is PIU and restricts to attempt between O_1 and O_2 and not interested to state R in M_1 then

$$P[X^{(2n)} = O_1] = \frac{\left[q(1-p)C^{(n)}\right]}{\left[L_1(1-p_A)(1-p_{R_1})\right]}$$

$$P[X^{(2n+1)} = O_1] = \left[qpC^{(n)}\right]$$

$$P[X^{(2n)} = O_2] = \frac{\left[qpC^{(n)}\right]}{\left[L_2(1-p_A)(1-p_{R_1})\right]}$$

$$P[X^{(2n+1)} = O_2] = \left[q(1-p)C^{(n)}\right]$$

Theorem 5.4: If user is CIU and attempts among O_1, O_2 and R only in M_1 then at n^{th} attempt the approximate probability expression are

$$P[X^{(2n)} = O_1] = \frac{\left[q(1-p)C^{(n)}\right]}{\left[L_1(1-p_A)(1-p_{R_1})\right]} + \frac{\left[pC^{(n)}p_{R_1}r_1\right]}{\left[L_2(1-p_A)(1-p_{R_1})^2\right]}$$

$$P[X^{(2n+1)} = O_1] = \left[qpC^{n}\right] + \frac{\left[(1-p)C^{(n)}L_2 p_{R_1}(1-r_1)\right]}{\left[L_1(1-p_{R_1})\right]}$$

$$P[X^{(2n)} = O_2] = \frac{[qpC^{(n)}]}{[L_2(1-p_A)(1-p_{R_1})]} + \frac{[(1-p)C^{(n)} p_{R_1}(1-r_1)]}{[L_1(1-p_A)(1-p_{R_1})^{(2)}]}$$

$$P[X^{(2n+1)} = O_2] = [q(1-p)C^{(n)}] + \frac{[pC^{(n)} L_1 p_{R_1} r_1]}{[L_2(1-p_{R_1})]}$$

7. BEHAVIOR OVER LARGE NUMBER OF ATTEMPTS FOR TRAFFIC SHARING

Suppose n is very large, then $\overline{P_k} = \left[\lim_{n\to\infty} \overline{P_k}^{(n)}\right]$, k=*1, 2* and we get final traffic shares,

$$[\overline{P_1}]_{FU} = \left\{\frac{(1-L_1).p}{1-[A^2]}\right\} + \left\{\frac{(1-L_1).qp[A]}{1-[A^2]}\right\}$$

$$[\overline{P_2}]_{FU} = \left\{\frac{(1-L_2).(1-p)}{1-[B^2]}\right\} + \left\{\frac{(1-L_2).q(1-p)[B]}{1-[B^2]}\right\}$$

$$[\overline{P_1}]_{PIU} = \left\{(1-L_1).p + \frac{(1-L_1).pq[C]}{1-[C^2]}\right\} + \left\{\frac{(1-L_1).qp[C]}{1-[C^2]}\right\}$$

$$[\overline{P_2}]_{PIU} = (1-L_2)(1-p) + \left\{\frac{(1-L_2)(1-p)q[C]}{1-[C^2]}\right\} + \left\{\frac{(1-L_2).q(1-p)[C]}{1-[C^2]}\right\}$$

$$[\overline{P_1}]_{CIU} = (1-L_1)p\left\{1 + \left[\frac{q[C]}{1-[C^2]}\right] + \left[\frac{[D r_1]}{1-[C^2]}\right]\right\} + \left\{\left[\frac{q(1-L_1)L_2(1-P_A)(1-P_{R_1})[C]}{1-[C^2]}\right] + \left[\frac{(1-L_1)(1-r_1)[E]}{1-[C^2]}\right]\right\}$$

$$[\overline{P_2}]_{CIU} = (1-L_2)p\left\{1 + \left[\frac{q[C]}{1-[C^2]}\right] + \left[\frac{[D(1-r_1)]}{1-[C^2]}\right]\right\} + \left\{\left[\frac{q(1-L_2)L_2(1-P_A)(1-P_{R_1})[C]}{1-[C^2]}\right] + \left[\frac{(1-L_2)r_1[E]}{1-[C^2]}\right]\right\}$$

8. AVERAGE BLOCKING PROBABILITY EXPERIENCE BY USERS

The user experiences varying average blocking probability, at n^{th} attempt, described as:

$$B_i^{(n)} = \frac{P[X^{(n-1)} = O_1]L_1 + P[X^{(n-1)} = O_2]L_2}{P[X^{(n-1)} = O_1] + P[X^{(n-1)} = O_2]}$$

[See Naldi (2002)]

In case of faithful user, by using theorem 5.1 and 5.2.

$$[B_i^{(n)}]_{FU} = pL_1 + (1-p)L_2 \quad \text{[See Naldi (2002)]}$$

For Partially Impatient User (PIU), using theorem 5.3

$$[B_i^{(n)}]_{PIU} = \frac{1}{pL_1 + (1-p)L_2} \quad for\ \ n\ \ even$$

$$[B_i^{(n)}]_{PIU} = p\,L_1 + (1-p)\,L_2 \quad for\ \ n\ \ odd$$

9. COMPARISONS AMONG USERS

(a) $[Bi^{(n)}]_{PIU} < [Bi^{(n)}]_{FU}$

when $p < 1$ along with $L_1 > L_2$

(b) $[Bi^{(n)}]_{CIU} < [Bi^{(n)}]_{FU}$

when $p < 1$ along with $L_1 > L_2$

(c) $[Bi^{(n)}]_{CIU} < [Bi^{(n)}]_{PIU}$

when $p < 1$ along with $L_1 > L_2$

10. INITIAL TRAFFIC SHARE ANALYSIS

According to figure 3 - 8 with the increase of blocking probability of operator O_1 the initial traffic share depends highly on opponents blocking probability L_2. If L_2 is high the initial traffic share of faithful users of O_1 is high.

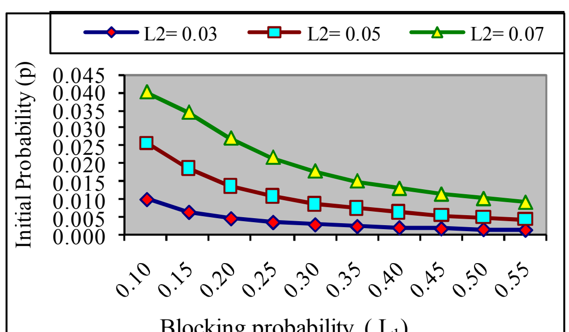

Fig 3. (q=0.6, p_A =0.6, p_{R1}= 0.3, r_1 = 0.3)
(Between FU and PIU over varying L_2)

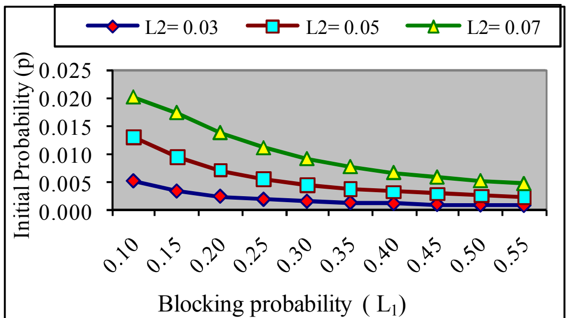

Fig 4. (q=0.6, p_A = 0.6, p_{R1}= 0.5, r_1 = 0.3)

When rest state probability p_{R1} is high then correspondely the traffic share of faithful users reduces for O_1. The rest state r_1 has negative impact over the group of partially impatient users (PIU).

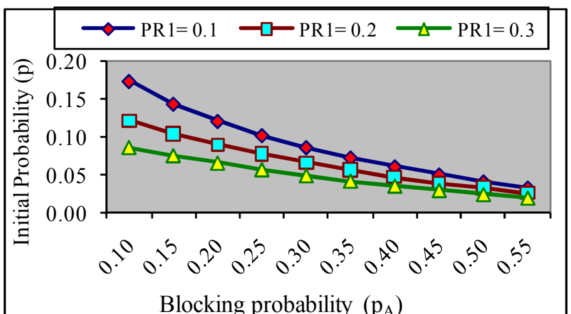

Fig 5. (L_1=0.4, L_2=0.3, q=0.6, p_{R1}= 0.1, r_1 = 0.3)
(Between FU and PIU over varying p_{R1})

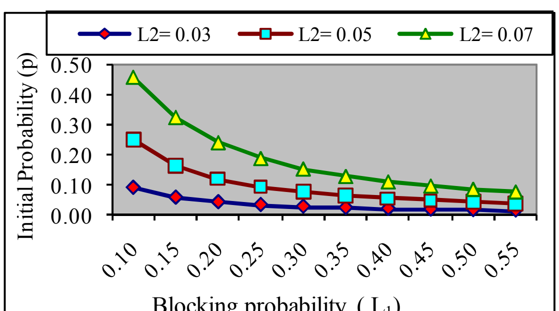

Fig 6. (q=0.6, p_A = 0.1, p_{R1}= 0.1, r_1 = 0.3)
(Between FU and PIU over varying L_2)

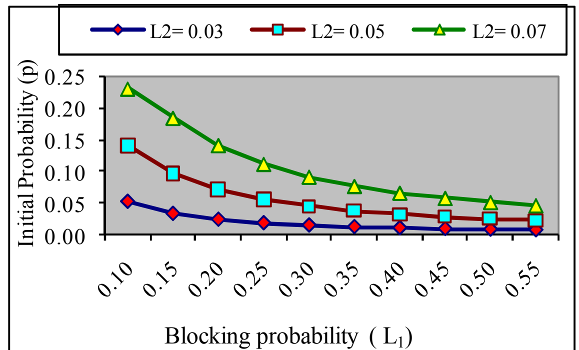

Fig 7. (q=0.6, p_A = 0.3, p_{R1}= 0.1, r_1 = 0.3)
(Between FU and PIU over varying L_2)

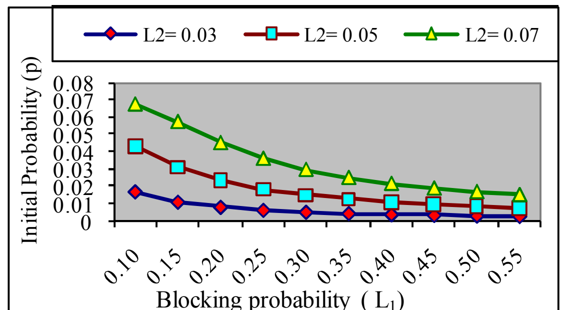

Fig 8. (q=0.6, p_A = 0.6, p_{R1}= 0.1, r_1 = 0.3)
(Between FU and PIU over varying L_2)

With the change of P_A probability which is the abandoning chance if high, reduces the initial traffic share of faithful users for operator O_1. Moreover, opponent blocking level, if high, then the loss of PIU users group is also high.

11. CONCLUDING REMARKS

The initial traffic share depends on the amount of faithful user that an operator bears. The self blocking probability of an operator, if high, reduces the initial traffic share. Moreover, if opponent blocking of network is high, than faithful user proportion for O_1 is also high. Therefore, in multi-market system a network operator is suggested keep attracting sources and try to reduce the network blocking in order to increase his faithful user group.

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