Share Loss Analysis of Internet Traffic Distribution in Computer Networks

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Abstract

In present days, the Internet is one of the most required tools of getting information and communicating data. A large number of users through out the world are joining the family of internet in huge proportion. At the same time commercial groups of Internet service provider are also growing in the market. Networks are being overloaded in terms of their capacity and probability of blocking being high day-by-day. This paper presents a share loss analysis of internet traffic when two operators are in competition in respect of quality of service in two markets. The analysis is performed by drawing Iso-share curves through a Markov chain model. The effected over initial traffic share (when final fixed) is examined through simulation study. It is found that network blocking probability highly affects to the initial share amount of traffic of a network operator.

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

1. INTRODUCTION

Suppose there are two operators (ISP) providing Internet services to people in two markets. Both are in competition to each other in terms of growing more and more to their customer base. Let p be initial market share of one operator and $(1\text{-}p)$ for other. There is another market which has operator O_3 and O_4 with similar initial share of customer base p and $(1\text{-}p)$ respectively. Every operator has tendency to improve upon their customer base constantly. But at the same time they bear constant blocking probability, say L_1 and L_2 in their networks. Because of this fact the quality of services also reduces. This paper presents customer proportion based share loss analysis of Internet Service Providers in two competitive markets when blocking probability increases overtime. The analysis is performed through a probability based Markov Chain model with simulation study of the system.

Markov Chain Model is a technique of exploring the transition behavior of a system. Medhi (1991, 1992) discussed the foundational aspects of Markov chains in the context of stochastic processes. Dorea and Rajas (2004) have shown the application of Markov chain models in data analysis. Shukla and Gadewar(2007) presented a stochastic model for Space Division Switches in Computer Networks. Yuan and lygevers (2005) obtained the stochastic differential equations and proved the criteria of stabilization for Mrakovian switching. Newby and Dagg (2002) presented a maintenance policy for stochastically deteriorating systems, with the average cost criteria. Naldi(2002) performed a Markov chain model based study of internet traffic in the multi-operators environment. Shukla and Thakur (2007, 2008), Shukla, Pathak and Thakur (2007) have shown the use of this kind of model based approach to explain and specify the behavior of internet traffic users. Babikur Mohd. et.al (2009) have shown the flow ased internet traffic classification for bandwidth optimization. Some other useful similar contributions are due to Aggarwal and Kaur (2008), and Agarwal (2009).

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 enter into cyber cafe (or shop) situated in that market where computer terminals for 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 fig.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 $L_1=L_3$, $L_2=L_4$.

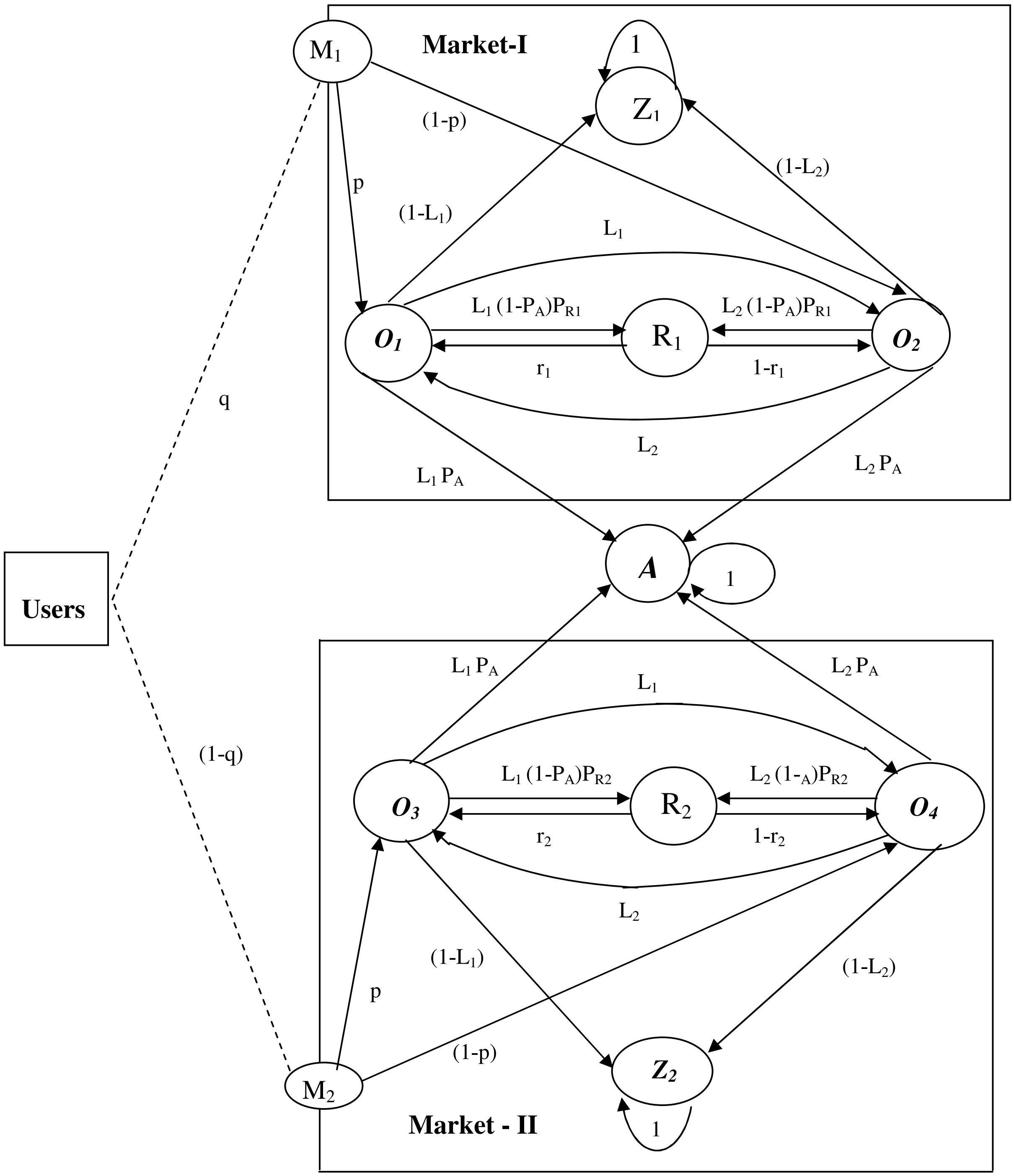

FIGURE 1: Transition Diagram of model.

2.1 The transition probability matrix

States $X^{(n)}$

$X^{(n-1)}$ States

$$
\begin{array}{c|ccccccccccc}
 & O_1 & O_2 & O_3 & O_4 & Z_1 & Z_2 & R_1 & R_2 & A & M_1 & M_2 \\
\hline
O_1 & 0 & \begin{bmatrix} L_1(1-P_A) \\ (1-P_{R_1}) \end{bmatrix} & 0 & 0 & [1-L_1] & 0 & \begin{bmatrix} L_1(1-P_A) \\ P_{R_1} \end{bmatrix} & 0 & [L_1P_A] & 0 & 0 \\
O_2 & \begin{bmatrix} L_2(1-P_A) \\ (1-P_{R_1}) \end{bmatrix} & 0 & 0 & 0 & [1-L_2] & 0 & \begin{bmatrix} L_2(1-P_A) \\ P_{R_1} \end{bmatrix} & 0 & [L_2P_A] & 0 & 0 \\
O_3 & 0 & 0 & 0 & \begin{bmatrix} L_1(1-P_A) \\ (1-P_{R_2}) \end{bmatrix} & 0 & [1-L_1] & 0 & \begin{bmatrix} L_1(1-P_A) \\ P_{R_2} \end{bmatrix} & [L_1P_A] & 0 & 0 \\
O_4 & 0 & 0 & \begin{bmatrix} L_2(1-P_A) \\ (1-P_{R_2}) \end{bmatrix} & 0 & 0 & [1-L_2] & 0 & \begin{bmatrix} L_2(1-P_A) \\ P_{R_2} \end{bmatrix} & [L_2P_A] & 0 & 0 \\
Z_1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
Z_2 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
R_1 & r_1 & [1-r_1] & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_2 & 0 & 0 & r_2 & [1-r_2] & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
A & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
M_1 & p & [1-p] & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
M_2 & 0 & 0 & p & [1-p] & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{array}
$$

FIGURE 2: Transition Probability Matrix.

2.2 Logic For Transition Probability In Model

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

$$
\left.
\begin{array}{lll}
P[X^{(0)} = O_1] = 0, & and & P[X^{(0)} = O_2] = 0, \\
P[X^{(0)} = R_1] = 0, & and & P[X^{(0)} = R_2] = 0, \\
P[X^{(0)} = Z] = 0, & and & P[X^{(0)} = A] = 0, \\
P[X^{(0)} = M_1] = q, & and & P[X^{(0)} = M_2] = 1-q,
\end{array}
\right\} \quad \ldots(2.2.1)
$$

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

$$P[X^{(n)} = A / X^{(n-1)}=O_i] = P\,[blocked\ at\ O_i].P[abandon\ the\ process]=L_i.P_A \quad \ldots(2.2.2)$$

Similar for O_j,

$$P[X^{(n)} = A / X^{(n-1)} =O_j] = P\,[blocked\ at\ O_j].P[abandon\ the\ process]=L_j.P_A \quad \ldots(2.2.3)$$

(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

$$P[X^{(n)}=Z_k / X^{(n-1)}=O_i] = P[\text{does not blocked at } O_i]=(1-L_i) \quad \text{…(2.2.4)}$$

Similar for O_j,

$$P[X^{(n)}=Z_k / X^{(n-1)}=O_j] = P[\text{does not blocked at } O_j]=(1-L_j) \quad \text{…(2.2.5)}$$

(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.

$$P[X^{(n)}=O_j / X^{(n-1)}=O_i] = P[\text{ blocked at } O_i].P[\text{does not abandon}]=L_i.(1-p_A) \quad \text{…(2.2.5)}$$

Similar for O_j,

$$P[X^{(n)}=O_i / X^{(n-1)}=O_j] = P[\text{ blocked at } O_i].P[\text{does not abandon}]=L_j.(1-p_A) \quad \text{…(2.2.6)}$$

(e) For operator O_i.

$$P[X^{(n)}=O_i / X^{(n-1)}=R_k] = r_k. \quad \text{…(2.2.7)}$$

Similar for O_j,

$$P[X^{(n)}=O_j / X^{(n-1)}=R_k] = 1-r_k. \quad \text{…(2.2.8)}$$

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

$$P[X^{(n)}=O_i / X^{(n-1)}=M_k] = p. \quad \text{…(2.2.9)}$$

Similar for O_j,

$$P[X^{(n)}=O_j / X^{(n-1)}=M_k] = 1-p. \quad \text{…(2.2.10)}$$

3. CATEGORIES OF USERS

Define three types of users as

(i) Faithful User (FU).
(ii) Partially Impatient User (PIU).
(iii) Completely Impatient User (CIU).

4. 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.

THEOREM 4.1: If user is FU and restrict to only O_1 and R_1 in M_1 then n^{th} step transitions probability is

$$\left.\begin{aligned} P[X^{(2n)}=O_1] &= \left[pL_1^{\ n}(1-p_A)^n\, p_{R1}^{\ n}\, r_1^{\ n}\right] \\ P[X^{(2n+1)}=O_1] &= \left[qpL_1^{\ n}(1-p_A)^n\, p_{R1}^{\ n}\, r^n\right] \end{aligned}\right\} \quad \text{..(4.1.1)}$$

THEOREM 4.2: If user is FU and restrict to only O_2 and R_1 then n^{th} step transitions probability is

$$\left.\begin{aligned} P[X^{(2n)}=O_2] &= \left[(1-p)L_2^{\ n}(1-p_A)^n\, p_{R1}^{\ n}(1-r_1)^n\right] \\ P[X^{(2n+1)}=O_2] &= \left[q(1-p)L_2^{\ n}(1-p_A)^n\, p_{R1}^{\ n}(1-r_1)^n\right] \end{aligned}\right\} \quad \text{…(4.1.2)}$$

THEOREM 4.3: If user is PIU and restricts to attempt between O_1 and O_2 and not interested to state R in M_1 then

$$
\begin{aligned}
P[X^{(2n)} = O_1] &= \left[q(1-p)L_1^{(n-1)}L_2^{(n)}(1-p_A)^{(2n-1)}(1-p_{R_1})^{(2n-1)}\right] \\
P[X^{(2n+1)} = O_1] &= \left[qpL_1^{(n)}L_2^{(n)}(1-p_A)^{(2n)}(1-p_{R_1})^{2(n)}\right] \\
P[X^{(2n)} = O_2] &= \left[qpL_1^{(n)}L_2^{(n-1)}(1-p_A)^{(2n-1)}(1-p_{R_1})^{(2n-1)}\right] \\
P[X^{(2n+1)} = O_2] &= \left[q(1-p)L_1^{(n)}L_2^{(n)}(1-p_A)^{(2n)}(1-p_{R_1})^{(2n)}\right]
\end{aligned} \qquad \ldots(4.1.3)
$$

THEOREM 4.4: 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

$$
\begin{aligned}
P[X^{(2n)} = O_1] &= \left[q(1-p)L_1^{(n-1)}L_2^{(n)}(1-p_A)^{(2n-1)}(1-p_{R_1})^{(2n-1)}\right] \\
&\quad + \left[pL_1^{(n)}L_2^{(n-1)}(1-p_A)^{(2n-1)}(1-p_{R_1})^{(2n-2)}p_{R_1}r_1\right] \\
P[X^{(2n+1)} = O_1] &= \left[qp.L_1^{n}L_2^{n}(1-p_A)^{2n}(1-p_{R_1})^{2n}\right] \\
&\quad + \left[(1-p).L_1^{(n-1)}L_2^{(n+1)}(1-p_A)^{2n}(1-p_{R_1})^{(2n-1)}p_{R_1}.(1-r_1)\right] \\
P[X^{(2n)} = O_2] &= \left[qp.L_1^{(n)}L_2^{(n-1)}(1-p_A)^{(2n-1)}(1-p_{R_1})^{(2n-1)}\right] \\
&\quad + \left[(1-p).L_1^{(n-1)}L_2^{(n)}(1-p_A)^{(2n-1)}(1-p_{R_1})^{(2n-2)}p_{R_1}.(1-r_1)\right] \\
P[X^{(2n+1)} = O_2] &= \left[q(1-p)L_1^{n}L_2^{n}(1-p_A)^{2n}(1-p_{R_1})^{2n}\right] \\
&\quad + \left[pL_1^{(n+1)}L_2^{(n-1)}(1-p_A)^{2n}(1-p_{R_1})^{(2n-1)}p_{R_1}r_1\right]
\end{aligned} \qquad \ldots(4.1.4)
$$

5. TRAFFIC SHARING AND CALL CONNECTION

The traffic is shared between O_i *and* O_j operators. Aim is to calculate the probability of completion of a call with the assumption that it is achieved at n^{th} attempt with operator O_i (i =1, 3) in market M_1.

$\overline{P_1}^{(n)}$ =*P[call completes in* n^{th} *attempt with operator* O_1*] = P[at* $(n-1)^{th}$ *attempt user is on* O_1*]. P[user is at Z in* n^{th} *attempt when was at* O_1 *in* $(n-1)^{th}$*]*

$$
\overline{P_1}^{(n)} = P\left[X^{(n-1)} = O_1\right]P\left[X^{(n)} = Z/X^{(n-1)} = O_1\right] = (1-\mathrm{L}_1)\left[\sum_{\substack{i=0\\ i=even}}^{n-1} P\left[X^{(i)} = O_1\right] + \sum_{\substack{i=0\\ i=odd}}^{n-1} P\left[X^{(i)} = O_1\right]\right]
$$

Similarly for operator O_2

$$
\overline{P_2}^{(n)} = P\left[X^{(n-1)} = O_2\right]P\left[X^{(n)} = Z/X^{(n-1)} = O_2\right] = (1-L_2)\left[\sum_{\substack{i=0\\ i=even}}^{n-1} P\left[X^{(i)} = O_2\right] + \sum_{\substack{i=0\\ i=odd}}^{n-1} P\left[X^{(i)} = O_2\right]\right]
$$

This could be extended for all three categories of users.

(A) TRAFFIC SHARE BY FAITHFUL USERS (FU)

The FU are those who are hardcore to an operator and never think about others to take services. Using expression (4.1.1) we write for M_1

$$
\left[\overline{P_1}^{(n)}\right]_{FU} = (1-\mathrm{L}_1)\left[\sum_{\substack{i=0\\ i=even}}^{n-1} P\left[X^{(i)} = O_1\right] + \sum_{\substack{i=0\\ i=odd}}^{n-1} P\left[X^{(i)} = O_1\right]\right] \text{ Under (4.1.1), (4.1.2)}
$$

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

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

For operator O_1, final traffic share by FU

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

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

Final traffic share for operator O_2 using (4.1.2)

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

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

(B) TRAFFIC SHARE BY PARTIALLY IMPATIENT USERS (PIU)

The PIU are those who only toggles between operators O_i and O_j but do not want temporary rest (not to chose R_k state). Using expression (4.1.3) for M_1

$$\left[\overline{P_1}^{(n)} \right]_{PIU} = (1-L_1) \left[\sum_{\substack{i=0 \\ i=even}}^{n-1} P\left[X^{(i)} = O_1\right] + \sum_{\substack{i=0 \\ i=odd}}^{n-1} P\left[X^{(i)} = O_1\right] \right]$$ Under theorem 4.1.3.

Final traffic share for operator O_1

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

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

Final traffic share for operator O_2

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

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

(C) TRAFFIC SHARE BY COMPLETELY IMPATIENT USERS (CIU).

The CIU are those who transit among O_i, O_j *and* R_k. Then using expression (4.1.4) we write for M_1

$$\left[\overline{P_1}^{(n)}\right]_{CIU} = (1-L_1)\left[\sum_{\substack{i=0\\ i=even}}^{n-1} P\left[X^{(i)}=O_1\right] + \sum_{\substack{i=0\\ i=odd}}^{n-1} P\left[X^{(i)}=O_1\right]\right]$$ Under theorem 4.1.4

Final traffic share for operator O_1

$$\left[\overline{P_1}^{(2n)}\right]_{CIU} = (1-L_1)p\left\{1+q[C]\left[\frac{1-\left[C^2\right]^{(n)}}{1-\left[C^2\right]}\right]+\left[D\,r_1\right]\left[\frac{1-\left[C^2\right]^{(n-1)}}{1-\left[C^2\right]}\right]\right\}$$
$$+(1-L_1)\left\{qL_2(1-P_A)(1-P_{R_1})[C]\left[\frac{1-\left[C^2\right]^{(n)}}{1-\left[C^2\right]}\right]+\left[E\,(1-r_1)\right]\left[\frac{1-\left[C^2\right]^{(n-1)}}{1-\left[C^2\right]}\right]\right\}$$

$$\left[\overline{P_1}^{(2n+1)}\right]_{CIU} = (1-L_1).p\left\{1+q[C]\left[\frac{1-\left[C^2\right]^{(n-1)}}{1-\left[C^2\right]}\right]+\left[D\,r_1\right]\left[\frac{1-\left[C^2\right]^{(n)}}{1-\left[C^2\right]}\right]\right\}$$
$$+(1-L_1)\left\{qL_2(1-P_A)(1-P_{R_1})[C]\left[\frac{1-\left[C^2\right]^{(n-1)}}{1-\left[C^2\right]}\right]+\left[E\,(1-r_1)\right]\left[\frac{1-\left[C^2\right]^{(n)}}{1-\left[C^2\right]}\right]\right\}$$

Final traffic share for operator O_2

$$\left[\overline{P_2}^{(2n)}\right]_{CIU} = (1-L_2)p\left\{1+q[C]\left[\frac{1-\left[C^2\right]^{(n)}}{1-\left[C^2\right]}\right]+\left[D\,(1-r_1)\right]\left[\frac{1-\left[C^2\right]^{(n-1)}}{1-\left[C^2\right]}\right]\right\}$$
$$+(1-L_2)\left\{qL_2(1-P_A)(1-P_{R_1})[C]\left[\frac{1-\left[C^2\right]^{(n)}}{1-\left[C^2\right]}\right]+\left[E\,r_1\right]\left[\frac{1-\left[C^2\right]^{(n-1)}}{1-\left[C^2\right]}\right]\right\}$$

$$\left[\overline{P_2}^{(2n+1)}\right]_{CIU} = (1-L_2).(1-p)\left\{1+q[C]\left[\frac{1-\left[C^2\right]^{(n-1)}}{1-\left[C^2\right]}\right]+\left[D\,(1-r_1)\right]\left[\frac{1-\left[C^2\right]^{(n)}}{1-\left[C^2\right]}\right]\right\}$$
$$+(1-L_2)\left\{qL_2(1-P_A)(1-P_{R_1})[C]\left[\frac{1-\left[C^2\right]^{(n-1)}}{1-\left[C^2\right]}\right]+\left[E\,r_1\right]\left[\frac{1-\left[C^2\right]^{(n)}}{1-\left[C^2\right]}\right]\right\}$$

6. BEHAVIOR OVER LARGE NUMBER OF ATTEMPTS

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,

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

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

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

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

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

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

7. TRAFFIC SHARE LOSS ANALYSIS

Share loss relates to the imbalance between the initial share and final share of traffic between the two operators. Defining loss Δp as the difference between the initial share of O_1 and the final share, derived by the theorem of Faithful User (FU), Partially Impatient User (PIU) and Completely Impatient User (CIU) for O_1

$$\Delta p = p - \overline{P_1}$$
$$\left[\Delta p\right]_{FU} = \frac{\left\{p(1-A^2) - p(1-L_1) + qpL_1(1-L_1)(1-P_A)P_{R_1}r_1\right\}}{1-A^2}$$

$$[\Delta p]_{PIU} = \frac{\left\{ pL_1\left[1 - C^2\right] - \left[2qp(1 - L_1).C\right]\right\}}{\left[1 - C^2\right]}$$

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

If Δp negative, means the operator O_1 has actually benefited from the repeated call attempts and has increased its traffic share beyond to its initial expectation *p.* If Δp is positive then operator O_1 has loss of traffic due to blocking and frequent call attempts.

8. INITIAL SHARE ANALYSIS

A. BY FU :

In fig. 8.1 and 8.2, this is to observe that final traffic share (for fixed initial share) has variation over increasing self blocking in the form of linear pattern. For maintaining 70% initial share of FU's operator O_1 has to keep blocking below 40%.

The P_R probabilities of rest state doesnot affect the loss of traffic of O_1. With the 50% of initial customer base and 25% blocking chances, the final customer share is likely to be nearly 15%.

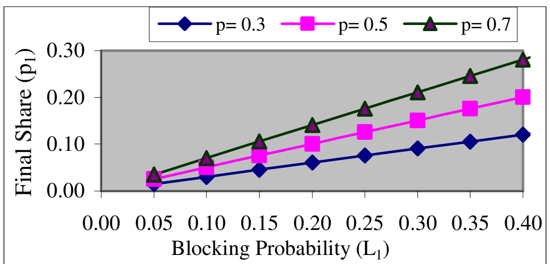

Fig. 8.1 (q=0.4, P_{R1}=0.1, P_A=0.6, r1=0.3 for FU User Iso-Share Curves)

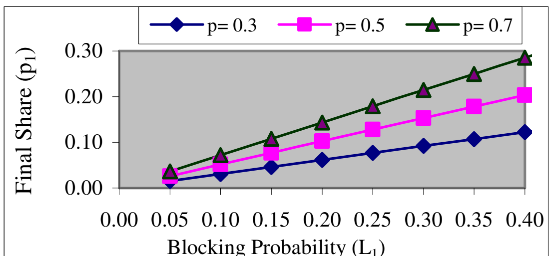

Fig. 8.2 (q=0.4, P_{R1}=0.7, P_A=0.6, r1=0.3 for FU User Iso-Share Curves)

When fig. 8.3-8.4 are underway, it seems that with increasing L_1 along with P_R probability, the final share has line based pattern. But when transition from rest state to O_1 increases (r_1), the proportion of final share by FU improves. So, increasing P_R and *r* simultaneously uplifts the final traffic of the operators. Both probabilities P_R and r have paritive impact over the final share of operator O_1.

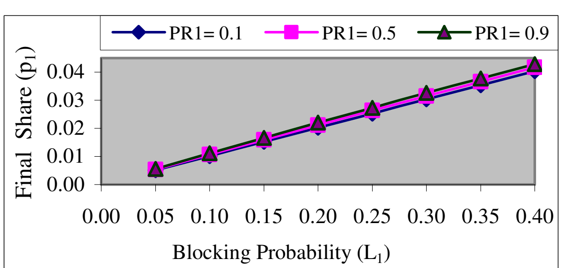

Fig. 8.3 (p=0.1, q=0.9, P_A=0.1, r1=0.2 for FU User Iso-Share Curves)

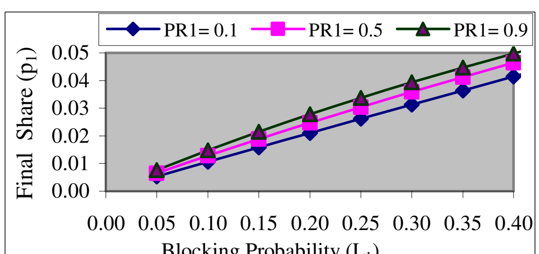

Fig. 8.4 (p=0.1, q=0.9, P_A=0.1, r1=0.5 for FU User Iso-Share Curves)

B. BY PIU :

By fig. 8.5 and fig. 8.6 with the increasing L_1 the final share loss of operator O_1 gets high. But when transition from operator O_1 (P_R) is high the proportion of PIU users is more so the final share loss of operator is higher with the variation of P_R probabilities.

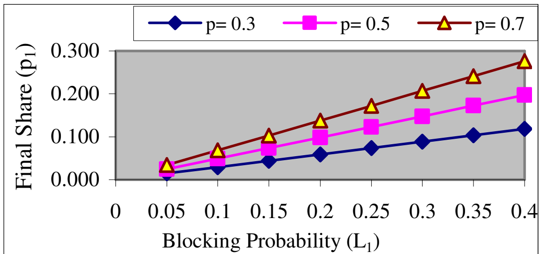

Fig. 8.5 (L_2=0.5, q=0.4, P_{R1}=0.7, P_A=0.2 for PIU User Iso-Share Curves)

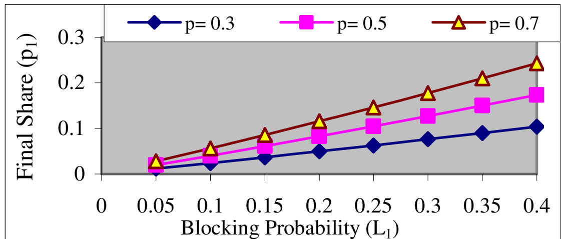

Fig. 8.6 (L_2=0.5, q=0.4, P_{R1}=0.08, P_A=0.2 for PIU User Iso-Share Curves)

For maintaining the 70% initial share operator O_1 has to compensate with 20% final share loss at 30% blocking probability. When P_R probability exceeds for maintaining the same level share operator has 25% initial share loss. This loss has to be compensate by operator because his PIU user proportions is decreased due to more P_R probability.

As per fig 8.7 and 8.8 final share loss with the variation of L_2 over the P_R probability has a downward trend. With increase of only P_R the final traffic share is relatively high. But when self blocking of operator O_1 is high with the opponent blocking then this initial share proposition improves with increasing P_R.

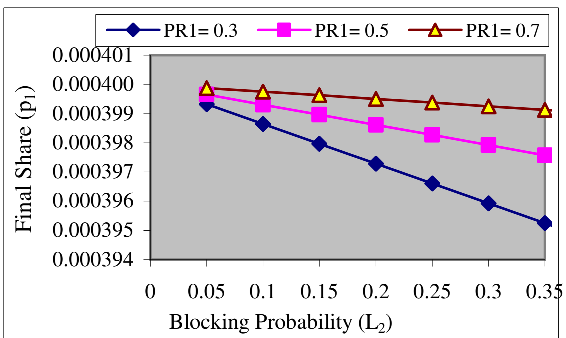

Fig. 8.7 (L_1=0.02, q=0.04, p=0.02, P_A=0.06 for PIU User Iso-Share Curves)

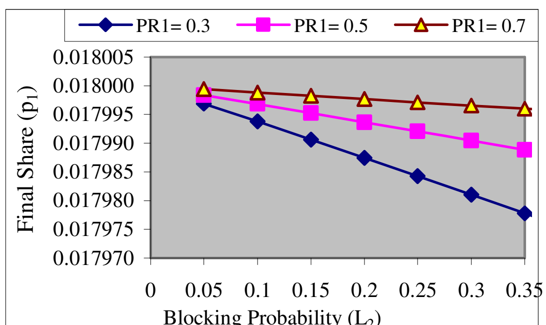

Fig. 8.8 (L_1=0.9, q=0.04, p=0.02, P_A=0.06 for PIU User Iso-Share Curves)

Therefore it is recommended that Internet Service Provider should implement P_R probability in the form of rest-state to improve upon his traffic distribution.

C. BY CIU :

When fig. 8.9 – fig. 8.10 are taken into consideration the final share of operator O_1 is having curve based increasing trend with the variation in opponent blocking L_2. When r_1 is high the final share of O_1 is low for the CIU, but when probability P_R is high along with r_1, final share of operator O_1 is declines constantly. When r_1 and P_R probability both are simultaneously upward operator has to bear the loss of CIU.

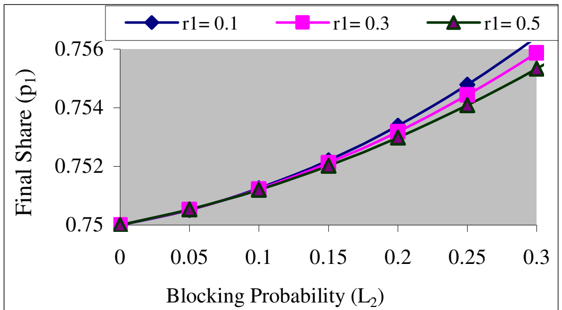

Fig. 8.9 (L_1=0.5, p=0.5, q=0.2, P_{R1}=0.2, P_A=0.3 for CIU User Iso-Share Curves)

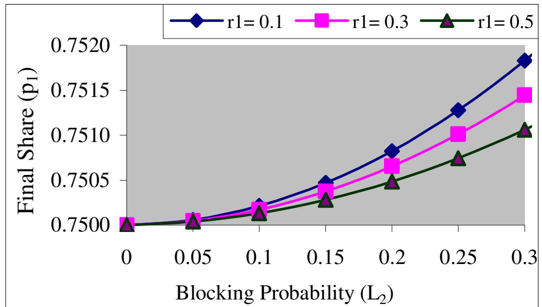

Fig. 8.10 (L_1=0.5, p=0.5, q=0.2, P_{R1}=0.9, P_A=0.3 for CIU User Iso-Share Curves)

By fig. 8.11 and 8.12 it is observed that increasing opponent blocking over P_R probability the final share by the CIU increases. But with the high opponent blocking the self blocking of operator O_1 is also increasing to keep final share of operator improved. So P_R probability is beneficial for increasing the final traffic preparations by the CIU.

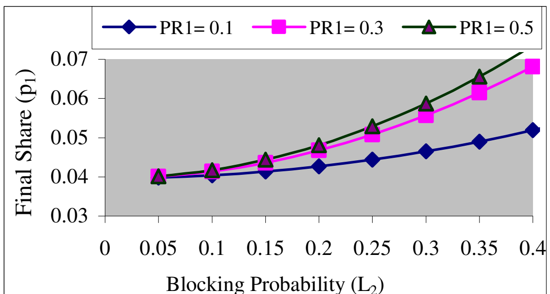

Fig. 8.11 (L_1=0..02, p=0.5, q=0.04, p=0.02, P_A=0.06, r_1=0.02 for CIU User Iso-Share Curves)

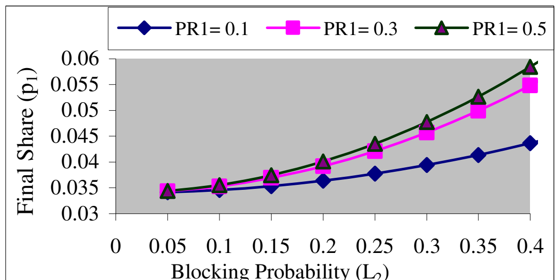

Fig. 8.12 (L_1=0..3, p=0.5, q=0.04, p=0.02, P_A=0.06, r_1=0.02 for CIU User Iso-Share Curves)

9. CONCLUDING REMARKS

The final share loss is of traffic for an operator is found as a linear function of self blocking probability of networks. If the final share goes high then operator of network has to reduce blocking probabilities. The proportion of FU users improves with the increment of r_1 parameter. Moreover P_R and r if both have increment then, faithful user proposition for operator O_1 uplifts. It seems the rest state has strong impact on upliftment of faithful users. To maintain the prefixed final share of PIU, operator O_1 has to reduce his blocking probability in order to keep the earlier initial share. Moreover P_{R1} probability related to rest state if high then operator O_1 has not too much bother about. The CIU users are high affected by opponent network blocking probabilities. They could move to group of FU for high L_2.

10. REFERENCES

[1]. Abuagla Babiker Mohd and Dr. Sulaiman bin Mohd Nor "Towards a Flow-based Internet Traffic Classification for Bandwidth Optimization", International Journal of Computer Science and Security (IJCSS), 3(2):146-153, 2009

[2]. Ankur Agarwal "System-Level Modeling of a Network-on-Chip", International Journal of Computer Science and Security (IJCSS), 3(3):154-174, 2009.

[3]. C. Yeian, and J. Lygeres,. "Stabilization of a class of stochastic differential equations with markovian switching, System and Control Letters", issue 9:819-833, 2005.

[4]. D. Shukla, S. Gadewar and R.K. Pathak "A Stochastic model for Space division switiches in Computer Networks", International Journal of Applied Mathematics and Computation, Elsevier Journals, 184(2): 235-269, 2007.

[5]. D. Shukla, Saurabh Jain, Rahul Singhai and R.K. Agarwal "A Markov Chain model for the analysis of Round Robin Scheduling Scheme", International Journal of Advanced Networking and Applications (IJANA), 01(01):01-07, 2009.

[6]. D. Shukla, R.K. Pathak and Sanjay Thakur "Analysis of Internet traffic distribution between two markets using a Markov chain model in computer networks", Proceedings of National Conference on Network Security and Management (NCSM-07), pp. 142-153, 2007.

[7]. D. Shukla and Sanjay Thakur, "Crime based user analysis in Internet traffic sharing under cyber crime", Proceedings of National Conference on Network Security and Management (NCSM-07), pp. 155-165, 2007.

[8]. D. Shukla and Sanjay Thakur, "Rest state analysis in Internet traffic sharing under a Markov chain model", Proceedings of 2nd National Conference on Computer Science & Information Technology, pp. 46-52, 2008.

[9]. Emanual Perzen "Stochastic Processes", Holden-Day, Inc., San Francisco, and California, 1992.

[10]. J. Medhi, "Stochastic Models in queuing theory", Academic Press Professional, Inc., San Diego, CA, 1991.

[11]. J. Medhi, "Stochastic Processes", Ed. 4, Wiley Eastern Limited (Fourth reprint), New Delhi ,1992.

[12]. M. Naldi, "Internet Access Traffic Sharing in A Multi-user Environment", Computer Networks, 38:809-824, 2002.

[13]. M. Newby and R. Dagg, " Optical inspection and maintenance for stochastically deteriorating systems: average cost criteria", Jour. Ind. Stat. Asso., 40(2):169-198, 2002

[14]. Rinkle Aggarwal and Dr. Lakhwinder Kaur "On Reliability Analysis of Fault-tolerant Multistage Interconnection Networks ", International Journal of Computer Science and Security (IJCSS), 2(4):01-08, 2008.