

**Introduction:** Gordon et. Al. (2006) has studied the CSI/FBI computer crime and security survey. Haries et al. (1999) have presented TCP/IP security threats and attack methods. Shukla and Gadewar (2007) discussed Stochastic model for cell movement in a Knockout Switch in computer networks. Shukla and Thakur (2007, 2009) described Modeling of behavior of cyber criminals when two Internet operators in markets and also have presented crime based user analysis in Internet traffic sharing under cyber crime. Shukla, Tiwari et al. (2009 a, b, c, 2010) used share loss analysis of Internet traffic distribution in computer networks. Also major discussion in disconnectivity, cyber criminals, congestion controls. Howard (1997) discussed an analysis of security incidents on the internet. Garber (2000) has discussed Denial of service attacks in the Internet. Danny (2010) has presented Cyber crime – a game of cat and mouse in 2009.

## **2. System and User Behavior:**

- (a) The user initially chooses one of the two operators, operator  $O_1$  with probability  $p$  and operator  $O_2$  with probability  $(1-p)$ . This we say is the initial preference to an operator.
- (b) When first attempt of connectivity fails user attempts one more to the same operator, and thereafter, switches over to the next one where two more consecutive attempts are likely to occur. This we say “two-call-basis” attempts for the effort of call connectivity.

- (c) User has two choices after each failed attempt
  - a. he can either abandon with probability  $p_A$  or
  - b. switch over to the other operator for a new attempt.
- (d) The blocking probability that the call attempt fails through the operator  $O_1$  is  $L_1$  and through  $O_2$  is  $L_2$ .
- (e) The connectivity attempts of user between operators are on two-call-basis, which means if the call for  $O_1$  is blocked in  $k^{th}$  attempt ( $k > 0$ ) then in  $(k+2)^{th}$  user shift over to  $O_2$ . Whenever call connects through either of  $O_1$  or  $O_2$  we say system reaches to the state of success in  $n$  attempts.
- (f) User can terminate the attempt process marked as the system to the abandon state  $A$  at  $n^{th}$  attempts with probability  $p_A$  (either  $O_1$  or from  $O_2$ ).
- (g) A successful call connection provides to user a marketing package related to cyber-crime, denoted as  $C$ , with attraction probability  $(1-c_1)$  and detention probability  $(1-c_2)$ .
- (h) After a successful attempt, user has two choices: he performs cyber-crime or can opt the usual web surfing through Internet (with probability  $c_1$ ). This choice is treated as an attempt related to web connectivity.
- (i) Attempt has two definitions like call connecting attempt and Surfing attempt (occurs when call attempt is successful).
- (j) User may come-back to usual net-surfing whenever willing (with probability  $c_2$ ), or may continue with cyber crime surfing state depending on attraction of marketing plan.
- (k) From  $C$ , user can neither abandon nor disconnect.
- (l) From state  $NC$ , user can not move to the abandon state  $A$ .
- (m) State  $NC$  and  $A$  are absorbing state.

**3. Markov Chain Model :** Under above hypotheses of user's behavior can be modeled by a five-state discrete-time Markov chain  $\{X^{(n)}, n \geq 0\}$  such that  $X^{(n)}$  stands for the state of random variable  $X$  at  $n$ th attempt (call or surfing) made by a user over the state space  $\{O_1, O_2, NC, A, C\}$  where ,

- State  $O_1$ :** Corresponding to the user attempting to connect a call through the first operator  $O_1$ .
- State  $O_2$ :** Corresponding to the user attempting to place a call through second operator  $O_2$ .
- State  $NC$ :** Success (in connectivity) but no cyber-crime.
- State  $A$ :** To the user leaving (abandon) the attempt process.
- State  $C$ :** Connectivity and cyber-crime conduct through surfing.

The connectivity attempts of user between two operators are on two-call basis, which means if the call for  $O_1$  is blocked in  $k^{th}$  attempt ( $k > 0$ ), then in  $(k+2)^{th}$  user shifts to  $O_2$ . Whenever call connects either through  $O_1$  or  $O_2$ , the user reaches to the state of success ( $NC$ ) and does not perform cyber crime in next attempt with probability  $c_1$ . From state  $C$ , user cannot move to states  $O_1$ ,  $O_2$  or  $A$  without passing  $NC$ . The  $A$  is absorbing state.

The diagrammatic form of transition between two operators is given in fig.1.1.

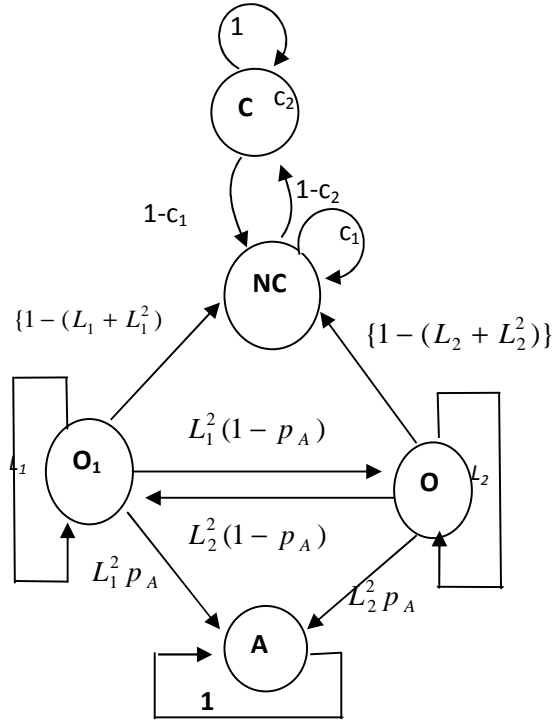


Figure- 1.1 Transition Diagram of Model

#### Transition Mechanism In Model And Probabilities

**Rule 1:** User attempts to  $O_I$  with initial probability  $p$  (based on QoS the  $O_I$  provides).

**Rule 2:** If fails, then reattempts to  $O_I$ .

**Rule 3:** User may succeed to  $O_I$  in one attempt or in the next. Since the blocking probability for  $O_I$  in one attempt is  $L_I$ , therefore, blocking probability for  $O_I$  in the next attempt is:

$$= P[O_I \text{ blocked in an attempt}] \cdot P[O_I \text{ blocked in next attempt / previous attempt to } O_I \text{ was blocked}]$$

$$= (L_I \cdot L_I) = L_I^2$$

The total blocking probability is  $(L_I + L_I^2)$  inclusive of both attempts. Hence, success probability for  $O_I$  is  $[1 - (L_I + L_I^2)]$

Similar happens for  $O_2$

$$= [1 - (L_2 + L_2^2)]$$

**Rule 4:** User shifts to  $O_2$  if call blocks in both attempts to  $O_1$  and does not abandon the attempting process. The transition probability is:

$$= P[O_1 \text{ blocked in an attempt}] \cdot P[O_1 \text{ blocked in next attempt / previous attempt to } O_1 \text{ was blocked}] \cdot P[\text{does not abandon attempting process}] = L_1^2 (1 - p_A)$$

Similar happens for  $O_2$

$$= L_2^2 (1 - p_A)$$

**Rule 5:** User earliest abandons the system only after two attempts to an operator which is a compulsive with this model. This leads to probability that user abandons process after two attempts over  $O_1$  is:

$$= P[O_1 \text{ blocked in an attempt}] \cdot P[O_1 \text{ blocked in next attempt / previous attempt to } O_1 \text{ was blocked}] \cdot P[\text{abandon the attempting process}] = L_1^2 p_A$$

Similar happens for  $O_2$

$$= L_2^2 p_A$$

**Rule 6:** for,  $0 \leq c_1 \leq 1$  and  $0 \leq c_2 \leq 1$

$$P\left[X^{(n)} = C \middle/ X^{(n-1)} = NC\right] = 1 - c_1 ; P\left[X^{(n)} = NC \middle/ X^{(n-1)} = NC\right] = c_1 ;$$

$$P\left[X^{(n)} = NC \middle/ X^{(n-1)} = C\right] = c_2 ; P\left[X^{(n)} = C \middle/ X^{(n-1)} = C\right] = 1 - c_2 ;$$

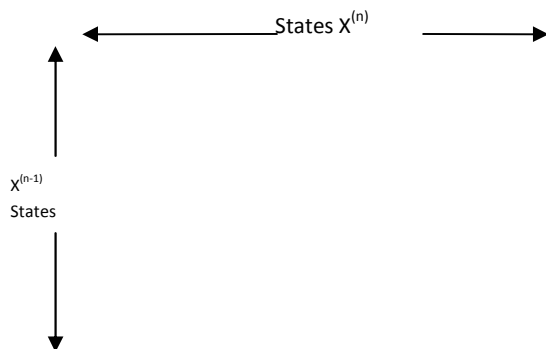
### 5. Transition Probability Between States

Define a Markov chain  $\{X^{(n)}, n=0,1,2,3,\dots\}$  where  $X^{(n)}$ , describes the state of user at  $n^{th}$  attempt to connect ( or succeed) a call while transitioning over five states  $O_1, O_2, NC, C$  and  $A$ . At  $n=0$ , we have

$$P[X^{(0)} = O_1] = p, \quad P[X^{(0)} = O_2] = (1 - p)$$

$$P[X^{(0)} = NC] = 0, \quad P[X^{(0)} = C] = 0, \quad P[X^{(0)} = A] = 0$$

Now, the transition probability matrix is



	$O_1$	$O_2$	$NC$	$C$	$A$
$O_1$	$L_1$	$L_1^2(1-P_A)$	$\{1-(L_1+L_1^2)\}$	0	$L_1^2 P_A$
$O_2$	$L_2^2(1-P_A)$	$L_2$	$\{1-(L_2+L_2^2)\}$	0	$L_2^2 P_A$
$NC$	0	0	$c_1$	$1-c_1$	0
$C$	0	0	$1-c_2$	$c_2$	0
$A$	0	0	0	0	1

## 6. Some Results for $n^{th}$ Attempts

In  $n^{th}$  attempt the probability of resulting state is derived in the following theorems for all  $n=0,1,2,3,4,5,\dots$ . If the user make attempt between  $O_1$  and  $O_2$ , then the  $n^{th}$  step transitions probability is:

$$P[X^{(0)} = O_1] = p; \quad P[X^{(0)} = O_2] = (1-p);$$

The details of transition probabilities, for  $n>0$ , are given in the above for the attempts  $n=0,1,2,3,4,5,\dots$  classified into four different categories A, B, C and D. The general expressions of probability of  $n^{th}$  attempts for  $O_1$  and  $O_2$  are:

**Type A :** when  $t=(4n+1)$ , ( e.g.  $t= 1,5,9,13,17,21,\dots$ ); ( $n>0$ )

$$P[X^{(4n+1)} = O_1]_A = L_1 [p L_1^{(3n)} L_2^{(3n)} (1-p_A)^{(2n)}]$$

$$P[X^{(4n+1)} = O_2]_A = L_2 [(1-p) L_1^{(3n)} L_2^{(3n)} (1-p_A)^{(2n)}]$$

**Type B :** when  $t=(4n-1)$ , ( e.g.  $t= 3,7,11,15,19,23,\dots$ ); ( $n>0$ )

$$P[X^{(4n-1)} = O_1]_B = [(1-p) L_1^{(3n-2)} L_2^{(3n)} (1-p_A)^{(2n-1)}]$$

$$P[X^{(4n-1)} = O_2]_B = [p L_1^{(3n)} L_2^{(3n-2)} (1-p_A)^{(2n-1)}]$$

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

$$P[X^{(4n)} = O_1]_C = [p L_1^{(3n)} L_2^{(3n)} (1-p_A)^{(2n)}]$$

$$P[X^{(4n)} = O_2]_C = [(1-p) L_1^{(3n)} L_2^{(3n)} (1-p_A)^{(2n)}]$$

**Type D :** when  $t=(4n-2)$ , ( e.g.  $t= 2,6,10,14,18,22,\dots$ ); ( $n>0$ )

$$P[X^{(4n-2)} = O_1]_D = [(1-p)L_1^{(3n-3)}L_2^{(3n)}(1-p_A)^{(2n-1)}]$$

$$P[X^{(4n-2)} = O_2]_D = [pL_1^{(3n)}L_2^{(3n-3)}(1-p_A)^{(2n-1)}]$$

## 7. Traffic Sharing and Call Connection:

We have assumed that the traffic is shared between two operators. Let us calculate the probability of the completion of a call with the assumption that this achieved in  $n^{th}$  attempt with operator  $O_i$  ( $i = 1, 2$ ).

$$\begin{aligned} \left[ \overline{P_1^{(n)}} \right]_{CU} &= P \left[ \begin{array}{l} \text{Call completes with } O_1 \text{ and user} \\ \text{is on crime state } (C) \text{ at } n^{th} \text{ attempt} \end{array} \right] \\ &= P \left[ \begin{array}{l} \text{At } (n-2)^{th} \text{ attempt at } O_1 \\ P \left[ \begin{array}{l} (n-1)^{th} \text{ on } NC \\ (n-2)^{th} \text{ on } O_1 \end{array} \right] \\ P \left[ \begin{array}{l} (n)^{th} \text{ on } C \\ (n-1)^{th} \text{ on } NC \end{array} \right] \end{array} \right] \\ &= P[X^{(n-2)} = O_1] P \left[ \begin{array}{l} X^{(n-1)} = NC \\ X^{(n-2)} = O_1 \end{array} \right] \\ &\quad P \left[ \begin{array}{l} X^{(n)} = C \\ X^{(n-1)} = NC \end{array} \right] \quad \text{For Operator } O_1 \\ &= (1 - (L_1 + L_1^2)(1 - c_1)) \left[ \sum_{i=0}^{n-2} P \{X^{(i)} = O_1\} \right], \quad n \geq 2 \end{aligned}$$

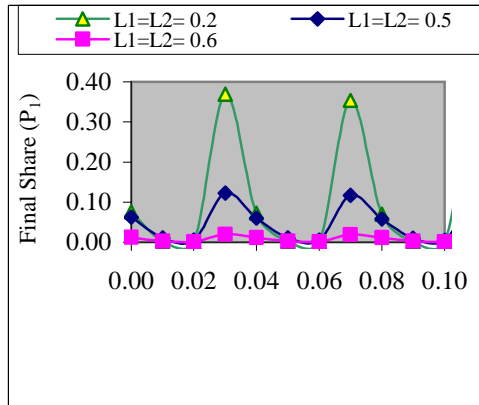
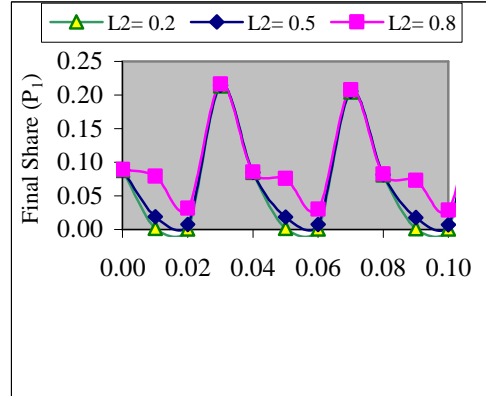
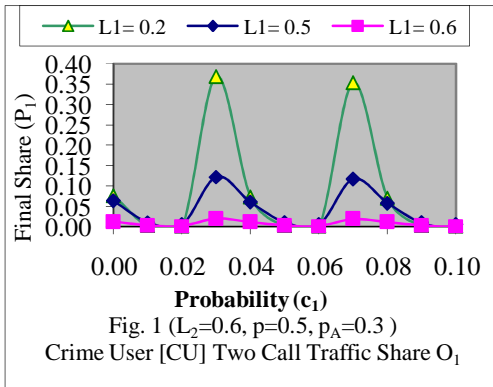
$$\begin{aligned} \left[ \overline{P_1^{(n)}} \right]_{CU} &= [1 - (L_2 + L_2^2)(1 - c_1)] \\ &\quad \left\{ (L_1 p + p) \left\{ \frac{1 - [L_1^{(3)} L_2^{(3)} (1 - p_A)^{(2)}]^n}{1 - [L_1^{(3)} L_2^{(3)} (1 - p_A)^{(2)}]} \right\} \right\} \\ &\quad + \left( (1 - P) + \frac{(1 - p)}{L_1} \right) [L_1 L_2^{(3)} (1 - p_A)] \\ &\quad \left\{ \frac{1 - [L_1^{(3)} L_2^{(3)} (1 - p_A)^{(2)}]^{n-1}}{1 - [L_1^{(3)} L_2^{(3)} (1 - p_A)^{(2)}]} \right\} \end{aligned}$$

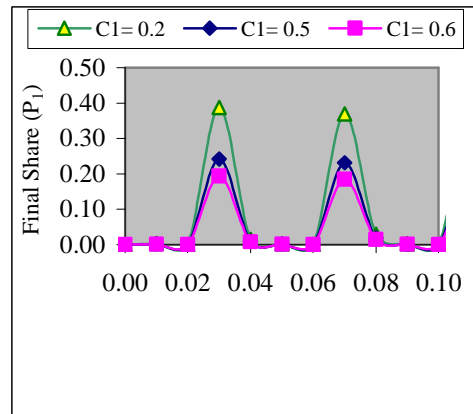
For operator  $O_2$

$$\begin{aligned}
\left[ \overline{P_2}^{(n)} \right]_{CU} &= \left[ \{1 - (L_2 + L_2^2)(1 - c_1)\} \right. \\
&\quad \left. \left\{ (L_2(1 - p) + (1 - p)) \left\{ \frac{1 - [L_1^{(3)} L_2^{(3)} (1 - p_A)^{(2)}]^n}{1 - [L_1^{(3)} L_2^{(3)} (1 - p_A)^{(2)}]} \right\} \right\} \right. \\
&\quad \left. + \left( P + \frac{p}{L_2} \right) [L_1^{(3)} L_2 (1 - p_A)] \right. \\
&\quad \left. \left\{ \frac{1 - [L_1^{(3)} L_2^{(3)} (1 - p_A)^{(2)}]^{n-1}}{1 - [L_1^{(3)} L_2^{(3)} (1 - p_A)^{(2)}]} \right\} \right]
\end{aligned}$$

## 8.Simulation Over Large Attempts:

With reference to fig. 1 to 4, the final share probability has fluctuating trend. The lower blocking probability  $L_I$  of operator  $O_I$  generates high CU proportion. The small  $c_I$  probability also produces high level of cyber criminals; therefore it is suggested to set high probability for  $c_I$  and low probability for  $L_I$ .





**9. Concluding Remarks:** In the two-call setup, with the increase of a  $c_l$  and  $L_l$  probability together, there is loss due to proportion of no-cyber criminals. But, with increase of  $c_l$  alone the proportion of non cyber criminals is high. In contrary, if  $c_l$  is low (10%). One can get high proportion of final traffic of CU group. It seems marketing plans related to promotion of cyber crimes help to uplift the internet traffic for an operator.

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