# Curve Fitting Analysis of Internet Traffic Sharing Management in Computer Network under Cyber Crime

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## ABSTRACT
Cyber crime is growing fast day-by-day through the spreading of Internet around the world. Many under-developed countries are using dial-up-setup network where a call is connected only after a little extra effort. Some identified cyber crimes are writing abusive letters, giving threats to other, sending unwanted mails, hacking secret data, phishing attack on websites etc. The Internet traffic growth has some positive correlation with the cyber crime as justified by the Markov Chain Model based analysis of authors to examine the interrelationship between traffic sharing and blocking probability. This analysis has been extended for two-call basis also and model based relations are derived. These relations are complicated in terms of mathematical structure. This paper presents least square based curve analysis for Markov Chain model based relationship between traffic sharing and network blocking. The earlier suggested complicated relationship has been simplified in the form of straight line showing a good fitting. The Coefficient of determination has been computed showing the high value towards unity. It proves that simplified linear relationships perform well as a thumb rule for expressing the complex relationship between traffic sharing and network blocking probability. .

## Keywords
User behavior, Transition Probability Matrix (TPM), Markov Chain Model (MCM), Coefficient of Determination (COD), Confidence Interval.

## 1. INTRODUCTION
Naldi [5] has suggested Markov Chain model for the analysis of Internet traffic sharing with the blocking probability of computer network. This approach was under assumption that there is only single call attempt allowed. Shukla *et al.* [32] have extended the problem to the case of call basis. Shukla, Tiwari and Thakur [25] has extend the approach of Naldi [5] of to the case of cyber crime presence. Cyber criminals get opportunities to perform harmful activities through computer network. When the call is connected few popular cyber crimes are hacking, phishing attack, unwanted mails, threatening mails etc. after the call connection using dial-up-setup, there are two possibilities. (i) either the user performs cyber crime or does not. Shukla, Tiwari and Thakur [32] established a relationship between traffic sharing by cyber criminals and blocking probabilities of computer network. This relationship is non linear contains many model parameters as input sources. This paper presents an approach to simplify the complex relationship into a linear form under the setup of cyber crime and two call basis attempts. The Markov chain based approach suggested by Naldi [5] is the main focus which has been extended in the environment of curve fitting approach. Shukla and Thakur [12] have some useful contribution on cyber crime analysis using a Markov Chain Model.

## 2. A REVIEW
The network system as a random process has been assumed by many researchers for the purpose of statistical modelling whose detailed description is in Medhi [1], [2]. Chen and Mark [3] discussed the fast packet switch shared concentration and output queueing for a busy channel. Hambali and Ramani [4] evaluated multicast switch with a variety of traffic patterns. Newby and Dagg [6] have a useful contribution on the optical inspection and maintenance for stochastically deteriorating system. Dorea *et al.* [8] used Markov chain for the modelling of a system and derived some useful approximations. Yeian and Lygeres [10] presented a work on stabilization of class of stochastic different equations with Markovian switching. Shukla *et al.* [11] advocated for model based study for space division switches in computer network. Francini and Chiussi [7] discussed some interesting features for QoS guarantees to the unicast and multicast flow in multistage packet switch. On the reliability analysis of network a useful contribution is by Shukla *et al.* [13] whereas Paxson [9] introduced some of their critical experiences while measuring the internet traffic. Shukla *et al*. [14], [15], [16], [17], [18], [19] and [20] presented different dimensions of Internet traffic sharing in the light of share loss analysis. Shukla *et al*. [21], [22], [23], [24], [25] and [26] have given some Markov Chain model applications in view to disconnectivity factor, multi marketing and crime based analysis. Shukla and Thakur [27] presented Index based internet traffic analysis of users by a Markov chain model . Shukla *et al.* [28], [29], [30], [31] and [32] discussed cyber crime analysis for multidimensional effect in computer network and internet traffic sharing. Shukla *et al*. [33], [34], [35], [36], [37], [38], [39] and [40] discussed the elasticity property and its impact on parameters of internet traffic sharing in presence blocking probability of computer network specially when two operators are in business competitions with each other in a market. Shukla *et al.* [41] presented analysis of user web browsing using Markov chain model for iso-browser share probability. Shukla *et al.* [43] studied least square curve fitting for Iso-failure in web browsing using Markov chain model. Shukla *et al.* [44] studied least square curve fitting in internet access traffic sharing in two operator environment. Shukla *et al*. [45] discussed least square curve fitting applications under rest state environment in internet traffic sharing in computer network. Shukla *et al.* [46] presented curve fitting approximation in internet traffic distribution in computer network in two market environments. Shukla *et al.* [47] studied cyber crime based curve fitting analysis in internet traffic sharing in computer network.

## 3. ASSUMPTIONS FOR SYSTEM AND USER BEHAVIOUR [As per Shukla, Tiwari and Thakur (2010 d)]

(a) The user chooses, operator $O_1$ with probability p or operator $O_2$ with probability (1 - p).

(b) When first attempt of connectivity fails he attempts one more to the same operator, and thereafter, switches to the next where two more consecutive attempts may appear. This we say "two-call-basis" attempts for call connectivity.

(c) User has two choices after each failed attempt;

   a. he can either abandon with probability $p_A$ or

   b. switch to the other operator for a new attempt.

(d) The blocking probability that a call attempt fails through the operator $O_1$ is $L_1$ and through $O_2$ is $L_2$.

(e) If the call for $O_1$ is blocked at $k^{th}$ attempt (k > 0) then in $(k + 2)^{th}$ user shifts to $O_2$.

(f) Whenever call connects through either of $O_1$ or $O_2$ we say system reaches to the state of success after n attempts.

(g) User can terminate the connectivity attempt process which is marked as abandon state A with probability $p_A$ (either $O_1$ or from $O_2$).

(h) A successful call connection has a marketing package related to cyber-crime, denoted as C, with attraction probability (1 - $c_1$) and detention probability (1 - $c_2$).

(i) After connectivity, user has two choices either to do or cyber-crime or to do usual web surfing through Internet (with probability $c_1$). This choice is treated as an attempt related to web connectivity.

(j) Attempt means call-connecting attempt or surfing attempt.

(k) User may come-back to usual surfing whenever willing (with probability $c_2$) or may continue with cyber crime depending on attraction of marketing plan.

(l) From crime, user can neither abandon nor disconnect.

(m) From state of normal surfing, user can not abandon.

(n) State non-crime and abandon are absorbing state.

## 4. MARKOV CHAIN MODEL [As per Shukla, Tiwari and Thakur (2010 d)]

Using above hypotheses about user's behavior it 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 $O_1$:** User attempting to connect a call through the first operator $O_1$.

**State $O_2$:** Corresponding to a call through second operator $O_2$.

**State NC:** Success (in connectivity) but no cyber-crime.

**State A:** User leaving (abandon) the attempt process.

**State C:** Connectivity gained and cyber-crime.

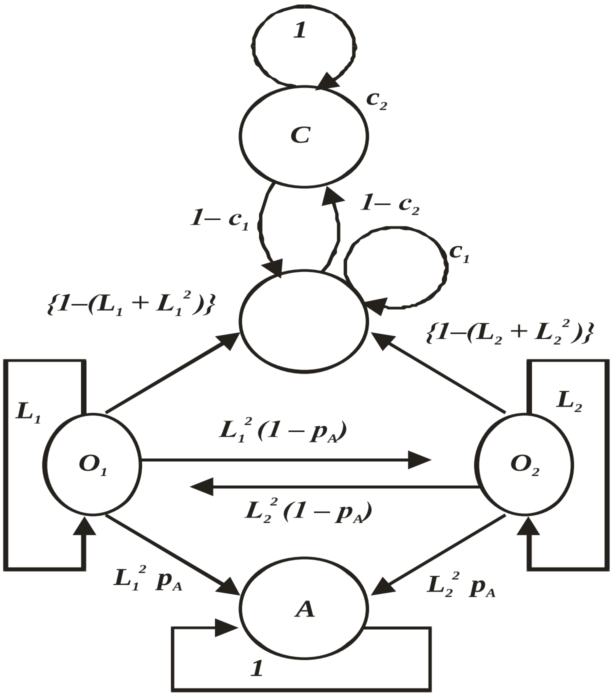


**Fig.:- 1 Transition Diagram of Model** [As per Shukla, Tiwari and Thakur (2010 d)]

The connectivity attempts 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 $O_2$. When call connects either through $O_1$ or $O_2$ the system 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 through NC. The A is absorbing state.

## 5. TRANSITION MECHANISM IN MODEL AND PROBABILITIES [As per Shukla, Tiwari and Thakur (2010 d)]

**Rule 1:** User attempts to $O_1$ with initial probability p (based on QoS the $O_1$ provides).

**Rule 2:** If fails, then reattempts to $O_1$.

**Rule 3:** User may succeed to $O_1$ in either of one attempt or next. Since the blocking probability for $O_1$ in one attempt is $L_1$, therefore, blocking probability for $O_1$ in the next attempt is:

= P [$O_1$ blocked in an attempt]. P [$O_1$ blocked in next attempt / previous attempt to $O_1$ was blocked] = $(L_1.L_1) = L_1^2$

The total blocking probability is $(L_1 + L_1^2)$ inclusive of both attempts. The success probability for $O_1$ is $[1-(L_1 + L_1^2)]$ Similar for $O_2 = [1-(L_2 + L_2^2)]$

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

= P [$O_1$ blocked in an attempt]. P [$O_1$ blocked in next attempt/previous attempt to $O_1$ was blocked]. P [does not abandon attempting process] = $L_1^2$ (1- $p_A$) Similar for $O_2 = L_2^2$ (1- $p_A$).

**Rule 5:** User either abandons the system atleast 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 [$O_1$ blocked in an attempt]. P [$O_1$ blocked in next attempt/previous attempt to $O_1$ was blocked]. P[abandon the attempting process] = $L_1^2\, p_A$ Similar happens for $O_2 = L_2^2\, p_A$

**Rule 6:** for, $0 \le c_1 \le 1$ and $0 \le c_2 \le 1$ we have

$$P\left[X^{(n)} = C \big/ X^{(n-1)} = NC\right] = 1 - c_1 \quad ...(5.1)$$

$$P\left[X^{(n)} = NC \big/ X^{(n-1)} = NC\right] = c_1 \quad ...(5.2)$$

$$P\left[X^{(n)} = NC \big/ X^{(n-1)} = C\right] = c_2 \quad ...(5.3)$$

$$P\left[X^{(n)} = C \big/ X^{(n-1)} = C\right] = 1 - c_2 \quad ...(5.4)$$

## 6. TRANSITION PROBABILITY BETWEEN STATES

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

$$\left.\begin{array}{l} P\left[X^{(0)} = O_1\right] = p \\ P\left[X^{(0)} = O_2\right] = (1-p) \\ P\left[X^{(0)} = NC\right] = 0 \\ P\left[X^{(0)} = C\right] = 0 \\ P\left[X^{(0)} = A\right] = 0 \end{array}\right\} \quad ...(6.1)$$

Now, the transition probability matrix is

States $X^{(n)}$

| $X^{(n-1)}$ | $O_1$ | $O_2$ | $NC$ | $C$ | $A$ |
|---|---|---|---|---|---|
| $O_1$ | $L_1$ | $L_1^2(1-p_A)$ | $\{1-(L_1+L_1^2)\}$ | 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 |

**Table: 6.1 [Transition Probability Matrix]** [As per Shukla, Tiwari and Thakur (2010 d)]

## 7. CURVE FITTING ANALYSIS OVER LARGE NUMBER OF ATTEMPT

$$\left[\bar{P}_1\right]_{CC} = \left[\left\{1-\left(L_2+L_2^2\right)\right\}\left(1-c_1\right)\left\{\begin{array}{l}\dfrac{\left[\left(L_1 p + p\right)\right]}{1-\left[L_1^{(3)}L_2^{(3)}\left(1-p_A\right)^{(2)}\right]} + \\ \dfrac{\left(L_1\left(1-P\right)+\left(1-P\right)\right)\left[L_2^{(3)}\left(1-p_A\right)\right]}{1-\left[L_1^{(3)}L_2^{(3)}\left(1-p_A\right)^{(2)}\right]}\end{array}\right\}\right] ...(7.1)$$

$$\left[\bar{P}_2\right]_{CC} = \left[\left[\left\{1-\left(L_2+L_2^2\right)\right\}\left(1-c_1\right)\right]\left\{\begin{array}{l}\dfrac{\left(L_2\left(1-p\right)+\left(1-p\right)\right)}{1-\left[L_1^{(3)}L_2^{(3)}\left(1-p_A\right)^{(2)}\right]} \\ + \dfrac{\left[\left(L_2 P + p\right)L_1^{(3)}\left(1-p_A\right)\right]}{1-\left[L_1^{(3)}L_2^{(3)}\left(1-p_A\right)^{(2)}\right]}\end{array}\right\}\right] ...(7.2)$$

$$\bar{P}_{1A\,CC} = \left[\frac{\left(1-C_1\right)L_1.p\left\{1-\left(L_1+L_1^2\right)\right\}}{1-L_1^3 L_2^3\left(1-p_A\right)^2}\right] \quad ...(7.3)$$

## 8. LEAST SQUARE CURVE FITTING

We suggest a linear relationship where a, b are constants

$$\bar{P}_1 = \hat{a} + \hat{b}.L_1 \quad ....(8.1)$$

Let ( $(\bar{P}_{1i}, L_{1i})$ $i = 1,2,3....n$ be n observations generated from equation (7.1) keeping values fixed for p, $p_A$ and $L_2$. Suppose n=9 and blocking probabilities for $L_1$ are (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9) then using (8.1), the generated data of $\bar{P}_1$ is in table (1, 2 and 3). The $\hat{P}_1$ is obtained using line equation (9.4) with $\hat{a}, \hat{b}$.

## 9. FITTING THE STRAIGHT LINE

We suggest an approximate the relationship between parameter $P_1$ and $L_1$ through a straight line $\hat{P}_1 = a + b.L_1$. The normal equations are

$$\left.\begin{aligned}\sum_{i=1}^{n} P_{1i} &= n.a + b\sum_{i=1}^{n} L_{1i} \\ \sum P_{1i}.L_{1i} &= a\sum_{i=1}^{n} L_{1i} + b\sum_{i=1}^{n} {L_{1i}}^2\end{aligned}\right\} \quad ...(9.1)$$

By solving the above equation the least square estimate are a and b are (denoted as $\hat{a},\hat{b}$ ):

$$\hat{a} = \left\{\frac{1}{n}\sum_{i=1}^{n} P_{1i} - \hat{b}\sum_{i=1}^{n} L_{1i}\right\} \quad ...(9.2)$$

$$\hat{b} = \left\{\frac{n\sum_{i=1}^{n} P_{1i}L_{1i} - (\sum_{i=1}^{n} P_{1i})(\sum L_{1i})}{n\sum_{i=1}^{n} {L_{1i}}^2 - (\sum_{i=1}^{n} L_{1i})^2}\right\} \quad ....(9.3)$$

Where n is the number of observations in sample (n) and the resultant straight line is

$$\hat{P}_1 = \left\{\hat{a} + \hat{b}\, L_1\right\} \quad ....(9.4)$$

The coefficient of determination (COD) is defined as

$$\text{COD} = \left\{\frac{\sum(\hat{P}_{1i} - \overline{P}_1)^2}{\sum(P_{1i} - \overline{P}_1)^2}\right\} \quad ...(9.5)$$

Where $\overline{P}_1 = \frac{1}{n}\sum P_{1i}$ is mean of original data of $P_1$ obtained through Markov chain model. The term $\hat{P}_1 = \hat{a} + \hat{b}.L_1$ is the estimated value give observation $L_1$. The COD lies between 0 to 1. If the line is good fit then it is near to 1. We generate pair of value ($L_1$, $P_1$) from express tables (1, 2 and 3) by providing few fixed input parameters.

**Table 1**

| **Fixed parameter** p=0.4, $L_2$=0.3, $p_A$=02, $C_1$=0.3 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $L_1$ | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| $P_1$ | 0.1498 | 0.1358 | 0.1212 | 0.1061 | 0.0903 | 0.0738 | 0.0566 | 0.0386 | 0.0197 |
| $\hat{P}_1$ | 0.1529 | 0.1366 | 0.1204 | 0.1042 | 0.0888 | 0.0717 | 0.0555 | 0.0393 | 0.0231 |
| **COD=0.997975** | | | | | | | | | |

$$\hat{a} = 0.1690; \quad \hat{b} = -0.1622; \hat{P}_1 = a + b.L_1; \quad \hat{P}_1 = 0.1690 - 0.1622.(L_1)$$

**Table 2**

| **Fixed parameter** p=0.6, $L_2$=0.5, $p_A$=02, $C_1$=0.5 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $L_1$ | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| $P_1$ | 0.3533 | 0.3248 | 0.2942 | 0.2615 | 0.2262 | 0.1881 | 0.1469 | 0.1022 | 0.0534 |
| $\hat{P}_1$ | 0.3685 | 0.3285 | 0.2912 | 0.2544 | 0.2167 | 0.1795 | 0.1422 | 0.1049 | 0.0677 |
| **COD=0.992526** | | | | | | | | | |

$$\hat{a}=0.4030;\quad \hat{b}=-0.3726;\hat{P}_1=a+b.L_1;\quad \hat{P}_1=0.4030-0.3726.(L_1)$$

**Table 3**

| **Fixed parameter** p=0.8, $L_2$=0.7, $p_A$=02, $C_1$=0.7 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $L_1$ | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| $P_1$ | 0.5579 | 0.5049 | 0.4499 | 0.3929 | 0.3337 | 0.2722 | 0.2082 | 0.1416 | 0.0723 |
| $\hat{P}_1$ | 0.5684 | 0.5078 | 0.4472 | 0.3866 | 0.3261 | 0.2653 | 0.2047 | 0.1441 | 0.0835 |
| **COD=0.998215** | | | | | | | | | |

$$\hat{a}=0.6289;\quad \hat{b}=-0.6060;\hat{P}_1=a+b.L_1;\quad \hat{P}_1=0.6289-0.6060.(L_1)$$

## 10. CONFIDENCE OF INTERVALS (COI)

The 100(1- $\alpha$ ) percent confidence interval for a and b are

$$\hat{a}\pm\left\{t_{(n-2)}\frac{\alpha}{2}\right\}.s\left[\sqrt{\frac{1}{n}+\frac{\overline{L_1}}{\sum_{i=1}^{n}(L_{1i}-\overline{L_1})^2}}\right]...(10.1)$$

Where $\overline{L_1}=\frac{1}{n}\sum_{i=0}^{n}L_{1i}$. The $\overline{L_1}$ = 4.5 from table (1, 2 and 3)

$$\hat{b}\pm\left\{t_{(n-2)},\frac{\alpha}{2}\right\}.s\left[\sqrt{\sum_{i=1}^{n}(L_{1i}-\overline{L_1})^2}\right]\quad ...(10.2)$$

Where s= $\sqrt{\frac{\sum(P_i-\hat{P}_i)^2}{n-2}}$ and $t_{(n-2)}\frac{\alpha}{2}$ is obtained from standard table. take α=0.05,n=9 then $t_7$,0.025=2.365

**Table: 4 Confidence interval for a and b**

| **Fixed parameter** | **Constant (a)** | **Constant (b)** | **Confidence Intervel** |
|---|---|---|---|
| p=0.4,$L_2$=0.3,$p_A$=0.2, $C_1$=0.3 | $\hat{a}$ =0.1690 | $\hat{b}$ =-0.1622 | For: (a=0.16381, a=0.17435) For: (b=-0.15800,b=-0.16642) |
| p=0.6,$L_2$=0.5,$p_A$=0.2, $C_1$=0.5 | $\hat{a}$ =0.4030 | $\hat{b}$ =-0.3726 | For: (a=0.38117, a=0.42489 ) For: (b=-0.35522, b=-0.39003) |
| p=0.8,$L_2$=0.7,$p_A$=0.2, $C_1$=0.7 | $\hat{a}$ =0.628 9 | $\hat{b}$ =- 0.6060 | For: (a=0.61121, a=0.64673) For: (b=-0.59188, b=-0.62018) |
| **Average Estimates** | $\bar{a}=0.40$ | $\bar{b}=-0.38$ | $\hat{P}_1=\bar{a}+\bar{b}(L_1)$ $\hat{P}_1=0.400915-0$ |

## 11. AVERAGE RELATIONSHIP

we define $\hat{P}_1=\bar{a}+\bar{b}(L_1)$ in table 4 where $\bar{a},\bar{b}$ are average estimate obtain through all tables. We found that

$$\hat{P}_1=0.400915-0.381292.(L_1)$$

## 12. CONCLUSION

In a contribution Shukla,Tiwari and Thakur [24] have suggested a mathematical relation depending on many model parameters. But there is no direct relation exist between $P_1$ and $L_1$. Using the model relation and least square method together we have obtained the simplified relation as $\hat{P}_1 = 0.400915 - 0.381292.(L_1)$.

The coefficient of determination is nearly equal to 1, showing strength of the fitting of straight line. This suggested linear relationship is just like a first hand preliminary rule. The beauty of expression is that it is independent of model parameters.

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