Models for Internet Traffic Sharing in Computer Network

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Abstract

Internet Service Providers (ISPs) constantly endeavor to resolve network congestion, in order to provide fast and cheap services to the customers.
This study suggests two models based on Markov chain, using three and four access attempts to complete the call. It involves a comparative study of four models to check the relationship between Internet Access sharing traffic, and the possibility of network jamming.
The first model is a Markov chain, based on call-by-call attempt, whereas the second is based on two attempts. Models III&IV suggested by the authors are based on the assumption of three and four attempts. The assessment reveals that sometimes by increasing the number of attempts for the same operator, the chances for the customers to complete the call, is also increased due to blocking probabilities. Three and four attempts express the actual relationship between traffic sharing and blocking probability based on Markov using MATLAB tools with initial probability values. The study reflects shouting results compared to I&II models using one and two attempts.
The success ratio of the first model is 84.5%, and that of the second is 90.6% to complete the call, whereas models using three and four attempts have 94.95% and 95.12% respectively to complete the call.

Key words:
Internet traffic, Call attempts, Call block, Markov chain, ISP.

1. Introduction

No one can deny the fact that internet network increases (expands) rapidly and as a result of this growth/expansion, the demand for service providers has also increased, especially in terms of quality of service (QoS) in networks. The packet/package loss can be due to either congestion or non-congestion losses such as random losses due to transmission errors. Network blocking may occur due to overflow/excessive traffic at a particular time or locality, insufficient number of modems, inefficient transmitters or inadequate care and services.

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Besides making investments to improve their services, operators are using innovative marketing strategies to retain and attract customers. On the other hand, customers' preferences include the quality of services in terms of cost, reliability and faster connectivity. This leads the customers to study the internet traffic and offers made to find the best quality level of service operators on the market.
Naldi [1][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 to complete the call, he used Markov chain model to analyze the relationship between traffic sharing and blocking probability in a network under the assumption of two networks operators based on the assumption that there is only one attempt allowed to complete the call.
Shukla and Thakur submit a wonderful study extended the assumption to convert the criteria of call-by-call attempt to two call attempts to complete the call [2,3,4,7,8,9].
These two models have a high rate of success when the blocking probability. However, when the blocking probability is increased the success rate will be decreased rapidly, especially with Naldi model [1].
Thus, when the probability percentage is increased, sequentially the successful to complete call is decreased too.
The objective of this paper to study the effects of the number of attempts on the success rate when the blocking probability coming high and by the way this will increase the successful of completing the call. The study presents two models to solve the call blocked problem, Model III performs two attempts and Model IV used three attempts to solve the call blocked problems.

The new applied models uses MATLAB, and The result shows that d the successful rate for Model III exceed 80%, and 90% for Model IV to complete the call.

1.1 Transition Matrices

A transition matrix P_t, for Markov chain $\{X_0, X_1, X_2, \ldots\}$ where X_t is the state at time t is a matrix containing information on the probability of transitioning between states when given an ordering of a matrix's rows and columns by the state space S, the (i, j) element of the matrix P_t is given by

$(P_t)_{i,j}=P(X_{t+1=j}|X_{t=i})$. this means each row of the matrix is a probability vector, and the sum of its entries is 1.

$$P_t^{(k)} = \begin{bmatrix} P(X_{t+k}=1\,|X_t=1)P(X_{t+k}=2\,|X_t=1)\ldots P(X_{t+k}=n\,|X_t=1). \\ P(X_{t+k}=1\,|X_t=2)P(X_{t+k}=2\,|X_t=2)\ldots P(X_{t+k}=n\,|X_t=2) \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \\ P(X_{t+k}=1\,|X_t=n)P(X_{t+k}=2\,|X_t=n)\ldots P(X_{t+k}=n\,|X_t=n) \end{bmatrix}$$

Here we have a property that product of subsequent ones describes a transition along the time intervals, spanned by the transition matrices that can be expressed by

$(P_t \cdot P_{t+1})i,j= P(X_{t+2}=j|\ X_{t=i})$ and $M=P_t\cdot P_{t+1}$. Represent a matrix multiplication

$M_{i,j}=\sum_{k=1}^{n}(P_t)_{i,k}(P_{t+1})_{k,j}$

$=\sum_{k=1}^{n}P(X_{t+1}=k\,|X_{t=i})P(X_{t+2}=j|X_{t+1}=k)$

$= P(X_{t+2}=j|X_t=i)$ give a transition Matrices [5,7,8,10].

The K-step transition matrix will be look like

$$P_t^K = P_t + P_{t+1} + \cdots . + P_{t+k-1}$$

Hence

1.2 Models

The network schema of four models are shown in Fig. 1, 3, 5 and 7 depending on two operators O_1 and O_2. Let $\{X^{(n)}, n\geq 0\}$ be a Markov chain having transitions over the state space $\{O_1, O_2, Z, A\}$ where:

State O_1: The user tries to connect through the first operator O_1.

State O_2: The user tries to connect through the second operator O_2.

State Z: The success of the call state.

State A: Leave attempts to contact state.

The probability used in these four models are (P, PA, L_1, L_2) where:

P: The initial probability of a user to choose the first operator O_1.

P_A: The user leaves an attempt to connect.

L_1: The probability of failure for the call attempt through the operator O_1.

L_2: The probability of failure for the call attempt through the operator O_2.

Let$\{X^{(n)}, n= 0\}$ be a Markov chain over four state O_1, O_2, Z, A. The $X^{(n)}$ is the position of user at the nth call attempt. The initial conditions are:

$P[X^{(0)} = O_1] = P$

$P[X^{(0)} = O_2] = 1 - P$

$P[X^{(0)} = Z] = 0$

$P[X^{(0)} = A] = 0$

A) Model-I:

The model suggested by Naldi [1], and its assumptions are:

1) The probability to choose O_1 is P, this means the probability to choose O_2 is (1–P).
2) The probability to succeed from O_1 is 1– blocking probability (L_1); this applies to O_2, the probability to succeed from O_2 is (1– L_2).
3) After blocking (L_1 or L_2) user can choose even leave attempts [with probability equal blocking probability (L_1) × leaving probability (P_A) from O_1 or (L_2. P_A) from O_2] or try again attempt with another operator [with probability equal blocking probability (L_1) × probability the user does not leave attempts (1 – P_A)], this mean the probability transfer from O_2 to O_1 is [L_2. (1 – P_A)].
4) If user reach state Z or state A then he cannot leave it, this means the probability transfer to another state is zero and probability remaining in the same state is one.

The transition diagram for model-I is shown in Fig. 1.

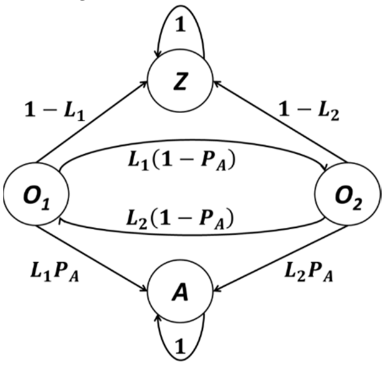

Fig. 1 Transition diagram for Model-I

The one-step transition probabilities matrix is:

$$M = \begin{bmatrix} 0 & L_1(1-P_A) & 1-L_1 & L_1P_A \\ L_2(1-P_A) & 0 & 1-L_2 & L_2P_A \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Fig. 2 shows a sample of user's call transitions over the state space (10 attempts) using model I (parameters P, P_A, L_1, L_2 are generated randomly).

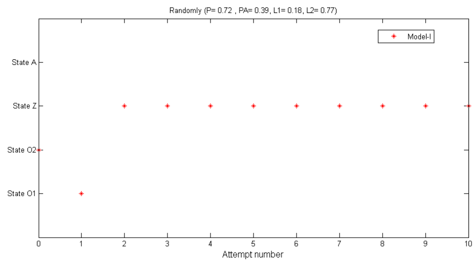

Fig. 2 The user call transitions using model-I

B) Model-II:

The model suggested by Shukla [2], and the difference in this model is that the user can try again with the same operator only once if the call is blocked. After choosing O_1 or O_2 the model assumptions are:

1) The probability to succeed from O_1 is [1– probability for first blocking (L_1) – probability for second blocking (L_1^2)] that because the call may succeed from first or second try, meaning thereby the probability to succeed from O_2 is [1– (L_2+ L_2^2)].
2) After first blocking user can try with same operator with probability (L_1) for O_1 and (L_2) for O_2.
3) The probability to leave attempts is [probability for all incidents of blocking (L_1^2) × leaving probability (P_A)].
4) The probability to transfer from O_1 to O_2 is [probability for all incidents of blocking (L_1^2) × probability the user does not leave attempts (1 – P_A)], the probability transfer from O_2 to O_1 is [L_2^2. (1 – P_A)].

The transition diagram for model-II is shown in Fig. 3.

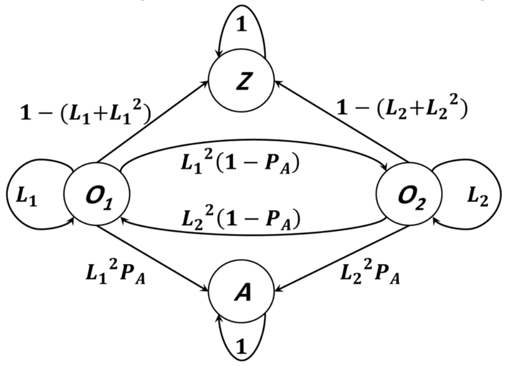

Fig. 3 The transition diagram of behavior model-II

The one step transition probabilities matrix is:

$$M = \begin{bmatrix} L_1 & L_1^2(1-P_A) & 1-(L_1+L_1^2) & L_1^2P_A \\ L_2^2(1-P_A) & L_2 & 1-(L_2+L_2^2) & L_2^2P_A \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Fig. 4 shows a sample of user call transitions over the state space (10 attempts) using model I (parameters P, P_A, L_1, L_2 are generated randomly).

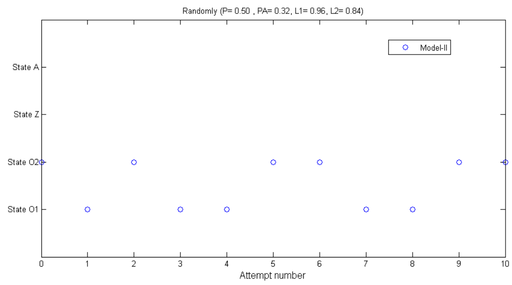

Fig. 4 The user call transitions using model-II

2. Methodology

Here by models III and IV derivation, the authors suggest this model, in model III the difference from previous models that the user can try again with the same operator only twice if the call is blocked. After choosing O_1 or O_2 the model-III assumptions are:

1) The probability to succeed from O_1 is $[1 - L_1 - L_1^2 - L_1^3]$ (similar to what is described in model II) and the probability to succeed from O_2 is $[1 - (L_2 + L_2^2 + L_2^3)]$.
2) After first blocking, the user can try again with the same operator with probability (L_1) for O_1. If the user gets blocked again, he can try for a second time with probability (L_1^2), which means the total probability a user can try with the same operator is $[L_1 + L_1^2]$; this applies also for O_2, the probability a user can try again with operator O_2 is $[L_2 + L_2^2]$.
3) The probability to leave attempts is [probability for all incidents of blocking (L_1^3) × leaving probability (P_A)].
4) The probability to transfer from O_1 to O_2 is [probability for all incidents of blocking (L_1^3) × probability the user does not leave attempts ($1 - P_A$)], also the probability transfer from O_2 to O_1 is $[L_2^3 . (1 - P_A)]$.

The transition diagram for model-III is shown in Fig. 5.

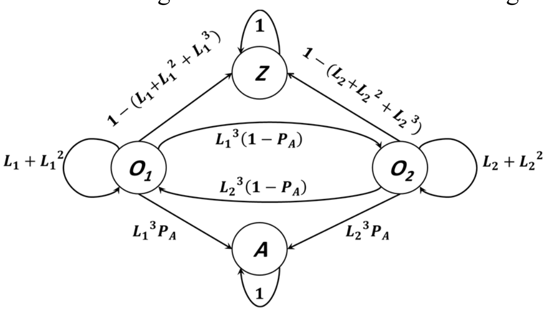

Fig. 5 The transition diagram of behavior model-III

The one step transition probabilities matrix is:

$$M = \begin{bmatrix} L_1 + L_1^2 & L_1^3(1-P_A) & 1-(L_1+L_1^2+L_1^3) & L_1^3P_A \\ L_2^3(1-P_A) & L_2+L_2^2 & 1-(L_2+L_2^2+L_2^3) & L_2^3P_A \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Fig. 6 shows a sample of user call transitions over the state space (10 attempts) using model I (parameters P, P_A, L_1, L_2 are generated randomly).

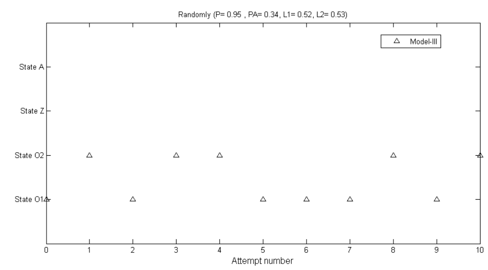

Fig. 6 The user call transitions using model-III

In Model-IV: the user can try again with the same operator three times only if the call is blocked. After choosing O_1 or O_2, the model assumptions are:

1) The probability to succeed from O_1 is $[1 - L_1 - L_1^2 - L_1^3 - L_1^4]$ and the probability to succeed from O_2 is $[1 - (L_2 + L_2^2 + L_2^3 + L_2^4)]$.
2) After first blocking, a user can try again with the same operator with probability (L_1) for O_1. If a user gets blocked again, he can try for the second time with probability (L_1^2). If he gets blocked again, then he can try for a third time with probability (L_1^3), which means the total probability a user can try with the same operator is $[L_1 + L_1^2 + L_1^3]$; this also applies for O_2. The probability for a user to try again with operator O_2 is $[L_2 + L_2^2 + L_2^3]$.
3) The probability to leave attempts is [probability for all incidents of blocking (L_1^4) × leaving probability (P_A)].
4) The probability to transfer from O_1 to O_2 is [probability for all incidents of blocking (L_1^4) × probability the user does not leave attempts ($1 - P_A$)], also the probability transfer from O2 to O1 is $[L_2^4 . (1 - P_A)]$.

The transition diagram for model-III is shown in Fig. 7.

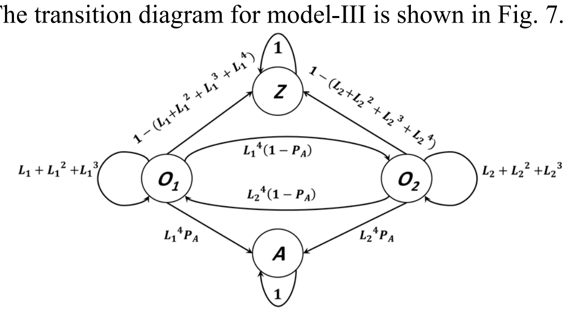

Fig. 7 The transition diagram of behavior model- IV

The one step transition probabilities matrix is:

$$M = \begin{bmatrix} L_1 + L_1^2 + L_1^3 & L_1^4(1-P_A) & 1-(L_1+L_1^2+L_1^3+L_1^4) & L_1^4P_A \\ L_2^4(1-P_A) & L_2+L_2^2+L_2^3 & 1-(L_2+L_2^2+L_2^3+L_2^4) & L_2^4P_A \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Fig. 8 shows a sample of user call transitions over the state space (10 attempts) using model I (parameters P, P_A, L_1, L_2 are generated randomly).

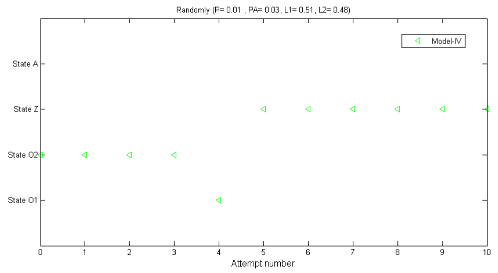

Fig. 8 The user call transitions using model-IV

3. Results

This section discusses the graphical comparison between the proposed models (III, IV) and existing models (I, II) using MATLAB application as shown in the figures (9 - 16). Parameters P, P_A, L_2 are selected to compare these models using various values once with high numbers and once with low numbers, and these numbers were selected based on previous studies [7,8,9,10] so that the comparison between models is useful.

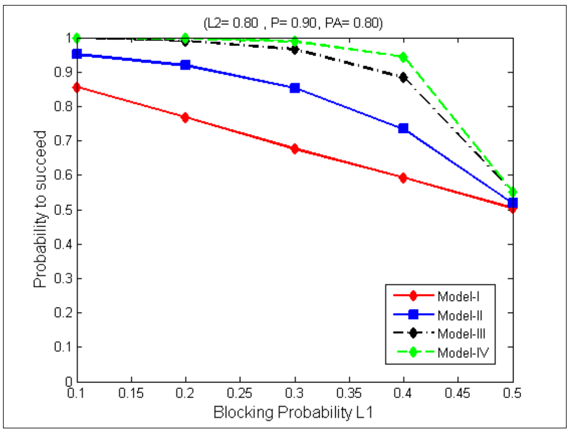

Fig. 9 (L_2=0.8, P=0.9, P_A=0.8)

Fig 9 shows the relation between the probability to succeed and blocking probability (L_1) for four models when L_2 (high), P (high) and P_A (high).

Graphs shows model-IV is the best model to complete the call when $0 \le L_1 \le 0.4$ and it is clear from the figures that there is no significant difference between models III and IV, after that when $L_1 > 0.4$, the curve of probability to succeed for models IV and III decreases rapidly.

All four models have almost the same (probability to succeed when L_1 is around 0.5 with a little preference for the models III and IV.

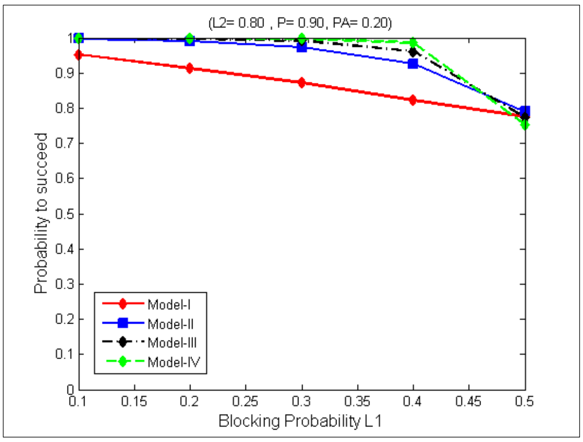

Fig. 10 (L_2=0.8, P=0.9, P_A=0.2)

Fig 10 shows the comparison when L_2 (high), P (high) and P_A (low), it shows model-IV is the best model to complete the call where $0 \le L_1 \le 0.4$. Also models II and III give almost the same result, after that where $L_1 > 0.4$, the curve of probability to succeed for models II, III and IV decreases rapidly.

All four models have almost the same probability to succeed when L_1 is around 0.5 with a little preference for the model-II.

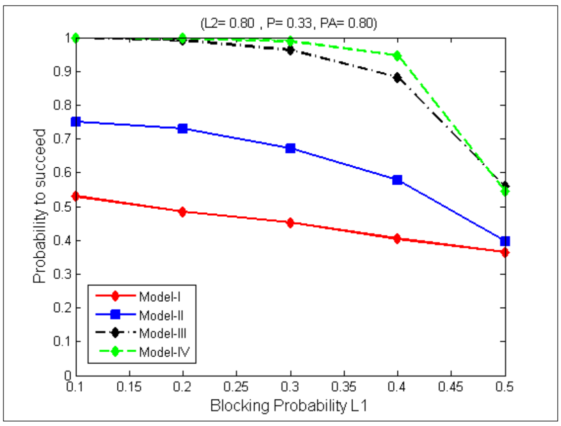

Fig. 11 (L_2=0.8, P=0.33, P_A=0.8)

Fig 11 shows the comparison when L_2 (high), P (low) and P_A (high), it shows model-IV is the best model to complete the call where $0 \le L_1 \le 0.4$, also model III gives almost the same result, after that where $L_1 > 0.4$, the curve of probability to succeed for models III and IV decreases rapidly.

When L_1 is around 0.5, the probability to succeed for models III and IV is almost the same with a little preference for the model-III.

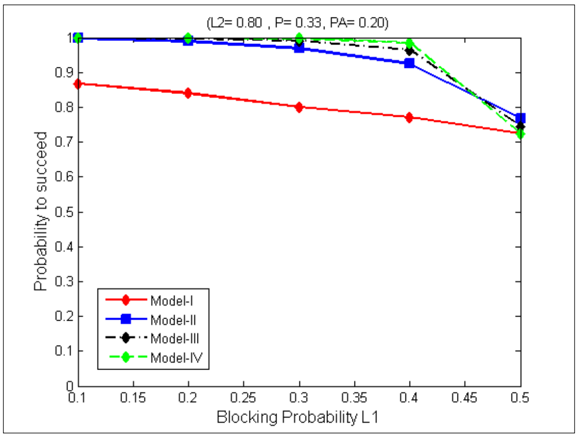

Fig. 12 (L_2=0.8, P=0.33, P_A=0.2)

Fig 12 shows the comparison when L_2 (high), P (low) and P_A (low). It shows almost the same result when L_2 (high), P (high) and P_A (low) that shown in Fig 10, and this means no effect when P (the initially user probability to choose the first operator O_1) is changing.

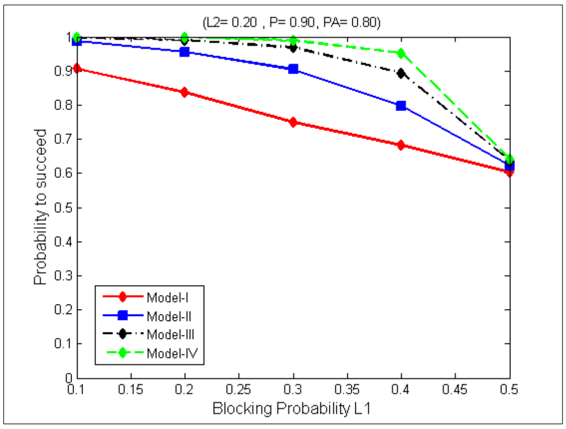

Fig. 13 (L_2=0.2, P=0.9, P_A=0.8)

Fig 13 shows the comparison when L_2 (low), P (high) and P_A (high), it shows model-IV is the best model to complete the call as compared to models III and II where $0 \leq L_1 \leq 0.4$. After that where $L_1 > 0.4$, the curve of probability to succeed for models IV, III and II decreases rapidly.

All four models have almost the same probability to succeed when L_1 is around 0.5 with a little preference for the model-IV.

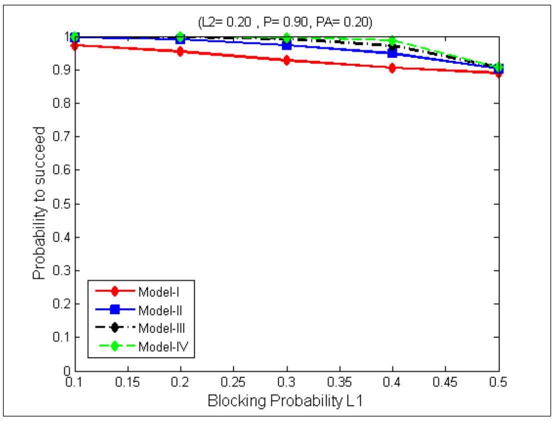

Fig. 14 (L_2=0.2, P=0.9, P_A=0.2)

Fig 14 shows the comparison when L_2 (low), P (high) and P_A (low), it shows models IV and III have almost the same probability to succeed where $0 \leq L_1 \leq 0.4$.

After that where $L_1 > 0.4$, all four models have almost the same probability to succeed when L_1 is around 0.5 with a little preference for model-IV.

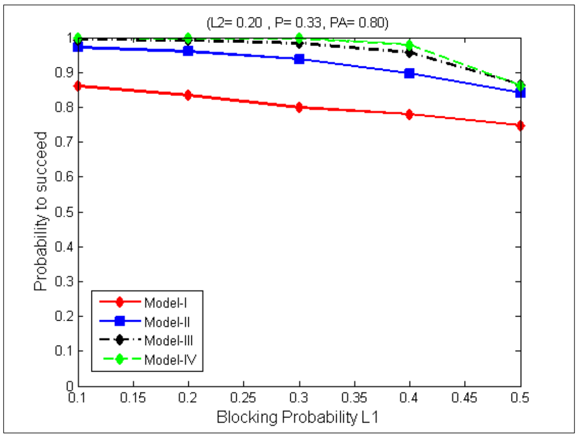

Fig. 15 (L_2=0.2, P=0.33, P_A=0.8)

Fig 15 shows the comparison when L_2 (low), P (low) and P_A (high), it shows model-IV is the best model to complete the call where $0 \leq L_1 \leq 0.4$ and also model III gives almost the same result. After that when $L_1 > 0.4$, the curve of probability to succeed for models IV and III decreases,

Models II, III and IV have almost the same probability to succeed when L_1 is around 0.5 with a little preference for model-IV.

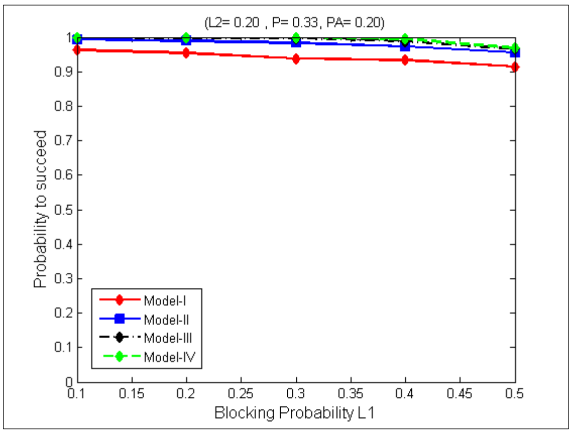

Fig. 16 (L_2=0.2, P=0.33, P_A=0.2)

Fig 16 shows the comparison when L_2 (low), P (low) and P_A (low), it shows almost the same result when L_2 (low), P (high) and P_A (low) shown in Fig 14 , and this means no effect when P is changing.

4. Conclusion

The four models are compared using the (MATLAB) software. The results clarified models states via Fig.9 and they show the states for the first model. Similarly, Fig. 10, 11 and 12 show the results for other models.

Fig.13 shows the comparison between the models to illustrate percentage of completion of calls, and for more details Fig.14, re-experience 10,000 times, and it worked out the call completion ratio.

The first model scored 84.5%, of success to complete the call.

The second model is 90.6% to complete the call, whereas the third model suggested by the study score 94.95%.The fourth model also suggested by the study has achieved impressive result with (95.12%) to complete the call compared with other models. Those results have been achieved after 10 steps per attempt.

It observed that when blocking probability at less than 0.5 with increasing the number of attempts would improve call completion rates

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