

PERFORMANCE OF ANALYSIS ON IEEE 802.15(MAC)

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Declaration

We, hereby certify that our thesis work solely to be our own scholarly work. To the best of our knowledge, it has not been shared from any source without the due acknowledgement and permission. It is being submitted in partial fulfillment of requirements for the degree of Bachelor of Science in Electrical and Communication Engineering. It has been submitted before any degree or examination of any other university.



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Abstract

In this project we deal with the detail analytical model of traffic of CSMA/CA based network. Here we consider mean service time and throughput of the network using statistical model of binary exponential back off algorithm and two dimensional Markov chain. Finally we plot throughput, failure probability & mean frame service time traffic parameters against number of nodes and got the results consistence with theoretical model.

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Chapter-1
INTRODUCTION

The wireless networks such as IEEE 802.15, use carrier-sense multiple access with collision avoidance (CSMA/CA) protocol which depends on a distributed backoff mechanism for efficient use of the shared channel. The medium access control (MAC) protocol plays a critical role To determine the capacity of a wireless network the medium access control (MAC) protocol plays a vital role. the main wireless MAC solution adopts the family of carrier sense multiple access with collision avoidance (CSMA/CA) protocols . Different flavors of CSMA/CA protocols are extensively applied in personal area networks (WPANs), e.g., the IEEE 802.15.4 [1]; The seminal work of Bianchi [4] injected a strong impetus to the Markov chain based MAC modeling. In principle, the Markov modeling could be applied to any CSMA/CA protocol, with either saturated traffic[4], [15],[16] or unsaturated bursty traffic [17]..

Chapter-2
SYSTEM MODEL

Node-state model:

$P(SN)$ is denoted as the event probability of SN where SN is the event that a node can detect the carrier or medium. $(s=i)$ means the event that implies the node is in backoff stage $i \in (0, \dots, M)$. the probability of the event that the node is in backoff stage is $P(s=i)$ is considering M as the maximum backoff stage. The conditional probability is ,

$$P(s=i, SN) = P(s=i | SN) \cdot P(SN)$$

$$= P(SN | s=i) \cdot P(s=i) \dots \dots \dots (1)$$

By solving we get =>

$$P(SN) \cdot \frac{P(s=i | SN)}{P(SN | s=i)} = P(s=i) = P(s=i) \dots \dots \dots (2)$$

As we know backoff stage $i \in (0, \dots, M)$,

So, considering the range of i we can say,

$$P(SN) = \sum_{i=0}^M \frac{P(s=i | SN)}{P(SN | s=i)} = \sum_{i=0}^M P(s = i) = 1 \dots \dots \dots (3)$$

The probability of the considering node is sensing the carrier can be shown as,

$$\sigma = P(SN) = 1 / \sum_{i=0}^M \frac{P(s=i | SN)}{P(SN | s=i)} \dots \dots \dots (4)$$

To show that the node is currently sensing the channel is in backoff stage i , the conditional probability is considered as $P(s=i|SN)$. The failure probability ϕ corresponds to the event that if the channel is found busy in first CCA or in second CCA (if first CCA goes idle).

So, the conditional states can be displayed with simple Markov chain which follows transition probabilities,

$$P(s(k+1)=i | s(k)=i-1)=\phi, \quad i=1, \dots, M$$

$$P(s(k+1)=0 | s(k)=i-1)=1-\phi, \quad i=0, \dots, M$$

$$P(s(k+1)=0 | s(k)=M)=1, \quad i=M$$

.....(5)

With the given finite sensing attempt limit M , equation (5) can be solved to obtain the steady –state probability of the tagged sensing node’s being in backoff stage i ,

$$P(s=i|SN)=\frac{(1-\phi)\phi^i}{1-\phi^{M+1}} \dots \dots \dots (6)$$

A node in backoff stage i spoils time in three ways=>

- ❖ When the node comes in backoff stage, it has to wait for some while. The duration of this waiting time is $E[b_i]$ time slots.
- ❖ After that time the node starts to sense the carrier. Let, the maximum sensing time is T_c . If two time slots is found idle between the interval $[0, T_c]$ interval; it will start to transmit. And if the node doesn’t get idle time slots, it will go to $(i+1)$ backoff stage. The average value of carrier sensing duration $[0, T_c]$ of the node is \bar{n}_σ .
- ❖ When two time slots are found idle, the node sends a frame. Let, the length of the frame is L time slots.

So, Average duration = $(0 \cdot \phi) + L(1 - \phi) = L(1 - \phi)$

Where ϕ = probability of failure & $(1 - \phi)$ = probability of success.

Total spending time = $E[b_i] + \bar{n}_\sigma + L(1 - \phi) = T_{\text{Expanded}}$

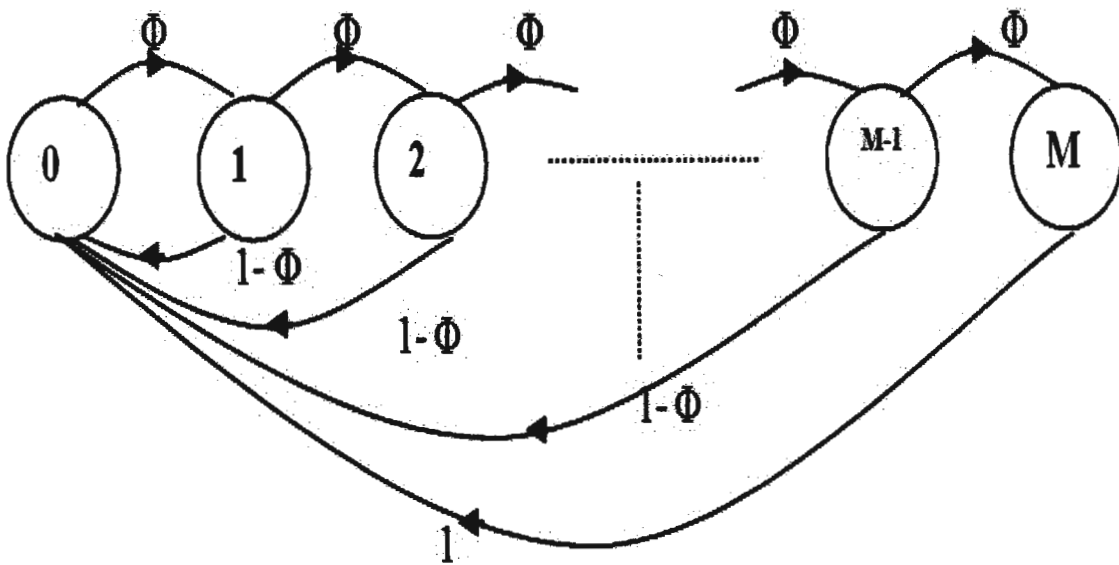
When the node is in stage i , the probability of sensing the carrier,

$$\begin{aligned}
 &= P(\text{SN} | s=i) \\
 &= 1 / (E[b_i] + \bar{n}_\sigma + L(1 - \phi)) \\
 &= 1 / T_{\text{Expanded}} \dots \dots \dots (7)
 \end{aligned}$$

Now taking eq.(4),(6) & (7) together ; we get,

$$\sigma = \frac{1 - \phi^{M+1}}{(1 - \phi) \sum_{i=0}^M \phi^i (E[b_i] + \bar{n}_\sigma + (1 - \phi)L)} \dots \dots \dots (8)$$

The Markov Chain:



Applying node equation at 1,

$$P_1 \{ \phi + 1 - \phi \} = P_0 \phi = P_1 = P_0 \phi$$

Applying node equation at 2,

$$P_2 \{ \phi + 1 - \phi \} = P_1 \phi = P_2 = P_1 \phi = P_0 \phi^2$$

$$P_{M-1} = P_0 \phi^{M-1}$$

$$P_M = P_0 \phi^M$$

For entire sampling space,

$$P_0 + P_1 + P_2 + \dots + P_M = 1$$

$$\Rightarrow P_0 + P_0\phi + P_0\phi^2 + \dots + P_0\phi^M = 1$$

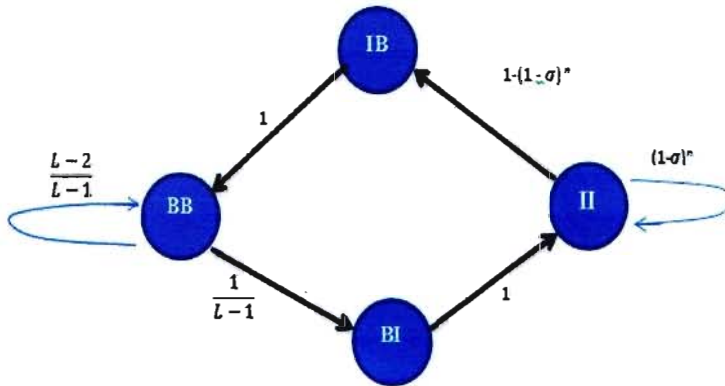
$$\Rightarrow P_0 \sum_{i=0}^M \phi^i = 1$$

$$\Rightarrow P_0 \frac{1 - \phi^{M+1}}{1 - \phi} = 1$$

$$\Rightarrow P_0 = \frac{1 - \phi}{1 - \phi^{M+1}}$$

$$\text{So, } P_i = P_0 \phi^i = \frac{(1 - \phi)\phi^i}{1 - \phi^{M+1}}$$

Channel state model:



Here we've to use a tiny Markov chain to derive the other relationship regarding σ & ϕ . While operating in CAP, the channel should be idle for two successive time slots before a node starts transmission. In a Markov model the channel state is modeled in terms of the states represented on an adjacent slot-pair basis rather than on a per slot basis to cope with the state-wise memory less property .

The probability is $1-(1-\sigma)^n$ to become a channel busy (IB) after leaving the state of successive idle-slots pair (II); as one or more nodes conduct carrier sensing, the probability of a channel to remain in idle state (II) is $(1-\sigma)^n$. Let the frame length be at least 3 (i.e. ≥ 3). The probability to retain busy slot pair state (BB) is $\frac{L-2}{L-1}$. The channel takes a transition to state BI with the probability $\frac{1}{L-1}$.

Now the relations among the stationary channel state probabilities are:

$$P_{BB} = P_{IB} + P_{BB} \frac{L-2}{L-1}, \quad P_{IB} = P_{II}(1 - (1 - \sigma)^n)$$

$$P_{II} = P_{BI} + P_{II}(1 - \sigma)^n, \quad P_{BI} = P_{BB} \frac{1}{L-1}$$

And, $P_{BB} + P_{IB} + P_{BI} + P_{II} = 1$

.....(9)

Solving the above equations gives,

$$P_{BB} = \frac{(L-1)\tau}{1 + \tau(1+L)}, \quad P_{II} = \frac{1}{1 + \tau(1+L)}$$

$$P_{IB} = P_{BI} = \frac{\tau}{1 + \tau(1+L)}$$

Here, $\tau = (1 - (1 - \sigma)^n)$(10)

During a sensing attempt, a node uses 1 slot with certainty & 1 more slot when the channel stays in II or IB states,

$$\overline{n}_\sigma = 1 + (P_{II} + P_{IB}) = \frac{2 + \tau(2+L)}{1 + \tau(1+L)} \dots\dots\dots(11)$$

When channel is in II state, successful carrier sensing is possible. The sensing probability is

$$\phi = 1 - P_{II} = \frac{\tau(1+L)}{1 + \tau(1+L)} \dots\dots\dots(12)$$

Proposed model

Let the number of user or nodes is N and the number of channel is n in the network. We can represent the traffic of the network using Engset traffic model like fig. 1 considering λ is the arrival rate per user.

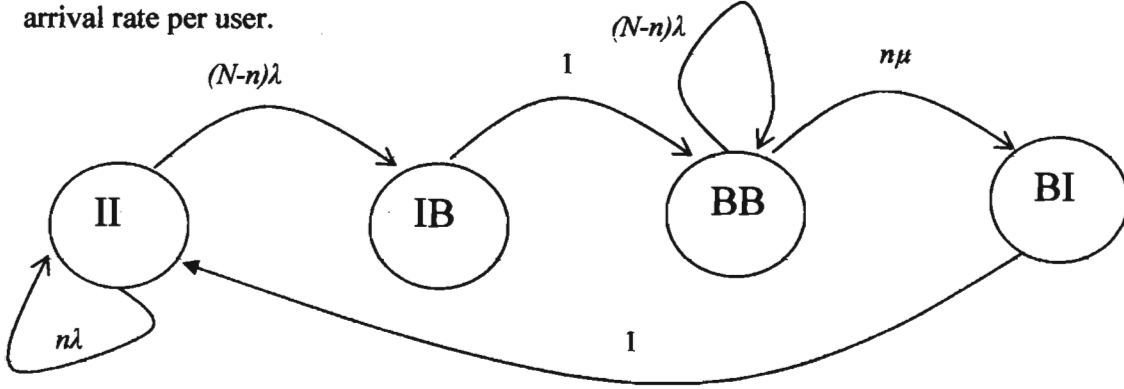


Fig.1 State transition chain of the network

Applying node equations,

$$P_{II}(N-n)\lambda + 0 \cdot P_{IB} + 0 \cdot P_{BB} - P_{BI} = 0$$

$$P_{II} \cdot 0 + P_{IB} - n\mu \cdot P_{BB} - 0 \cdot P_{BI} = 0$$

$$P_{II} \cdot 0 + 0 \cdot P_{IB} - n\mu \cdot P_{BB} + P_{BI} = 0$$

$$P_{II} + P_{IB} + P_{BB} + P_{BI} = 1$$

Solving above equation the probability states can be evaluated as:

$$P := \begin{bmatrix} (N-n) \cdot \lambda \cdot [1 - (1-\sigma)^N] & 0 & 0 & -1 \\ 0 & 1 & \frac{-n \cdot \mu}{L-1} & 0 \\ 0 & 0 & \frac{-n \cdot \mu}{L-1} & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}^{-1} \cdot \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix}$$

Chapter-3

RESULTS

MAC Performance Metrics

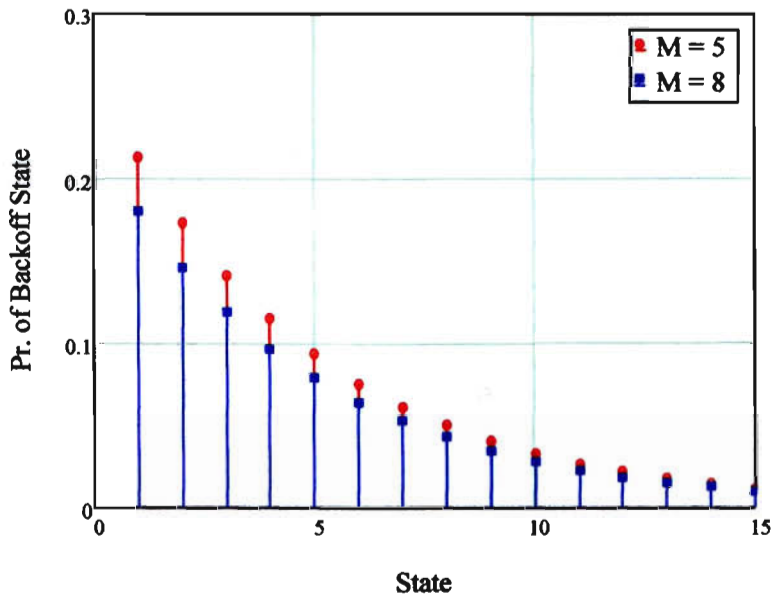


Fig 1. Pr. OfBackoff State.

Fig 1. Shows the probability state of backoff algorithm for M=5 and M=8. This backoff states follow the Exponential Probability Density Function.

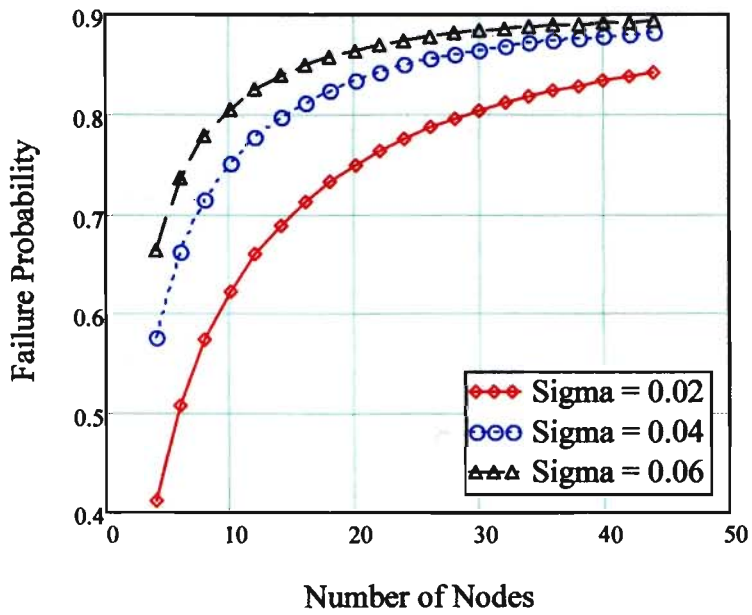


Fig 2. Failure Probability

Fig 2. Shows the profile of Failure Probability against the no. of nodes taking σ as a parameter, where σ stands for sensing probability of a node. Failure Probability increases with the increase in both the no. of nodes and σ . We consider $L=8$, $M=5$.

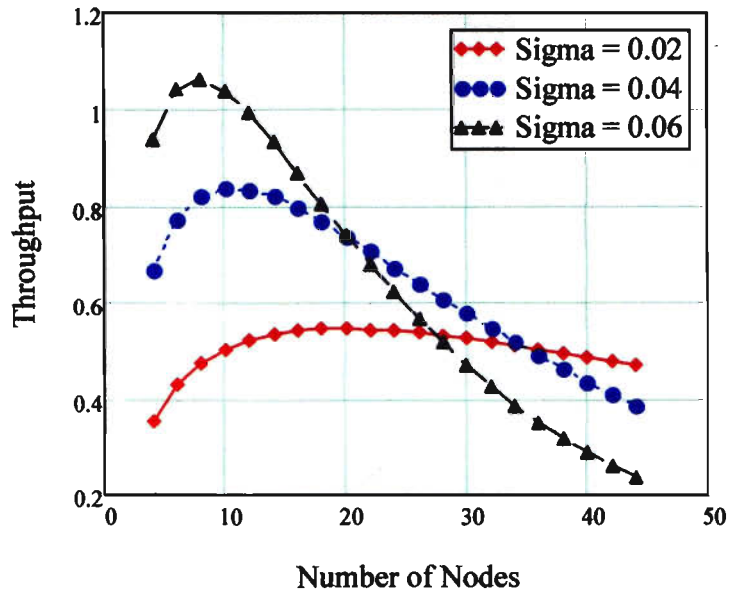


Fig 3. Throughput

Fig 3. Shows the variation of throughput against the no. of nodes taking σ as a parameter. The throughput initially increases and reaches at the peak, the decreases exponentially. From this fig we can say, the network operates most effectively with an optimum no. of users.

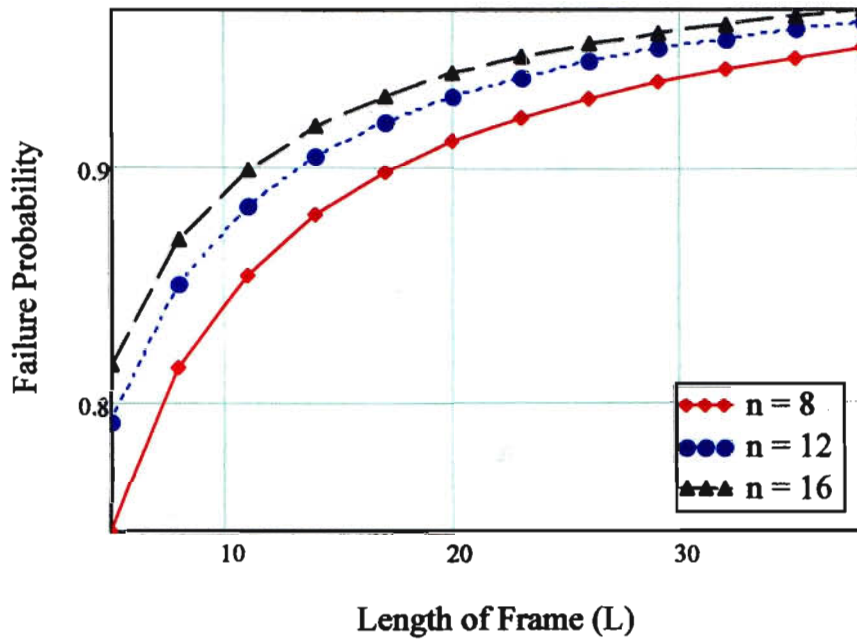


Fig 4. Failure Probability

Fig 4. Shows the failure probability against the length of frame (L). Here this probability increases with the increase in both the no. of nodes and length of frame.

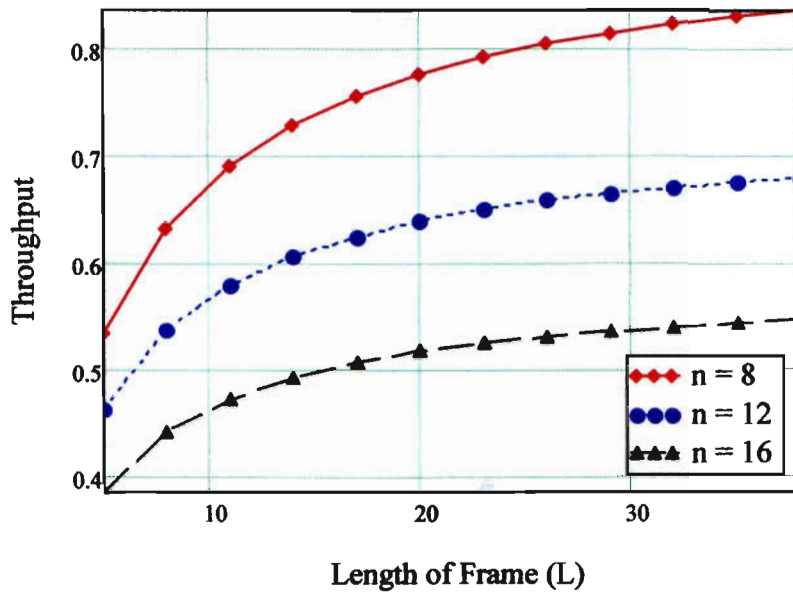


Fig 5. Throughput

Fig 5. Shows the variation of throughput against the length of frame taking no. of nodes as a parameter. Here, the throughput increases with the increase in the length of frame but decreases with the increase in the no. of nodes.

Our contribution

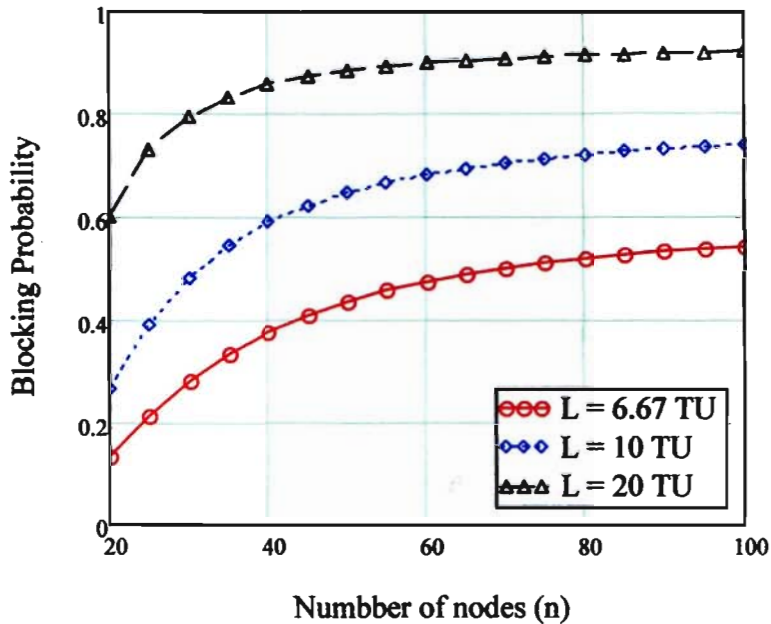


Fig 6. Variation of blocking probability against the number of nodes

In Fig 6. Taking the following traffic parameters, $\sigma := 0.02$, $N_{\text{max}} := 20, 25, 100$, $\lambda := 0.02$ packets/sec/user, $n := 12$ the blocking probability P_{BB} is plotted against the number of node N taking the length of frame L as a parameter. The blocking probability increases with increase in both N and L .

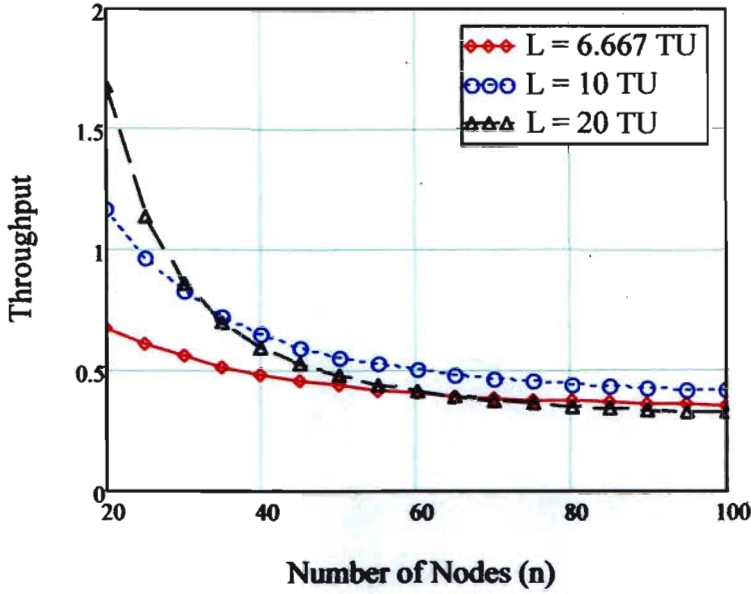


Fig 7. Variation of throughput against the number of nodes

The variation of throughput against the number of node is shown in fig 7. The throughput decreases with increase in L and N .

The throughput of the network is expressed as, $\bar{X} = (1 - B) \frac{\lambda}{\mu} \bar{N}$; where \bar{N} is the average number of users in the network.

$$C(x, y) := \frac{x!}{y! \cdot (x - y)!}$$

$$\bar{N} := \sum_{x=0}^n \frac{C(N, x) \cdot \left(\frac{\lambda}{\mu}\right)^x}{\sum_{i=0}^n \left[C(N, i) \cdot \left(\frac{\lambda}{\mu}\right)^i \right]}$$

Chapter-4
CONCLUSION

In this project work we have performed the study of performance of analysis on IEEE 802.15 (MAC) considering probability of failure, mean service time and throughput. The entire work can be extended for 4g network like WiMax advance using that markov chain of channel allocation of bandwidth reservation.

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