EVALUATION AND COMPARISON OF IMROVED OPTIMAL SLOTTED CSMA/CA PROTOCOL OVER SLOTTED AND UNSLOTTED CSMA/CA

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Abstract- **Carrier sense multiple access with collision avoidance (CSMA/CA) in computer networking, is a network multiple access method in which carrier sensing is used, but nodes attempt to avoid collisions by transmitting only when the channel is sensed to be "idle". Like most other protocols, CSMA/CA was designed with the assumption that the nodes would play by the rules and control the deferment themselves .However, with the higher programmability of the network adapters, the temptation to tamper with the software or firmware is likely to grow. The key point is to find the most appropriate and efficient way, in which a user could obtain a much larger share of the available bandwidth at the expense of other users . Various authors have proposed different techniques for improving the fairness and performance of CSMA/CA. This paper shows the comparative study of various proposed methodologies and also shows Improved Slotted CSMA/CA protocol.**

Keywords: Carrier Sense Multiple Access (CSMA), Collision Avoidance (CA), Request-To-Send (RTS), Clear-To-Send (CTS), Distributed Coordinate Function (DCF), Point Coordinate Function (PCF), NIC (Network Interface Card).

1. INTRODUCTION

Carrier sense multiple access/collision avoidance (CSMA/CA) [1]-[9] protocols rely on the random deferment of packet transmissions for the efficient use of the shared wireless channel among many nodes in a network. In spite of its short comings, this class of MAC protocols is one of the most popular for ad hoc networks. A network is a connection between devices that can communicate with each other. Everything from Bluetooth device, to WiFi computer, to cell phone operates on a network. Networks come in all shapes and sizes, and complexities. Implementing the right network for our needs is vital. Wired networks [8] provide stability and security but setting the network for the first can be challenging. Wireless networks are hard to keep secure. The most challenging implementations involve a secure combination of both a wired and wireless networks. Expert advice is vitally important for choosing the right network as per our needs.

Various strategies have been proposed for reducing the overheads of slotted CSMA/CA by improving the slotted time of the existing slotted CSMA/CA in such a way that it will provide lower delay and also will not increase the cost of existing slotted CSMA/CA. The Cost and delay depends upon the time, slotted CSMA/CA take to do its decision making. This paper focus on evaluation and comparison of various slotted CSMA/CA techniques. For this different parameters regarding wireless networks and CSMA/CA are calculated. Suitable comparisons are drawn among proposed and existing strategies. (CSMA/CA) access method as the name indicates, has several characteristics in common with CSMA/CD.Instead of detecting data collisions, the CSMA/CA method attempts to avoid them altogether. Although it sounds good in theory, the method it uses to do this causes some problems of its own, which is one reason CSMA/CA is a far less popular access method than CSMA/CD. CSMA/CA can optionally be supplemented by the exchange of a Request to Send (RTS) packet sent by the sender S, and a Clear to Send (CTS) packet sent by the intended receiver R. Thus alerting all nodes within range of the sender, receiver or both, to not transmit for the duration of the main transmission. This is known as the IEEE 802.11 RTS/CTS exchange. Implementation of RTS/CTS helps to partially solve the hidden node problem that is often found in wireless networking [10].

1.1)**Wireless Networking**

Wireless networks [4] are becoming ever more popular and easy to set up. Although setting up a wireless network is becoming easier, doing it correctly is still a challenging task. Wireless networks are now faster, have broader ranges, and are more reliable than they used to be. They are also easy to hack, suffer from various from of interfaces, and can drop devices from the network if they are not setup properly. For stability and security of network, it is important to take advice of an experienced network expert while implementing it.

1.2) Wired Networking

Wired networks [1] & [7] are the fastest and most reliable networks that can be implemented. They are not, however, easy to implement. Various wiring standards, the need for additional hardware, and complicated computer configurations require an expert approach. Frequently enough homes and small offices are turning to wireless networks to provide blanket coverage with minimal costs and infrastructure, but wireless networks are frequently not properly secured, can lack speed, and can frequently fail from poor implementation or from interference. When we require the reliability, speed, and security of a wired network it's absolutely vital that we consult a professional who can help to plan and implement the network properly.

1.3) Ad hoc network

An ad hoc network, or MANET (Mobile Ad hoc Network), is a network composed only of nodes, with no Access Point. Messages are exchanged and relayed between nodes. In fact, an ad hoc network has the capability of making communications possible even between two nodes that are not in direct range with each other: packets to be exchanged between these two nodes are forwarded by intermediate nodes, using a routing algorithm. Hence, a MANET may spread over a larger distance, provided that its ends are interconnected by a chain of links between nodes (also called routers). In the ad hoc network shown in Figure 1.4, node A can communicate with node D via nodes B and C, and vice versa. A sensor network [3] is a special class of ad hoc network, composed of devices equipped with sensors to monitor temperature, sound, or any other environmental condition. These devices are usually deployed in large number and have limited resources in terms of battery energy, bandwidth, memory, and computational power.

1.4) CSMA/CA

Carrier sense multiple access with collision avoidance (CSMA/CA) has been adopted by the IEEE 802.11 standards for wireless local area networks (WLANs). Using a distributed coordination function (DCF), the slotted CSMA/CA protocol reduces collisions and improves the overall throughput. To mitigate fairness issues arising with slotted CSMA/CA in wireless networks, a modified version of slotted CSMA/CA is proposed that term CSMA with copying collision avoidance (CSMA/CCA).

1.5) How CSMA/CA works

On a network that uses the CSMA/CA access method, when a computer has data to transmit, its NIC first checks the cable to determine if there is already data on the wire. So far, the process is identical to CSMA/CD. However, if the NIC senses that the cable is not in use, it still does not send its data packet. Instead, it sends a signal of intent--indicating that it is about to transmit data out onto the cable. CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) is the channel access mechanism used by most wireless LANs in the ISM bands. A channel access mechanism is the part of the protocol which specifies how the node uses the medium .

1.6) CSMA/CA and wireless LAN

Wireless LAN cannot implement CSMA/CD for three reasons:

- Station must be able to send and receive data at the same time.
- Collision may not be detected because of the hidden terminal problem.
- Distance between stations in wireless LANs can be great. Signal fading could prevent a station at one end from hearing a collision at other end.

- Before sending a frame, source senses the medium by checking the energy level at the carrier frequency.

- Backoff until the channel is idle.

- After the channel is found idle, the station waits for a period of time called the Distributed interframe space (DIFS); then the station sends a control frame called request to send (RTS).

- After receiving RTS, the destination waits for a period called Short interframe space (SIFS), thedestination station sends a control frame, called Clear to Send (CTS) to source.

This control frame indicates that the destination station is ready to receive data.

- Source sends data after waiting for SIFS

- Destination sends ACK after waiting for SIFS.

2. RELATED WORK

Zhang, Yijin et al. (2006) [1] in paper "Throughput Analysis of IEEE 802.15.4 Slotted CSMA/CA Considering Timeout Period and Its Improvement" has proposed and validated an analytical model for the capacity throughput of the IEEE 802.15.4 slotted CSMA/CA which can be studied as slotted non-persistent CSMA. Key to the accuracy of our model is a careful study of the idle period after last collision, which has not been considered by all previous 802.15.4 models. Specifically, Zhang, Yijin et al. (2006) [1] has also derived the probability of sensing the channel that maximizes the throughput and provide analytical closed formulas. With results from the OPNET simulator, Zhang, Yijin et al. (2006) [1] has shown that their model can accurately predict the saturation throughput over a wide range of scenarios.

Ben othmon jalel, et.al (2008) [2] in paper "A Multiservice MAC protocol in a multichannel CSMA/CA for IEEE 802.11 network" proposed a new MAC protocol that considers different types of traffic and assign a different priority level to each traffic. To improve the Qos of IEEE 802.11 Mac protocol over multichannel CSMA/CA protocol,.A new admission policy is developed for both voice and data traffic. According to this protocol a channel is reserved for voice traffic while for data traffic the access is random using CSMA/CA mechanism is used which employs selective reject and push out mechanism. To study the performance of proposed protocol a mathematical model using markov chains is built. An aggregated markov chain model with smaller state space is bulid which allows the performance measures to be computed easily. Comparisons of markov chains are used to prove that the proposed protocol gives less loss rate of high priority connections than the traditional one.

Pollin, et al. (2008) [3] in paper "Performance analysis of slotted carrier sense IEEE 802.15.4 medium access layer" has studied the advances in low-power and low-cost sensor networks have led to solutions mature enough for use in a broad range of applications varying from health monitoring to building surveillance. The development of those applications has been stimulated by the finalization of the IEEE 802.15.4 standard, which defines the medium access control (MAC) and physical layer for sensor networks. One of the MAC schemes proposed is slotted carrier sense multiple access with collision avoidance (CSMA/CA), and Pollin, et al. (2008) [3] has analyzed whether this scheme meets the design constraints of those low-power and low-cost sensor networks.

Wang, Feng et al. (2009) [4] in research work entitled "Analysis and compare of slotted and unslotted CSMA in IEEE 802.15. 4" has analyzed the carrier sense multiple access (CSMA) mechanism, and simulates its application in IEEE 802.15.4. Wang, Feng et al. (2009) [4] has found that the throughputs are relevant to the normalized propagation delay and the basic time period (BTP) of slotted CSMA. The throughputs of slotted and unslotted CSMA are almost equal when the normalized propagation delay is much less than 1 and the BTP is equal to the propagation delay. Moreover, for slotted CSMA, the BTP selection should be cautious because an unsuitable BTP will make the performance of the protocol worse.

Wen et al. (2009) [5] in paper "An improved Markov model for IEEE 802.15.4 slotted CSMA/CA mechanism" has studied IEEE 802.15.4 protocol is proposed to meet the low latency and energy consumption needs in low-rate wireless applications, however, few analytical models are tractable enough for comprehensive evaluation of the protocol. To evaluate the IEEE 802.15.4 slotted CSMA/CA channel access mechanism Wen et al. (2009) [5] has proposed a practical and accurate discrete Markov chain model, which can dynamically represent different network loads. By computing the steady-state distribution probability of the Markov chain, we obtain an evaluation formula for throughput, energy consumption, and access latency. Then Wen et al. (2009) [5] has further analyzed the parameters that influence performance including packet arrival rate, initial backoff exponent and maximum backoff number. NS2 simulator has been used to evaluate the performance of the 802.15.4 CSMA/CA mechanism under different scenarios and to validate the accuracy of the proposed model.

Caishi huang ,et al. (2010) [6] in paper "on fairness enhancement of CSMA/CA wireless network "proposed an analytical model to study the probability of exposed receiver problem of location dependency, which creates the most severe unfairness scenario in CSMA/CA protocol and how this probability varies with carrier sensing and transmission ranges. The analytical model also shows the likelihood of successful RTS/CTS handshake of the disadvantaged link under the exposed receiver scenario. A receiver assistance feature is proposed in addition to CSMA/CA protocol which ensures that the receiver of disadvantaged link help the sender to contend for channel access. Keeping the compatibility of existing 802.11 protocol in mind, the proposed feature requires only one bit of modification in packet header. The proposed feature significantly improved the fairness and throughput of CSMA/CA protocol without creating any side effects.

Wang, et al. (2010) [7] in paper "An Enhanced Collision-Avoidance MAC Protocol for IEEE 802.15.4" has shown that when an IEEE 802.15.4 network has many nodes and is almost saturated, the probability of collision is large, and the throughput is small. The main reasons are the adoption of slotted CSMA/CA and the mechanism that if a data transmission cannot be completed before the end of contention access period (CAP), it has to wait until the start of the CAP in the next superframe. Wang, et al. (2010) [7] has proposed an enhanced collision-avoidance MAC protocol for IEEE 802.15.4, and establishes a simulation model to analyze and compare the enhanced collision-avoidance MAC and the IEEE 802.15.4 MAC. The proposed protocol, compatible with the IEEE 802.15.4 protocol, has less probability of collision (almost 0), higher probability of successful transmission (close to 1), and larger network throughput (more than two times of that of IEEE 802.15.4).

Jing, Hui, and Hitoshi Aida (2011) [8] in paper "An analytical approach to optimization of throughput for IEEE 802.15.4 slotted CSMA/CA networks" has discussed the most widely implemented standards for wireless networks, IEEE 802.15.4 defines physical and MAC specifications for low data rate wireless personal area networks (WPANs). To accurately analyze the performance of slotted CSMA/CA (SCSMA) algorithms Jing, Hui, and Hitoshi Aida (2011) [8] has optimized the network throughput by considering the number of 802.15.4 devices and the data payload by nonlinear programming (NLP). Comparing with the SCSMA protocol of IEEE standard through the simulation, performed by Jing, Hui, and Hitoshi Aida (2011) [8] has improved network throughput with non-ACK and ACK modes up to 4.8% and 8.1% on average, respectively. The performance analysis doubled progressively: 15, 31, 63,...1023, until a data warehouse also facilitates the integration of also shows that the network scalability is improved, that is the system can accommodate more contending devices in Jing, Hui, and Hitoshi Aida (2011) [8]'s proposal.

Alvi (2012) [9] in paper "Evaluation of Slotted CSMA/CA of IEEE 802.15.4" has discussed the IEEE 802.15.4 standard is specifically designed for low Rate Wireless Personal Area Network (LR-WPAN) with low data rate and low power capabilities. Due to very low power consumption with duty cycle even less than 0.1, the standard is being widely applied in Wireless Sensor Networks applications. It operates in Beacon and Non Beacon enabled modes. During Beacon enabled mode, it has Contention Access Period (CAP) and optional Contention Free Period. We have analyzed its performance during CAP where slotted CSMA/CA algorithm is used. The performance analysis includes channel access busy, transmission failure chances along with reliability and throughput against all three frequency bands with load variation.

3. COMPARATIVE STUDY

Ref No.	Author(s)	Year	TITLE	Technique	Results
[1]	Zhang et al.	2006	Throughput Analysis of IEEE 802.15.4 Slotted CSMA/CA Considering Timeout Period and Its improvement	Adaptive Neural Fuzzy Inference System and Linear Genetic Programming	LGP has better detection accuracy than ANFIS
[2]	Ben othoman jalel et al.	2008	A Multiservice MAC protocol in a multichannel csma/ca for IEEE 802.11 network	Admission policy for both data and voice traffic	Improved QoS of IEEE 802.11 MAC protocols over a multi-channel CSMA/CA
[3]	Pollin et al.	2008	Performance Analysis of Slotted Carrier Sense IEEE 802.15.4 Medium Access Layer	A Star Topology Network for both saturated and unsaturated periodic traffic	Shows that for saturated networks, it is best to choose a larger exponential delay backoff and for unsaturated networks, smallest backoff values improve the energy consumption
[4]	Wang et al.	2009	Analysis and Compare of Slotted and Unslotted CSMA in IEEE 802.15.4	Basic Time Period(BTP) and Slotted CSMA/CA	Combination of both DM and NBA overcome the limitation of traditional IDS
[5]	Wen et al.	2009	An improved Markov model for IEEE 802.15. 4 slotted CSMA/CA	Discrete Markov chain Modal, CSMA/CA mechanism	The proposed model is more applicable for different network loads
[6]	Caishi Huang et al.	2010	Fairness enhancement for CSMA/CAS wireless network	Analytical model with receiver assistance feature	Improved Fairness and throughput of csma/ca protocol.
[7]	Wang et al.	2010	An Enhanced Collision-Avoidance MAC Protocol for IEEE 802.15.4	Enhanced collision – avoidance MAC protocol	The proposed protocol, compatible with IEEE 802.15.4 protocol, has less probability of collision, higher probability of successful transmission, and the larger network throughput.
[8]	Jing, et al.	2011	An Analytical Approach to Optimization of Throughput for IEEE 802.15.4 Slotted CSMA/CA Networks	Nonlinear Programming(NLP), Simple Markov model	Algorithm can perform adaptive backoff processing to maximize the throughput.
[9]	Alvi, et al.	2012	Evaluation of Slotted CSMA/CA of IEEE 802.15.4	Contention Access Period(CAP), Slotted CSMA/CA algorithm	Find high detection rates for U2R and R2L attacks.

4. PROPOSED WORK

A node which want to send data, start sending, if the channel is sensed free. If the medium is busy, the node continues to monitor until the channel is idle. Then it starts sending data. If the channel is sensed free, the node starts sending the packet. Otherwise, the node waits for a random amount of time (slot) and then monitors the channel, and sends data after the slotted time interval. In improved slotted CSMA/CA, if the channel gets free at run time the node is free to transmit the data.

Working of protocol in steps is as follow

Step 1: Wireless network initialization.

Step 2: Define parameters:

First define number of stations
Define radio range of stations
Set time slot of random motion.
Set Average transmission time.

Step 3: Network is initialized and it is assumed that user has started the transmission. Firstly the collision will be checked, if no collision is detected the process of transmission will start.

Step 4: If collision is detected, then wait for slotted time and try again after slotted time.

Step 5: If the channel gets idle before the slotted time (at run time) transmit the data

5. EXPERIMENTAL RESULTS

Due to the non-availability of the physical environment suitable simulation will be done in the MATLAB. The proposed algorithm is designed and run in the MATLAB by considering various scenarios of CSMA/CA protocol. A script is developed in MATLAB which behave same as slotted CSMA/CA protocol. To do performance analysis multiple simulation results of proposed technique is compared with existing unslotted and slotted CSMA/CA. Figure1,2 and 3 shows output of matlab simulation representing Throughput, Delay due to early request finish and Delay due to early request finish respectively

.Figure1 shows in the form of matlab line graph that for several number of outputs, the improved slotted CSMA/Ca gives better result as compared to slotted and unslotted CSMA/CA

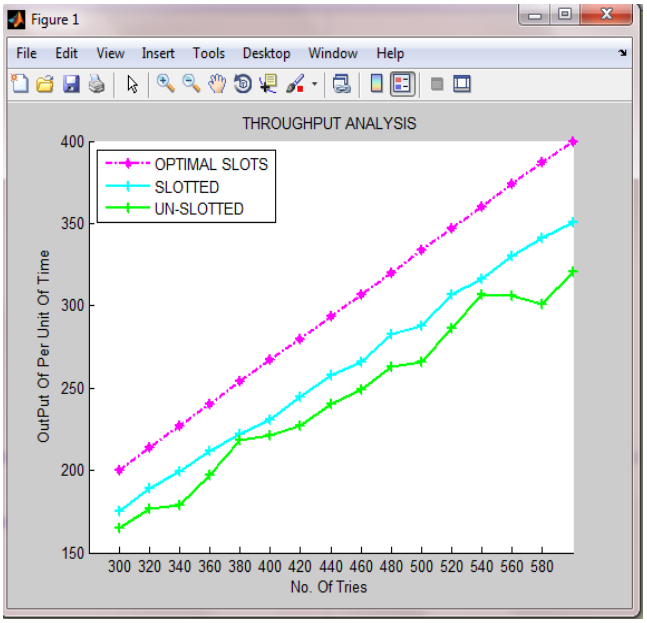

Figure1 Throughput analysis

Figure2 shows that the delay due to spinlocking in optimal slots is less as compared to delay in slotted and unslotted CSMA/CA.

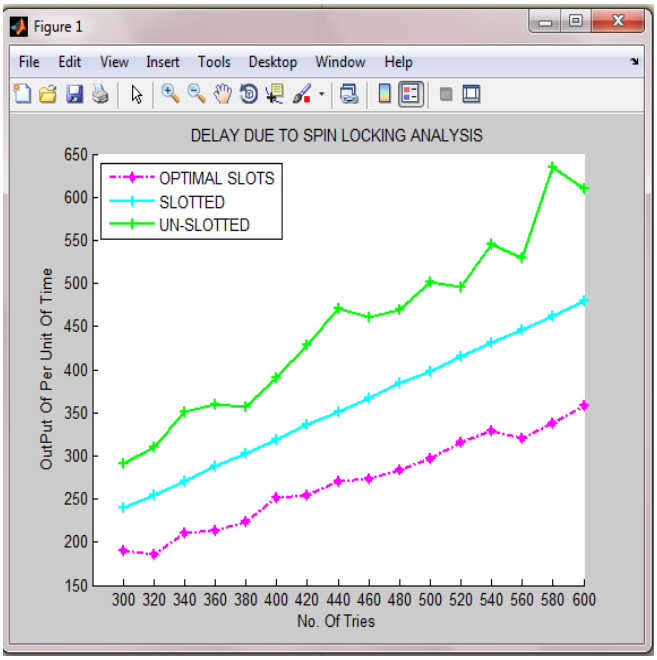

Figure 2 Delay due to spinlocking

Figure 3 is showing that the delay due to early request finish is far less as compared to delay in Slotted and unslotted CSMA/CA. Delay due to early request finish in optimal slots is 0 for all input values which is represented by magenta line at bottom.

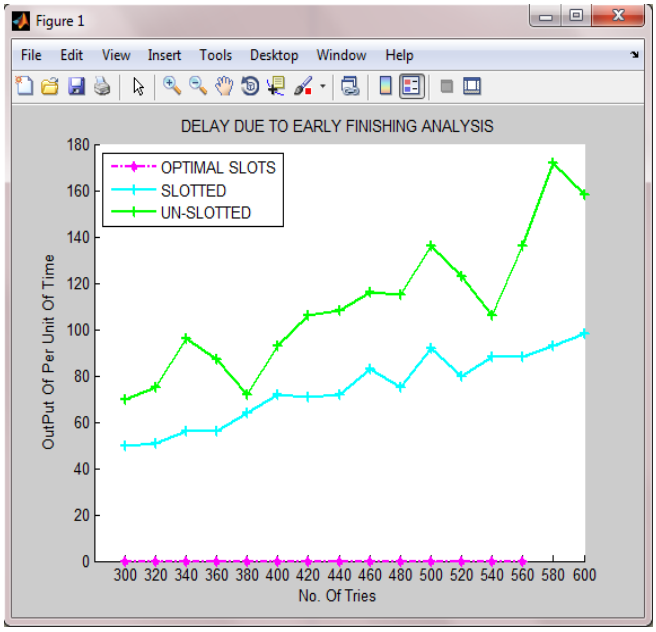

Figure 3 Delay due to early request finish

The experimental results are further enhanced and graphs are drawn in word to clearly show the improvement in proposed technique as compared to existing ones. Figure 4 clearly shows that throughput provided by optimal slots is far better than slotted and unslotted protocols.

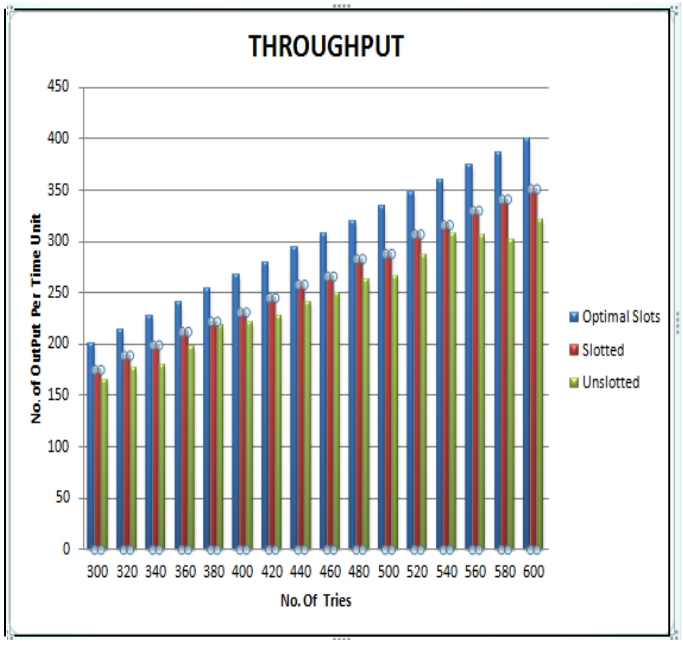

Figure4 Graph for throughput

Figure 5 indicates towards a graph which is showing vital improvement in optimal slots as compared to existing techniques and the improvement is shown using delay due to spinlocking parameter.

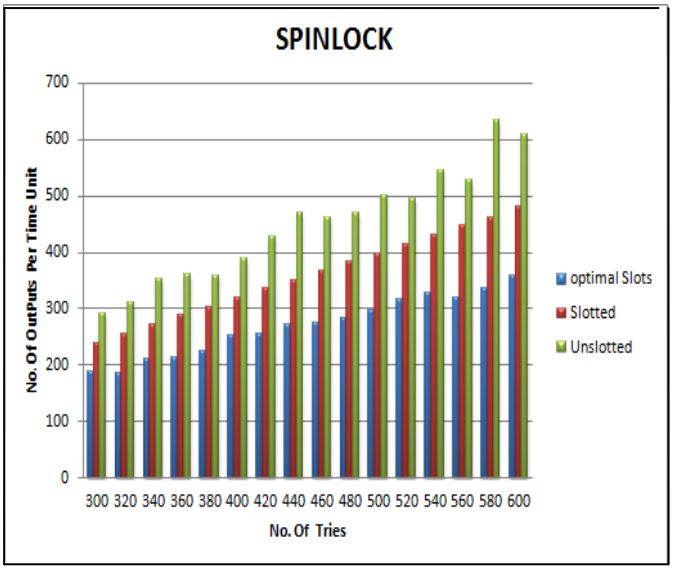

Figure 5 Graph for delay due to spinlocking

Figure 6 shows the comparison between proposed and existing technologies using delay due to early request finish parameter. As shown in the graph the delay bar for optimal slots never grew up because the delay due to early request finish in optimal slots is 0 for all inputs whereas the bars representing delays in slotted and unslotted protocols are clearly visible.

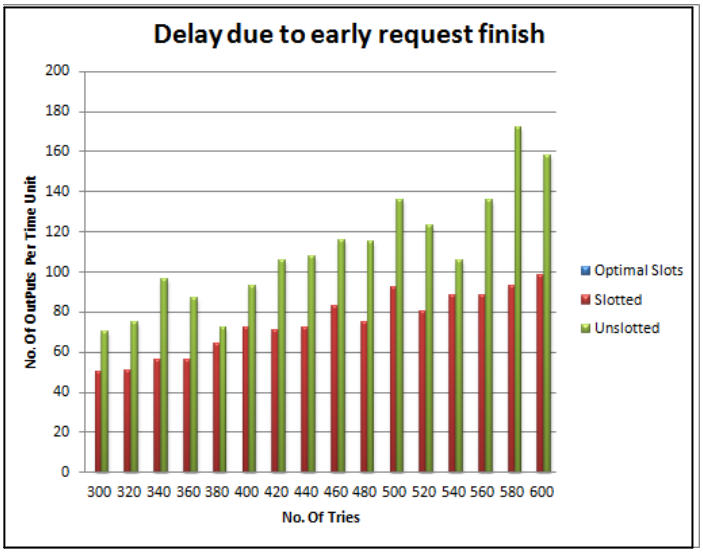

Figure 7 Graph for delay due to early request finish

6. CONCLUSION

In this work we have studied different versions of CSMA/CA protocol. It is shown that CSMA/CA works well than another protocol. So in this paper we have studied the slotted CSMA/CA in detail i.e. how it works?. What are its advantages and disadvantages etc. Various performance parameters of CSMA/CA. A CSMA/CA protocol is proposed which is adaptive to select slot time on run time. So it can reduce the delay time (approx zero) due to early finish of requests. The proposed protocol is implemented in MATLAB and checked on different number of tries. The proposed protocol has ability to remove the early request finish delay time because it selects

slots based upon the currently running requests. Comparison among proposed and existing protocols has shown that the proposed protocol provide quite better results than existing protocols. In near future we will implement this protocol in real time environment.

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