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A Sense-based Registration Process for TDMA in IEEE 802.11 Network

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ABSTRACT

TDMA implementation offer better fairness and throughput in IEEE 802.11. To implement TDMA, new registration process is needed, because current registration mechanism can disrupt TDMA process. This paper proposes a sense-based TDMA registration process using service slot and random timer. Simulation result shows, by using our mechanism, we can reduce the number of unused timeslot, and for 10 new nodes, each node only need 7 ms to complete the registration process.

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1. INTRODUCTION

IEEE 802.11 is a fast-growing standard for wireless network connectivity. Since its birth in 1997, many mobile devices use it as a standard connecting platform to the Internet. With the latest speed up to 780Mbps (802.11 ac standard), wireless connectivity can compete with cable in delivering hi-speed connection to people. Although current standard has a relatively high data rate, IEEE 802.11 still suffer with the common problem that already exists in its previous standard. IEEE 802.11 use CSMA/CA mechanism to distribute network access to its station. According to [1], CSMA/CA only suitable for network with low number of stations and low arrival rates.

Some research has been done to maximize the quality of IEEE802.11 [2] use hybrid coding technique to maximizing bandwidth efficiency while some other researcher proposes the use of TDMA to replace CSMA/CA in IEEE 802.11 [3-5]. TDMA can eliminate fairness problem in CSMA/CA, because each node has exclusive transmission slot and get the same opportunity to send its data. Fairness is a crucial problem in IEEE 802.11, because each node did not have the same opportunity to send its packet, and sometimes nodes does not have enough throughput to start transmitting data.

This paper proposes a new registration control to be used in TDMA based IEEE 802.11 network. The registration control is responsible to create slot allocation and manage nodes in wireless network. Using current CSMA/CA based registration control can affect and disrupt TDMA slot allocation. Disruption in slot allocation can affect the overall performance of TDMA network. This paper will not address power management issues in IEEE 802.11. Unlike wireless sensor that need longer lifetime [6], IEEE 802.11 capable device usually have bigger battery power and easy to connect to external power sources.

2. PREVIOUS WORKS

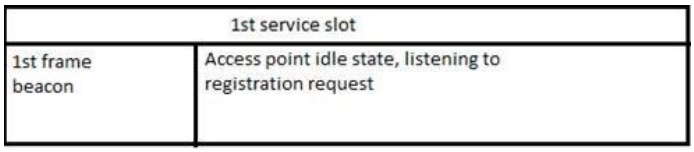
There are two kinds of approach to implement TDMA in IEEE 802.11. The first approach works by implementing pure TDMA to replace CSMA/CA mechanism. This kind of approach needs clock synchronization between nodes to create fixed transmission slot for each node [7]. In 2005, [3] use this approach by creating active time and passive time for each node. Node can transmit its data in active time, and can only listen in passive time. While [8] implement TDMA in application layer, and create application wide clock synchronization between nodes while [4] implements TDMA in mobile ad hoc network. [3], [8] doesn't declare specific mechanism in node registration, while [4] explain a brief mechanism in node registration by using idle sensing for node advertisement.

Another approach to implement TDMA is using CSMA/CA mechanism to create TDMA like behavior. This kind of implementation, also known as pseudo TDMA first appear in [9] by modifying CSMA/CA back off mechanism and contention control. In 2011, [10] improve previous pseudo TDMA implementation by optimizing idle slot between transmission and in 2015, [5] implement pseudo TDMA and optimize it by creating adaptive transmission length to minimize idle slot between transmission. Pseudo TDMA use CSMA/CA based registration control. It does not need specialized registration control because it runs on top of CSMA/CA implementation.

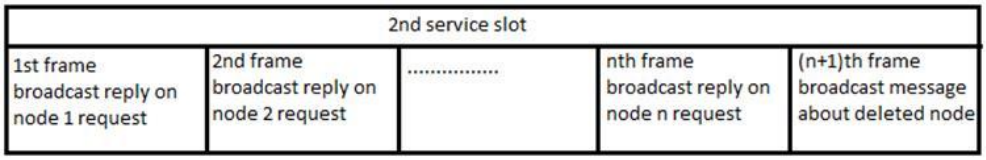
Non-pseudo TDMA implementation need a new mechanism for nodes registration. A common registration process for standard TDMA is to register participating node when building network. This is a simple and fast process, but it cannot handle new node registration when network already running [11]. Another alternative in admission control process is using time synchronization, but it takes another complex process to synchronize time between nodes [12].

3. PROPOSED REGISTRATION CONTROL PROCESS

This paper proposes specialized registration control for TDMA by creating two service slots to manage registration process. The first service slot used by nodes to register themselves to the wireless network. The second slot used by access point to confirm the registration process and notify the newly joined nodes. Order of data frames in first and second service slot can be seen in Figure 1(a) and 1(b).



(a)



(b)

Figure 1. (a) The first service slot, (b) The second service slot

In the first service slot, access point broadcast a beacon frame to the network. Beacon frame is IEEE 802.11 management frame that contains all information about the network. After broadcasting a beacon frame, access point enters idle state to listen registration request from nodes. In [4], nodes will send request frame when it sense idle. In reality, if more than one nodes sense idles and transmit the request message at the same time, collision will occur. To overcome this problem, we divide the access point idle state into several timeslots and each node run a random timer mechanism to choose the timeslot. Hopefully it will decrease the collision probability between nodes. To simplify the process, we can use IEEE 802.11 association packet as the registration request.

After the first service slot, access point will enter the second service slot. In the second service slot, access point will reply the registration request from new nodes. Access point will reply using IEEE 802.11

association reply frame using broadcast mechanism. If the request packet collide, access point will discard those packets and nodes will start over the process by transmitting request in the first slot. Second service slot can also be used by access point to inform the deleted nodes. Nodes on the deleted list will need to start over the registration process in order to join the network.

In each TDMA cycle, access point will occupy the first and the second slot of the cycle to be used as 1st and 2nd service slot. The process flow of access point in this registration process can be seen in Figure 2(a), while the process flow of node can be seen in Figure 2(b).

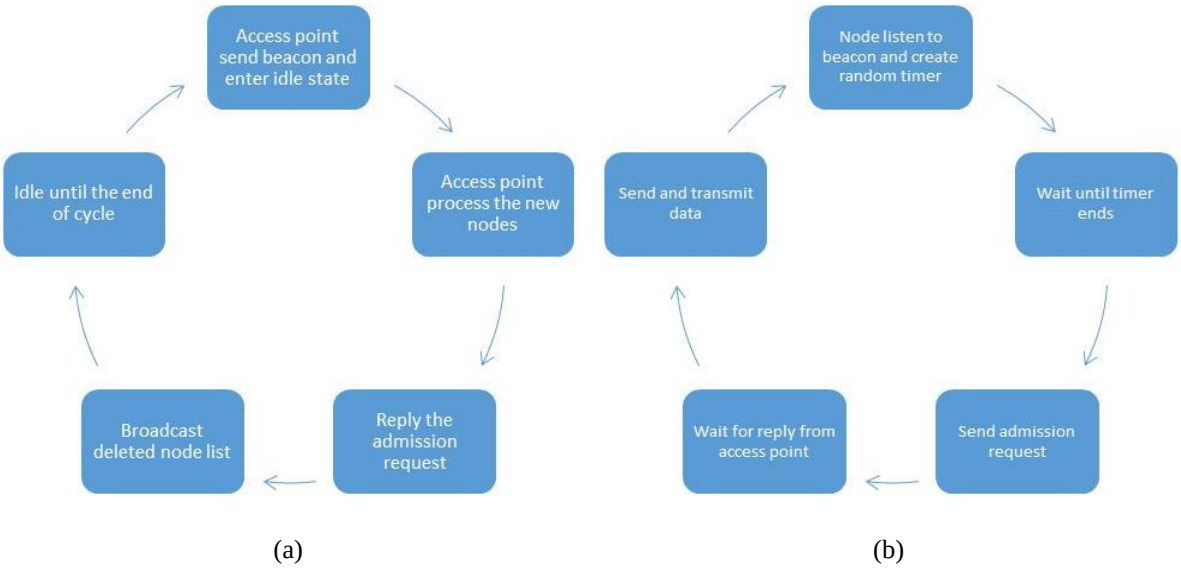


Figure 2. (a) Process flow of access point, (b) Process flow of node

4. SIMULATION AND EVALUATION

We conduct simulation to evaluate the performance on the proposed registration control. The simulator will simulate node registration process using random timer output the number of cycle needed to complete the registration process for all nodes. The simulation starts with registration control of two nodes to ten nodes and five time slot. We repeat each simulation for 100 times and count the average of cycle needed to complete the registration process. Result of the simulation can be seen in Table 1.

Table 1. Simulation Result

Number of Node	Average of TDMA Cycle
2	1.25
3	1.85
4	2.16
5	2.52
6	3.26
7	3.83
8	4.45
9	4.97
10	5.95

To estimate the time needed for a single TDMA cycle, we assume maximum transmission length on each slot is the same as MTU size, which is 1500 bytes. If we use IEEE 802.11b with 11Mbps data rate we can compute number of cycle per second.

$$Cycle\ per\ second = \frac{data\ rate}{N \times slot\ length}$$

By using the above formula, now we can compute the time needed to complete node registration process. Table 2 show the time needed to complete the registration process.

Table 2. Time Needed to Complete the Registration Process

Number of Node	Average of TDMA Cycle	Cycle per second	Total registration time (ms)
2	1.25	480	4.17
3	1.85	320	6.25
4	2.16	240	12.5
5	2.52	192	15.63
6	3.26	160	25
7	3.83	137	29.2
8	4.45	120	41.67
9	4.97	106	47.17
10	5.95	96	62.5

From table 2 we can see the registration process only take 62.5ms to complete registering ten new nodes. On average, for ten nodes, each node will take 7ms to complete the process.

To see its performance, we compare wasted timeslot between our proposed mechanism with synchronous TDMA process. Wasted timeslot is the amount of time wasted in registration process. Wasted slots are calculated by number of unused timeslot in millisecond. Synchronous TDMA registration works using round robin based process. Round robin algorithm is similar to first come first serve process, and designed for time sharing operation [13]. In TDMA, the process works by allocating pre-defined number of slot before the connection begin, the registration process works by assigning the empty slot to each new station. In this simulation, we assume each time slot is 0.13ms (number of time needed to send 1 MTU), number of timeslot is 20 and number of service slot is 10 frames. Result of the simulation can be seen in Table 3 below:

Table 3. Wasted Timeslot between Synchronous TDMA and Proposed TDMA Registration Process

Number of Node	Wasted slot (sync. TDMA) (ms)	Wasted slot (proposed) (ms)
2	4.68	1.56
3	4.42	1.69
4	4.16	1.82
5	3.9	1.95
6	3.64	2.08
7	3.38	2.21
8	3.12	2.34
9	2.86	2.47
10	2.6	2.6

We can see from Table 3, our proposed registration process more efficient in utilizing time slot than standard synchronous TDMA registration process. By using sense-based mechanism, rather than pre-determined slot, the number of wasted slot can be reduced and can be allocated for transmitting data.

4. CONCLUSION AND FUTURE WORKS

In this paper, we propose a registration control to use in TDMA based IEEE 802.11 network. From the simulation result, with ten nodes, the average time taken for each node to complete the process is about 7ms, which is still acceptable. The proposed mechanism also reduces the number of wasted timeslot in TDMA process. Implementation of our registration control need some modification in current data link layer without hardware modification. In client side, modification can be done by modifying open source WLAN driver in Linux operating system [14], while in access point, a modification firmware is needed. A DD-WRT firmware can be used as an alternative to implement the registration process in access point [15].

In this research, we use a fix number of frames in service slot. For future works, to improve the registration process we need to create an adaptive process to calculate optimum number of frames based on number of new nodes. Another open research issue is load balancing process between access points to create reliable connection in high density network users.

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