International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 09 | Sep-2016 www.irjet.net p-ISSN: 2395-0072

A Novel Technique for Efficient Power Management in IEEE 802.11WLAN'S

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Abstract - IEEE 802.11WLAN (Wireless local area network) is a network that allows two or more computers or devices to communicate with each other within a limited range. IEEE 802.11 WLANs are becoming more and more popular in homes and urban areas. IEEE 802.11 WLAN provides multimedia services like live telecast, video streaming, video conferencing, Voice over IP (VoIP) to its users. In this work the authors have illustrate on one of the limitation of WLAN i.e., battery life of device. In WLANS in order to conserve energy we have one of standard method as Power Saving Mode(PSM). In this mode the stations will wake up at pre-defined interval to receive the frames from AP. The authors have perform the enhancement on basic power saving mode (PSM) mechanism.In specific the authors have focused on one of the power saving scheme i.e., delayed wakeup scheme(DL) and the improved the scheme to avoid rush hour problem. The authors have proposed a new scheme called Dynamic Listen Interval(DI) inorder to overcome unnecessary wakeup's problem. The simulation results shows that Dynamic Listen Interval scheme is showing better results when compared with previous technique.

***Key Words*: IEEE 802.11 WLAN, Powersaving, Acess Point(AP),Nodes.**

1. INTRODUCTION

Devices equipped with IEEE 802.11 WLAN or WiFi-enabled devices, are everywhere, including cell phones, tablets, laptops, and even smart bulbs . There is no doubt that WLAN will play an even more prominent role in the era of Internet of Things. Due to the mobility requirement, a major concern in choosing an 802.11 device is its power consumption.IEEE 802.11 WLANs [1] can operate in both infrastructure mode and ad hoc mode.

In practice, majority WLANs operate in the infrastructure mode, with 802.11 enabled devices taking the role of stations (STAs) and communicating with the WLAN access point (AP) using the distributed coordination function (DCF)[2]. The AP and the set of STAs communicating with it form a basic service set, which share a common radio channel using the well-known carrier sense multiple access with collision avoidance (CSMA/CA) protocol.

Fig -1: Adhoc mode and Infrastructure mode

In CSMA/CA protocol[1], a STA needs to continuously listen to the channel to determine its current status even though it has nothing to transmit or receive. To address this issue,a power save mode (PSM) is defined [1].Based on it, a STA can be configured to function either in the continuous active mode (CAM), i.e, a CAM-STA, or power save mode (PSM), i.e, a PSM-STA. A CAM-STA carries out one of the three activities, idle, receiving, and transmitting. A PSM-STA does one extra thing, sleeping when there is no data to transmit or receive data .The power management mechanisms defined in the 802.11 standards, which we refer to as the basic PSM (BPSM) scheme, only apply to PSM-STAs. (When there is no ambiguity, we may also use STA to refer to a PSMSTA.)

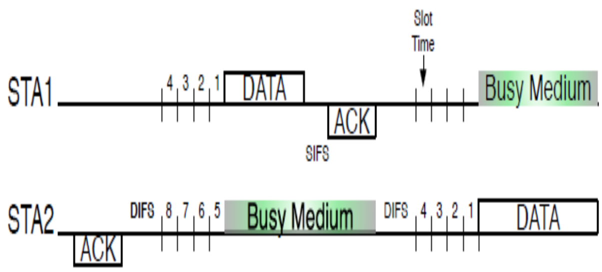

Fig-2:Working of CSMA/CA

2.Previous work

2.1 Power Save Mode in IEEE 802.11

Mobile devices work on battery. According to the statistics energy consumed by WiFi accounts for about 10% of the total energy consumption in current laptops, and the percentage grows up to 50% in hand-held devices. Power management technology in WLAN has become a critical issue. From the operation of the CSMA/CA protocol, we can see that a STA needs to continuously listen to the channel even through it has nothing to transmit or receive. To conserve battery power, a power save mode (PSM) is defined in the 802.11 standard Based on it, a STA can be configured to function either in the continuous active mode (CAM), i.e, a CAM-STA, or power save mode (PSM), i.e, a PSM-STA. A CAM-STA carries out one of the three activities, *idle*, *receiving*, and *transmitting*. A PSM-STA does one extra thing, *sleeping* when there are no data to transmit/receive. Understandably, an AP must always work in CAM, and with assumptions that a CAM-STA is always available to transmit/receive, and a sleeping PSM-STA is unable to receive until it wakes up. Frames destined to a PSM-STA, therefore, need to be temporarily buffered at the AP.

The power management mechanisms defined in the 802.11 standard, which we refer to as the basic PSM (BPSM) scheme[3], only apply to PSM-STAs (When there is no ambiguity, we may also use STA to refer to a PSM-STA). Ranking the four 802.11 radio activities above in the ascending order of power consumption, we have sleeping, idle, receiving, and transmitting.

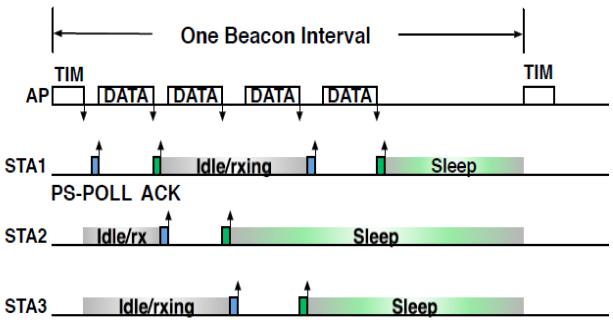

Fig-3 :Operation of PSM Mode

In a WLAN, AP transmits *beacon* frames periodically (as shown in Fig. 2.1). The period is called beacon interval (BI), and a default value of 100 ms is usually used. Beacons provide essential information for new STAs to join (i.e. to associate with) the AP. A smaller BI allows faster association, but at the cost of more communication overhead. When a STA associates with the AP (via *association request* and *association response* frames), a unique 14-bit association ID (AID) is created/assigned to the STA.

Beacon consists of many information elements and fields. Among them, the traffic indication map (TIM) information element is essential for power management. In TIM, the most important field is a partial virtual bitmap (PVB), where each bit of PVB corresponds to a specific PSM-STA (identified by its unique AID). If this bit is equal to one, it indicates that unicast traffic is buffered at the AP for this PSM-STA. Otherwise, the bit is zero. TIM also contains many other fields. In our work, we focus on designing efficient power management for unicast traffic.

The basic power save mode (BPSM) scheme in works as follows. When a PSM STA associates with an AP, it specifies its preferred *listen interval* (LI) in the association request frame. LI is a 16-bit value and specifies the maximum number of beacon intervals that may pass before the STA wakes up to receive a beacon . Upon receiving a beacon frame, if the TIM indicates that no buffered frames at AP, the STA will go back to sleep immediately and wake up again LI beacon intervals later. In practice, LI=1 is usually used, which means the STA wakes up to receive every beacon broadcast. If AP accepts an association request, it will make sure that it has enough buffer for storing data arrived while this STA is sleeping.

Accordingly, AP can reject an association request if LI chosen by the STA is too large. If the TIM indicates buffered frames at AP, the STA stays awake and sends a *PS-Poll* frame to retrieve each buffered frame, as shown in Fig. 3. For each PS-Poll received, AP sends one buffered frame and the STA acknowledges its correct reception by an *acknowledgement* (ACK) frame. If there are more buffered frames, AP tells the STA by setting the More Data flag in the data frame header to 1.

2.2 Problems in PSM:

The major problems that were identified in the PSM mode are
a)Rush Hour problem
b) Unnecessary wakeup's problem

Rush Hour problem: PSM-STAs wake up at every beacon frame broadcast,or beacon interval (BI). From the traffic indication map (TIM) in the beacon, a PSM STA learns if there are any buffered frames at AP. If yes, it will stay awake until all buffered frames are retrieved. This creates a *rush hour* on the shared channel right after a beacon broadcast. If the channel is congested, having all PSM-STAs staying awake and consumes more power.

Unnecessary wakeup's problem: When a PSM-STA wakes up to receive a beacon and found that there are no buffered frames at AP, the PSM-STA experiences an unnecessary wakeup.Accordingly, the associated mode transition energy is wasted.The occurrence of unnecessary wakeup is shown in fig-4.

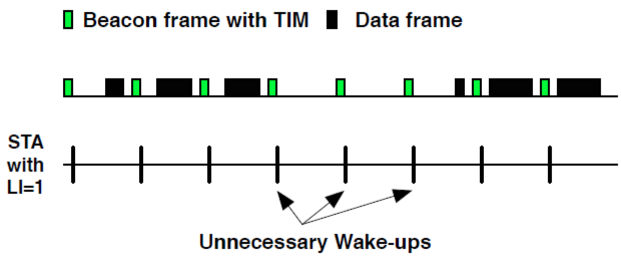

Fig-4 Unnecessary wake-up problem

2.3 Delayed Wakeup (DW) Scheme

The design goal of delayed wakeup (DW) scheme is to save battery power while *not* adversely affecting the system delay-throughput performance. Approach is simple: if the channel is congested, we identify "excess" STAs and put them into sleep and wake them up later at a non-congested time. Notably, "excess" STAs refer to the STAs whose traffic cannot be completely transmitted in a specific time interval even if the channel is fully utilized. Specifically under the assumption that all STAs with listen interval equals to one, we divide a beacon interval (BI) into n sub-BIs.

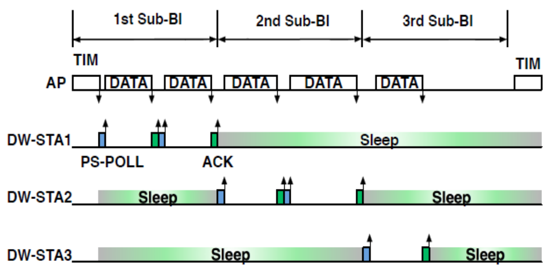

Fig-5 Operation of working of delayed wakeup scheme

The Fig-5 shows the using our DW scheme. Although all three DW-STAs have buffered frames, the received TIM instructs them to act differently: STA 1 stays awake until all buffered frames are retrieved; STA 2 and STA 3 go back to sleep immediately and wakeup in the 2nd and 3rd sub-BIs, respectively. In doing so, unnecessary idle time in is avoided, and the rush hour problem is solved.

2.3.1 Algorithm

The algorithm of delayed wakeup scheme is obtained by making modifications to standard PSM mode.

Steps:

- Frames are buffered temporarily at AP.
- AP transmits beacon frames periodically(BI).
- The beacon interval is sub-divided(1 sub BI…..etc).
- Based on this STA will be in active or sleep mode .
- TIM instructs which station to be in active or sleep in which sub BI.
- Station will send PS Poll and retrieves the data from AP.

3.Proposed Work

The proposed work in this paper is to identify the problems in existing system and to design and implement dynamic listen interval scheme inoder to overcome the problems.

3.1 Dynamic Listen Interval

This scheme is mainly designed *to avoid unnecessary wakeup* problem is due to the fact PSM-STAs wake up and find there are no buffered frames for them.Note that a PSM-STA carries out one of the four activities, idle, receiving, transmitting (here we say the PSM-STA is in awake mode), and sleeping (or in doze mode). During the mode transition, a PSM STA will consume twice the power of idle. For one unnecessary wakeup, a PSM-STA will have 2 mode transitions (i.e from awake to doze or doze to awake). The associated mode transition energy will be wasted. Under bursty traffic, such unnecessary wakeup problem will be intensified.

According to the IEEE 802.11 standard, a PSM-STA informs the AP its preferred LI by sending an association request frame at the time of association. If the AP accepts the request, it will reserve buffer space according to the LI, and send an association response frame to the PSM-STA. The PSM-STA will wake up periodically to check if there are buffered frames at AP using its LI. If LI=1, a PSM-STA wakes up at every beacon interval (as that in DW scheme). Although packet delay is minimized in this case, the chance of unnecessary wakeup can be high.

On the other hand, a large LI can reduce the chance of unnecessary wakeup but delay penalty will be suffered by the STA. To solve the *unnecessary wakeup* problem while maintaining an acceptable delay performance, we propose a dynamic listen interval (DLI) scheme.

When a PSM-STA wakes up and finds there is no backlogged traffic at AP according to the periodic beacon frame, the PSM-STA will increase its LI by one up to a predefined upper bound U (system predefined, known by AP and DLI-STAs). If the PSM-STA is informed that there are buffered frames at AP, it will reset the LI to one and send a PS-Poll frame to retrieve the buffered frames. When there are no pending frames, increasing LI can help the PSM-STA to reduce unnecessary wakeups.

On the other hand, resetting LI to one aims at minimizing the delay penalty when the PSM-STA finds there are no buffered frames. Therefore, our DLI scheme can help the PSM-STAs to save mode transition energy while maintaining an acceptable delay performance.

3.1.1 Algorithm

The steps of dynamic listen interval scheme is similar to delayed wakeup scheme with some modifications

Steps

- Frames are buffered temporarily at AP.
- AP transmits beacon frames periodically(BI).
- When a STA wakes up and finds there is no buffered frames at AP according to the periodic beacon frame, STA will increase its LI by one up to a predefined U
- If STA has buffered frames at AP, it will reset the LI to one and send a PS-Poll frame to retrieve the buffered frames.

3.1.2 Special case:

In this method we have consider one of the practical case that if suppose the node is outside the coverage then how can a node communicate with AP and the method is shown below.Consider the nodes present outside the coverage area as outside users and nodes inside the coverage as inside users.Now for the communication to happen between the outside users and AP the inside users will be helping them.

Steps:

- When AP sends beacon then inside user will send activation beacon to outside user.
- Outside user will send the request to inside user inoder to communicate with A.P.
- Inside User forwards request to AP and AP stores in its memory.
- AP will send confirmation message to Inside user then to outside user.
- Data transmission takes place.

Here outside user will receive multiple request from many outside users but based on parameters like remaining energy, scheduling time etc.In activation beacon message the information present is like node ID,AP ID,energy level etc.

4. Simulation

The simulation tool used is NS2. It simply simulates a network, and provides a trace file of all the events that occurred.Using this tool we have compared the performance of basic standard method-Power Save Mode(PSM),Delayed wakeup scheme(DW),Dynamic Listen Interval(DI).The parameters that are used for simulation are listed in the table.

Table -1: Simulation Parameters

No of nodes	9
Data rate	10Mbps
Beacon interval	100ms
TX Power	1000mw
RX Power	800mw
Idle Power	500mw
Sleeping Power	100mw
Coverage of beacon message	100m
Coverage of activation beacon	10m

Using the specifications mentioned in Table-1 the performance of all 3 methods comparsion is shown in graphs.The parameters used to compare are power consumed and throughput.

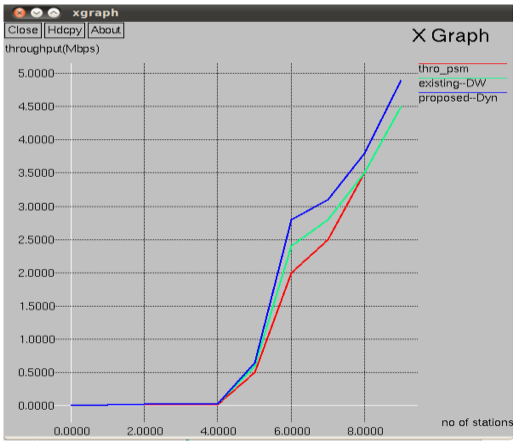

Chart -1: Comparsion of all 3 methods with throughput

From the chart-1 it is clearly shown that throughput is more in proposed method dynamic listen interval when compared with PSM and delayed wakeup scheme.The main reason is the number of collisions are reduced in proposed method .

In chart-2 the comparision is performed for powerconsumed in 3 methods .From chart-2 it is clearly shown that power consumption is less in proposed method when compared with previous methods as unnecessary wakeups are reduced.

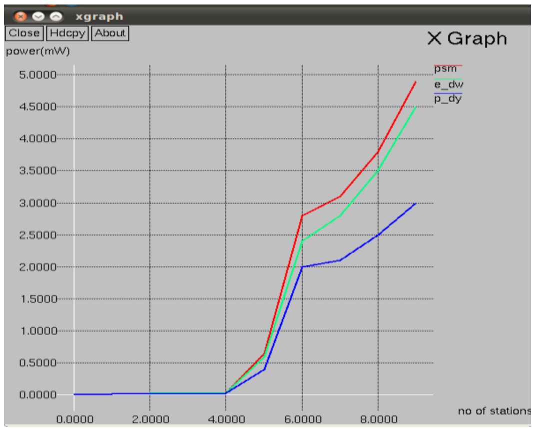

Chart-2-Comparision of all 3 methods with power consumption

5. CONCLUSIONS

An efficient power management mechanisms which can enhance the basic power save mode (BPSM) in IEEE 802.11. In this paper we have addressed the *rush hour* problem and the *unnecessary wakeup* problem. We implemented delayed wakeup (DW) scheme and proposed a new method i.e dynamic listen interval (DLI) scheme to solve these two problems, respectively. The simulations have been performed and results of proposed method is better when compared with previous methods. In DLI scheme LI linearly is increased , possible extension can be exponentially increase the LI to save more transition mode energy.We focused on unicast traffic ,possible extension can be done with broadcast traffic.

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