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Investigating the Analysis of Power Saving Mode in IEEE 802.11 for Wi-Fi Communication

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Abstract*:* One of the major global issues today is energy consumption. Consequently, power management was introduced in various communication technologies. For IEEE 802.11wireless communication, there is a Power Saving Mode scheme (PSM) for increase the battery life of cell phone. In this PSM, there are two key parameters: beacon period interval (BI) and listen interval(LI). In most work these values are chosen arbitrary. Here, a scheme to determine the optimal BI and LI for accomplishing the most astounding conceivable vitality proficiency is introduced. This is implemented with the application of a numerical sample to the standard IEEE 802.11 PSM and Access Point-PSM (AP-PSM) schemes. To ensure the quality of network performance analysis on the normal and change of parcel delays is doing. The well-known queuing (M/G/I) model with bulk services are utilized. After the implementation of the proposed analysis, "maximum rest plan time ratio optimal Sleep Scheme (OSS)" which is when participate stations stay in the doze mode it can be determined. In this research shows that the optimal BI and LI produce optimal OSS time ratio scheme also achieved optimal average and variance of packet delay.
Key word*: power management, standard "IEEE 802.11, infrastructure" wireless (LAN), PSM mechanism, beacon interval, listen interval*

تحليل خزن الطاقة فيIEEE802.11

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الخلاصة:- استهلاك الطاقة تعتبر واحدة من القضايا العلمية الكبرى ، بناءا على ذلك اداره الطاقة قدمت حلول متنوعه في مجال الاتصالات لتلافي الاستهلاك، منها ما يوجد في نظم الارسال IEEE.812.11 نظام لتوفير الطاقة يسمى power saving mode يستخدم لإطالة عمر البطارية خصوصا في اجهزه الموبايل ،توجد في نظام توفير الطاقة عاملان يعتبران اساسيان في عمل نظام توفير الطاقة يتم اختيار قيمتهما عشوائيا في اغلب الاعمال. في هذا البحث تم اعداد مخطط رياضي لاختيار افضل قيمتان للعاملين الاساسيين للحصول على اعلى نسبه من توفير الطاقة، المخطط هو عباره عن مودل رياضي تم العمل به وفق الاصول الثابتة لنظم الارسال IEEE 802.11 بين المضياف والعملاء التابعين له، وللتأكد من اداء الشبكة كان جيدا في نظام الارسال والاستقبال تم حساب معدل و متغير تأخير الحزمة وفقا للنظام الطابور المشهور في ارسال الحزم تباعا M/G/1 ، بعد تطبيق المودل الرياضي لاختيار العاملان الاساسيان(BI and LI) حيث تم حساب الوقت الذي تكون فيه البطارية في حالة سكون .بينت النتائج ان قيم العاملان الاساسيان حققت نتائج جيده في معدل ومتغير تأخير الحزم.
ادارة الطاقة , المعيار *IEEE 802.11* , التركيب اللاسلكي (*LAN*), وقت تجميع المعلومات, زمن استماع العميل لمعلومته.

I. INTRODUCTION

Wireless communication has become an integral part of our life since more applications are switched on mobile device with wireless connectivity. The main problem of developing a wireless communication device lies in the issue of 'energy efficiency'. Many approaches were suggested to address this issue. This includes the mechanism of PSM in IEEE 802.11 where an idle user is either assigned to a scheduled packet transmission class or low power consumption class. The focus in this paper is on the latter and within infrastructure network architecture that consists not more than 10 stations support by an AP. Typical low power consumption class of PSM operation allows a station to enter the doze state whenever it is idle. A pivotal role is given to the AP, since it broadcasts the beacon frames at each BI, in order to wake-up the stations periodically for checking whether they have buffered frames at the AP. After receiving the beacon frame, all the stations go into wakes-up mode each for a period called LI. In most work both BI and LI values are assumed and their magnitude have direct impact on the performance of PSM. Furthermore, IEEE 802.11 does not specific values for BI and LI. In most cases, these values are chosen in order for PSM to operate effectively [5].There are two power-saving schemes developed for PSM. One class [5, 1,4] proposes a power management scheme where each station can save more energy by decreasing the number o un essential of wake-ups. This is accomplished by selecting an optimal schedule to go into wake-up mode. This class is based on station-centric operation without coordination by an AP. However, this class of power saving scheme is unable to reduce energy consumption due to medium contention. Later, the work will show that channel contention leads to wastage in energy. The other [10, 2 ,7] develop an AP-centric schemes, whereby the AP relays the buffered frames to all stations in the wireless network in order to achieve high energy efficiency. The AP has the features of adaptive packet transmission schedule or to calculate the wake-up schedule of the station as in [3] to alleviate channel contentions.

This paper suggests a new PSM scheme Optimal Sleep Scheme time ratio to equip the AP with the ability to select the optimal BI and LIs. These selections allow the stations that offer a similar reference point of periodic time to get their packets frame from AP based on the network traffic patterns. These periodic times which are selected by the APs to achieve higher energy efficiency and reduce the unnecessary wake-ups for the stations and channel contentions among them. The rate of power consumption in channel contentions is a very important amount because of all the stations involved cannot go to the sleep mode during the contention period [8]. The insights of the parcel landing designs in OSS time ratio can be determined easily. Also, the OSS time ratio, is made independently of the higher layer's protocols. The rest of this paper is organized as follows. Section II provides a description of the PSM in IEEE 802.11 infrastructure wireless network. Section III deals with the summary of the previous energy-saving schemes suggested for IEEE 802.11 infrastructure wireless networks. Section IV provide example for illustrating the PSM in an IEEE 802.11 infrastructure wireless networks. Section V analyses the significant impact of BI and LIs on energy efficiency. The section of VI represents the calculations of the optimal BI and LI intervals within PSM mechanism and a precise average ratio of the time when participate stations stay in the sleeping mode (OSS) time ratio. Finally, section VII provides the evaluation of this model as the conclusion with future work.

II. "SAVING POWER MODE IN IEEE 802.11

INFRASTRUCTURE NETWORK

This section presents the PSM mechanism in IEEE 802.11 infrastructure wireless network, which is known in the IEEE 802.11 typical. The station which uses the PSM mechanism, is in one of these two modes, namely, a wake-up mode and sleep mode. In the wake-up mode the station is among three states which is transmission, received and idle where all of them are fully charged, so the station can send or receive packet data efficiently. In the sleep mode the consume of stations is very low power compared with the wake-up mode; hence, the station is unable to send or receive any packet data. The PSM mechanism, each station listens to the indication of traffic map (TIM) periodically, to check whether the AP has pending buffered packets frame directed to its destination. The TIM is included as a gradient inside the beacon. The broadcasts of AP beacon at regular periodic time to check the presence of buffered packets frame for all the stations. If a station has protected packets frame, it remains in the awake-up mode and create Power Saving poll (PS-Poll) frame by continuing the transmission to the AP of the packet until all the frame of buffered packets stations are received. If a station does not have any packets of buffered frame at the AP, the station will go to the switch off mode immediately. The consumption of power for the station from sleep mode to the awake-up mode is the same amount in fully powered, but from on mode to rest mode the quantity of power consumption is unimportant because the time is very small value. The period of time that the station stays at wake-up is defined as a LI which is a multiple of the BI [5, 8].

III. RELATED WORK

The smart PSM [10] examined the implementation of the saving power mode mechanism of 802.11 and showed that the circumstantial of traffic network can have a majorly affect the power utilization of portable stations. A planned PSM rules based on time division is chosen to build control effectiveness. The protocol adopts the mechanism of the slides of time. The researchers [5] Lie and Nilsson suggest the saving of power method in IEEE 802.11 structure network that is worked by M /G /1 with global service, that accomplishes the mean parcel delay and the average percentage of time a station remains in the rest state. The researchers in [8] proposed an organization of sparing mode power (C-PSM) and an AP-centric PSM for 802.11 framework networks. The AP chooses default values for the parameters of PSM, such as beacon and listen intervals. C-PSM is fit for expanding the aggregate vitality proficiency for all stations in wireless networking, but with a slight delay.

IV. POWER SAVING MODE IN IEEE 802.11

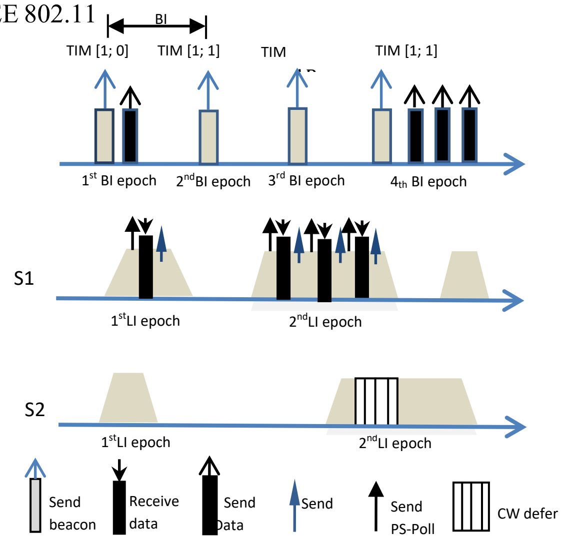

Fig1.An example of PSM operation for two wire less station [8]

Fig. 1 shows a case of the PSM mechanism in an IEEE 802.11 structure wireless system. The PSM operates for two wireless stations S1 and S2. The first bit in the TIM check the buffer status for station S1 and the second bit indicates there is no buffered status in S2 at the first beacon period. The shaded district shows that the station is in the awake status. At the starting of the listen interval, station S1 activates its wake-up mode and generates PS-POLL frame to retrieve all its packets frame, while S2 activates its wake-up mode, but goes to sleep mode immediately. At the second LI there are buffered frames for both stations, but S2 cannot obtain its buffered packets frame because the channel is busy with S1. According to the Carrier Senses Multiple Accesses Collision Avoidance (CSMA/CA) is not allowed to S2 send its PS-POLL, even though S1 has received all its packets frame. Hence, S2 must remain in the idle state for a long time to retrieve its packets frame. Finally, after each station has received its packets data successfully it sends an acknowledgment message (ACK) to the AP. After a frame such as data frame or PS-POLL frame and ACK frame is sent, there is a time interval of Short Inter frame Space, (SIFS). The AP sends the time interval of distribution inter frame space (DIFS) before sending packets of frames to the stations to inform them the packets frame are arriving shortly. The AP sends each packet data to the station with minimum contention window (CW). This is to take into consideration should a collision happen. The exponential back off will be used for retransmission of the packet of data until it is successful or the packet of data transmission is dropped [10].

V. PRELIMINARY ANALYSIS SIGNIFICANT IMPACT OF BI AND LI ON THE ENERGY EFFICIENCY

Energy consumption takes place during channel contention between the PS-POLL frames of the stations and unnecessary wake-up for the stations. From previous example, it is obvious that there are buffered frame to S2 station at the second beacon frame, but S2 is unable to obtain its buffered frame because the medium is busy with S1 and the medium does not allow to PS-POLL frame from S2 to be transmitted to the AP. So for S2 to obtain its buffered frames it must stay at wake-up mode until S1 has received all its buffered frames. This means S2 consumes a lot of energy just waiting for its turn to send PS-POLL frame to recover its buffered packets slide. In other words, S2 has entered into unnecessary wake-up mode. Clearly, at the fourth BI there are buffered slides for S1and S2 simultaneously, whereby both of the frames will transmit their PS-POLL frames to the AP to recover their buffered frames. In infrastructure wireless network there is no relationship between the stations. So the station has to maintain and communication solely with the AP. Hence that is the reason for the inevitable collision. When that happens the back off process take place, which may take a long time to retransmit the packet frames. Subsequently, each station must remain wake-up mode until it receives its packet frames. Therefore, rescheduling the wake-up for the stations at the different times will help to reduce overlapping of LIs for the stations. Hence, greatly reduce energy consumption, then the chosen of ideal BI value will also assist to conserve energy, since BI value is used to determine the granularity of LIs [5].

VI. DETERMINING OPTIMAL BL AND LIS

For power saving scheme to operate in an infrastructure wireless network, the network need to not be in a heavy load state. That due to the fact the PSM mechanism operates ideally when the utilization of network (ρ) is equivalent or under 30%for each station and its equal one or close to one at the AP [8]. Therefore, in this analytical research, the benchmark of the usage approximately must be equivalent or under 30%. Therefore, it is very important to check the utilization value before choosing the ideal BI and LIs, the equation for utilization is

$$\rho = S \times \sum_{J=1}^{C} \frac{1}{U} \quad (1)$$

where S represents the time covering the exact sending time from the AP to the station and to PS-POLL structure with acknowledging the frame from the station to the AP with additional overhead of IEEE 802.11Distribution Coordinate Function (DCF) free of channel contention. This communication interval value must be greater than the actual transmission value between the AP and the stations, nd C represents the quantity of stations in the remote system framework. Additionally, the arbitrary variable U represent the average of the arrival of inter-frame time which can be sorts three forms of distribution namely, deterministic (DET), uniform(UNI), and exponential (EXP).The parameters that are used to calculate the actual transmission timers shown in table

Parameters	Values
Number of stations	1 to 10
Data transmission rate (DTR)	11Mbps
Basic transmission rate (BTR)	2Mbps
Size of packet data (PDS)	6000 bits
Size of PS-POLL frame (PFS)	14 bytes
Size of ACK frame (ACK)	14 bytes
Short Inter frame space time (SIFS)	10 µs
Distribution of inter frame space (DIFS)	50µs
Minimum Contention Window (MCW)	31
Preamble	192µs
Time slot	20 µs

Table 1. parameters used in this paper [5] [9]

Based on the components of the Medium access layer (MAC) with sub-layer DCF, S becomes

$$S_{act} = \frac{PDS}{DTR} + \frac{PFS}{BTR} + \frac{ACK}{BTR} + CW + DIFS + 3SIFS = 2ms \quad (2)$$

and must add the preamble time for each transmission frame by the formula is

$$192\mu s + \frac{\text{frame size} \times 8}{\text{transmission time}} = ms \quad (3)$$

The exceptional distribution with PSM mechanism is EXP distribution [9]. therefore, all the sooner elements mentioned are critical in stabilizing the network gadget. According to the condition of the stability 30% of Wi-Fi network system as referred before, the equation of the average of total arrival of packet frames (λ) in a remote system framework is : -

$$\lambda = \sum_{J=1}^{C} \frac{1}{U} \quad (4)$$

The AP uses of the main algorithms to calculate and deploy the maximum PSM parameters (BI, LIs) and settings on itself and all the stations to increase energy efficiency. The operation methodology of the AP starts with the chosen of three gathering of inter frame arrival time. Each gather consists of three values each value represents one station $(U_1\ U_2\ U_3;\ U_1\ U_2\ U_3;\ U_1\ U_2\ U_3)$. Then the AP chooses three numerical values (NV)from all the integer numbers indicates by $(\alpha)(\alpha_{1;}\ \alpha_{2;}\alpha_{3;})$ after which each NV is multiplied with one gather from the inter frame the time of arrival to get the (LIs) competitors. The connection between all NV to each gathering of inter the time of arrival is a linear one to one corresponding. This shows that each

$$\text{LI competitor} = \alpha \times U \quad (5)$$

and the estimation of integer number must be not exceeding three, because the LI competitor period should be not very big, otherwise, the AP will collect many cradled outlines and the stations will spend a lot of vitality to recover their parcels of information. The AP choses the base value of BI signified by (β=10ms). the base value cannot be under β=10ms, because the unnecessary wake-up modes will boom the energy intake and the utilization of the system can even increase, resulting in serious channel contention. Therefore, many researchers [9] have mentioned the minimum value of BI should as a minimum 10ms. The AP chooses three values of the BI applicant; indicates by $(\alpha)(\alpha_1;\ \alpha_2;\alpha_3;)$. Each esteem must be higher by at least five times the minimum value of BI. Be that as it may, the esteem ought not go past 100ms. Because a lot of researchers establish that when the value of BI is exceeding100ms there is event unsatisfactory defer [10]. To get the ideal BI there is one contribution of the input calculation meant by (ε) which correspond two as

$$G = LI_{min} - B_{min} / \text{step size} \quad (6)$$

Then the values of three applicants from ideal BI

$$BI = \delta + G \times \alpha \quad (7)$$

Whereby the relationship between each value of NV to the value of BI candidate is a one to one match that can be resolved an incentive from perfect BI is doled to one value from applicants of BI, where Microsoft visual C++ 2010 express programing has been applied to calculate optimal BI as shown in figure 2 by using C++ programming.

Figure 2 Main interface to calculate the optimal BI and LI

Because the optimal value of BI will be one from the optimal BI candidates that is corresponding to BI candidate which result in largest ratio of standard deviation to average value for largest LI group from largest common multiple (LCM) iteration process that will be discussed below.

Most of the researchers said that in order to save energy the value of BI =100 ms as an arbitrary value and beyond this value unacceptable delay is happened and value of LI is N times of BI where N always is equal to one. these assumptions have been done on experiences data [5 ,10,2]. The vary value of G can be found from the least value of LI and BI. The maximum value of BI cannot exceed 100 ms. The variable of G depends on interval of LI because the maximum value of BI is correlated with maximum value of LI. To evaluate the least common of multiple (LCM) over each two parameters of BI and LI. Because the pattern of traffic of each group, Due to traffic pattern of each group. Three parts for BI candidate and three parts of LI candidate are recognized for chosen of maximum LIs candidate. As such three LCM groups candidate are found from each value of BI candidate with each LI group candidate. Finally, the mathematical principle of the LCM gives the least value. So, from three LCM groups candidates, the biggest LCM group candidate is chosen. Hence, the number of largest group of candidates is three. Because the largest LCM group have a less number of unessential wake-up. Then the standard interval for each of the biggest LCM group candidate is determines. Hence, three values of standard interval are obtained. The criterion to select the optimal LI value is depending on the biggest spread of their elements, that is evaluated from the proportional of each value of standard interval to the average value of the biggest LCM group candidate, where both candidates are from one group. From the three ratios, the top one is chosen (Q) and adds the Q to the value of maximum BI to get the maximum LI depend on the formula 8

$$\text{Optimal LI} = \text{optimal BI} \times Q + \text{optimal BI} \quad (8)$$

To prevent the correlation and reduce the periodically of wake-up, the maximum value of BI is selected from maximum value of BI groups. The maximum value of BI value is selected from optimal BI group candidates depend on the BI candidate is chosen to the biggest ratio (Q) of the standard interval to the biggest LCM group candidate.
The AP in this OSS time ratio scheme determines the best optimal value of BI and LI as shown in fig.3,4. The minimum congestion window size is assigned according to the traffic pattern of each station.

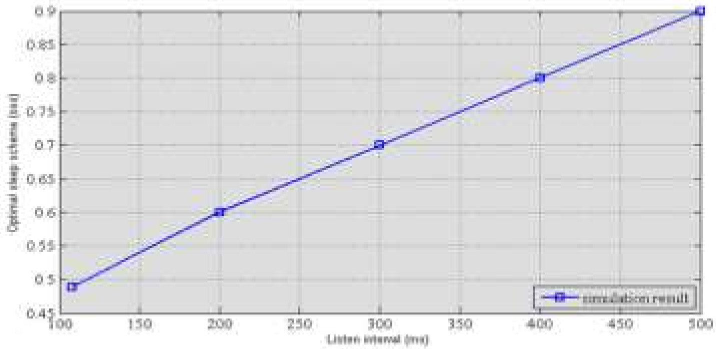

Figure 3 The relation between OSS scheme and optimal LI

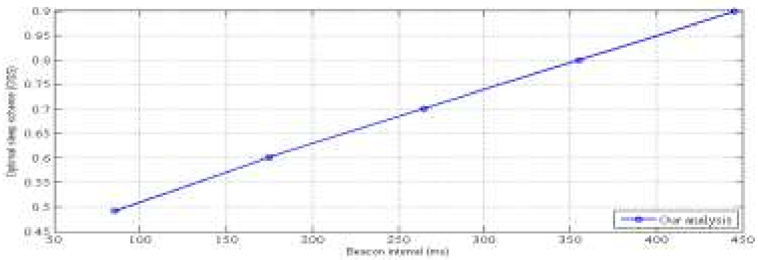

Figure 4 The relation between OSS scheme and optimal BI In addition, the variance of delay shows an increase, on the condition that the QoS is acceptable as the requirement based on the IEEE 802.11 standard as shown in figures 5,6.

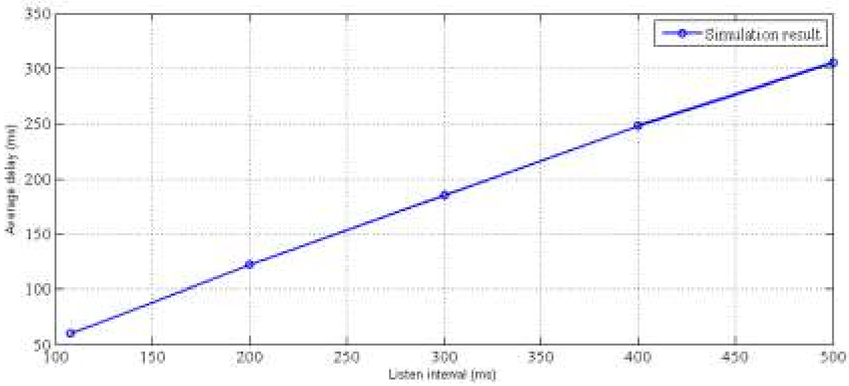

Figure 5 The relation between Average delay and optimal LI

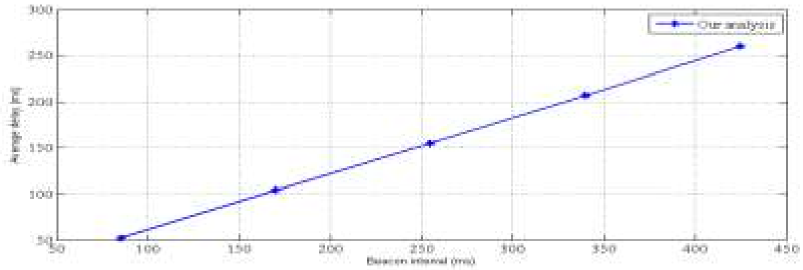

Figure 6 The relation between Average delay and optimal BI

VII. CONCLUSION AND EVALUATION OF THIS MODEL

The qualities from BI and LI period can decrease the much of the time of wake-ups and channel conflict for the stations. At the point when these qualities are consolidated, they will convert into vitality sparing and lessening in the buffering delay. The minimal congestion home windows are also helpful in reducing un equal among stations. The average of the OSS time ratio increases as the listen interval increases. There is an exchange off between the power wastage and the average delay of wireless network. The main sources for energy consumption in an infrastructure wireless network are channel contention between the PS-POLL frames of their stations and the frequency of wake-up for stations that share the same BI to retrieve their data packets. Therefore, during the implementation of the OSS scheme there is a significant reduction in the amount of energy consumed by channel contention and frequency wake-up. The reduction is due to several reasons. First, the optimal values of BI and LI were assigned according to the traffic pattern of each station with an acceptable utilization value in order to save energy. Secondly, both the BI and LI values are longer than the minimum value of BI by more than five times.

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