ISSN : 0976-8491 (Online) | ISSN : 2229-4333 (Print)

Analysis of Energy and Delay for Zigbee based Power Saving Mechanism in Mobile Devices

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Abstract
The vast advancements of upcoming new computing, communication and entertainment applications on wireless handsets, power demands are increasing rapidly day by day. Power consumption is the limiting factor for the functionality offered by portable devices that operate on batteries hence Power Saving Management (PSM) Mechanism has been widely used in WiFi devices for power saving. Each of this access points and clients has ZigBee (802.15.4) and a WiFi (802.11) interface by which regular and on demand wakeups are scheduled to minimize overall energy consumption. The proposal is to use a ZigBee assisted PSM (ZPSM) Mechanism for mobile devices to study the nature of delay and energy parameter. The sensor data is sent to each of the client through wifi or through zigbee module and received by the clients. It is observed that communication through wifi or zigbee provides more battery life than by using 3G in PSM Mechanism. This research elevates the behavior of the delay, time and data consumption with respect to battery life.

Keywords
Zigbee, Wifi, Power Saving Mechanism. Delay Analysis, Energy Patterns

I. Introduction

Wireless network connection is a fundamental feature of a mobile device. Infrastructure mode is most commonly used for networking communication devices. With this mode, the network is composed of numerous mobile devices, which are also called stations or nodes hereafter, distributed in a certain area, and an Access Point (AP). All communications are centered at the AP.

A Wi-Fi interface consumes a high level of energy in data transmitting and receiving, and a considerable amount of energy even in the idle listening state when Wi-Fi radio does not transmit or receive, but stays awake. While the energy consumed for data transmission and reception is inevitable, the major purpose of Wi-Fi power management is to reduce idle listening. The intuitive idea is to turn off Wi-Fi radio as long as possible when it is idle listening, so that the waste of energy can be minimized. However, since Wi-Fi cannot send or receive data when radio is turned off, the radio needs to be turned on appropriately in order not to lose incoming data, which poses as a challenge.

In such circumstances our idea is to study the delay and energy patterns by frequently sending the sensor data and retrieving it.

II. Methodology

Power Management for WiFi Devices usually supports two power modes. They are the power saving mode (PSM) in which the radio wakes up to receive the data packets periodically so as to reduce the duration for idle listening and also the energy consumption. The other mode is the constantly awake mode (CAM) in which data packets can be received but at the cost of high power consumption. In the simple PSM, the AP will broadcast beacon frames every beacon interval (BI); each client wakes up for every certain number of BIs, which is called listening interval (LI), to check whether it has any data packets buffered at the AP. This AP shows the presence of buffered packets by setting the Traffic Indication Map (TIM) fields in the beacon frame. If a client finds the corresponding TIM field is set, it sends a Power Save Polling (PS-POLL) frame to retrieve the buffered packets from the AP. Besides, the AP uses more bits in the data packet if any to indicate if more packets are buffered, thus helping the client to decide when to go to sleep. Parameter LI is configurable, and its setting directly influences the performance. While the WiFi interface is for data transmission the ZigBee interface is for power management. Both the WiFi and ZigBee interfaces of the AP are always awake, while the WiFi and ZigBee interfaces of clients are awaked sporadically for energy conservation. In addition to that, each client runs in either the standard PSM (SPSM) or the ZigBee-assisted PSM (ZPSM). Particularly, when a client is out of the ZigBee range (but still in the WiFi range) of the AP, it switches back by default to SPSM. The percentage of packets received with a delay below than the desired delay bound di among all incoming packets must be δi (called delay-meet ratio), where $0 < \delta i < 1$. This is the delay requirements. Here, the delay is defined as the time elapsed from the arrival of a packet at the AP to the receipt of the same packet at the destination client. For compatibility with SPSM, ZPSM clients are allowed only to retrieve packets after receiving a beacon frame as specified in the SPSM. In SPSM, we assume all clients are in synchronization with the AP and in addition, due to the unreliable link quality of ZigBee channel, ZigBee transmission can fail; and the ZigBee interface at a client might be used for many other purposes, packets transmitted by the ZigBee interface at the AP may also fail to reach the client occasionally. We use the link quality pi to represent the probability that a packet is sent by the AP from its ZigBee interface arrives at client i successfully. Noting that the value of pi might vary over time the AP is stationary while the clients mobile with relative mobility. Through minimizing unnecessary wakeups and idle listening, our design should significantly decrease the overall power.

A. Bounded Delay

Our system should satisfy the delay requirements for each client.

B. Compatibility

Our proposed system should not be against the IEEE 802.11 standards. The system must be built atop the standard PSM and further must be synchronized to the standard PSM.

III. Implementation

The percentage of packets received with a delay lower than the desired delay bound di among all incoming packets should be at least δi (called delay-meet ratio), where $0 < \delta i < 1$. This is called delay requirement. Here, the delay is defined as the time elapsed from the arrival of a packet at the AP to the receipt of the packet at the destination client. Besides, client i is called short delay (SD) client if di is smaller than two BIs; otherwise, it is called long delay (LD) client.

The AP is static while the clients can be mobile. We assume that the mobility of clients is relatively low.

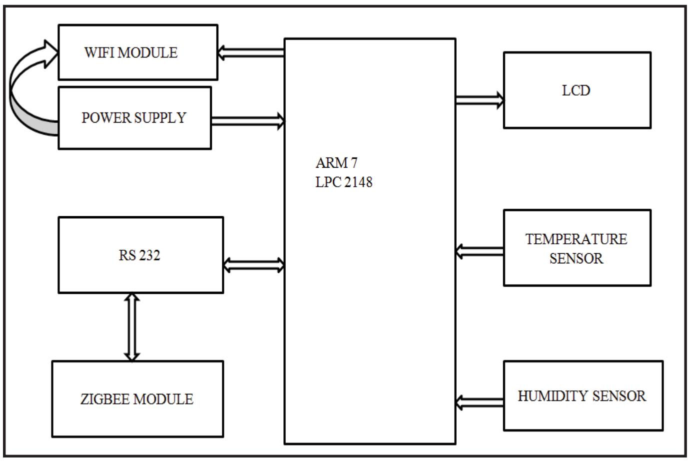

Fig. 1: Transmitter Block Diagram

The transmitter block contains wifi module which is controlled by a zigbee module.there atre two zigbee modules both at receiver and transmitter side.There are two sensors which collect data and send to wifi which is controlled by zigbee module.

To deal with ZigBee transmissions fails we assume that, once the AP sets the corresponding bit in wakeup frame, it sets the bit until the AP receives a PS-POLL (indicating the client wakes up and retrieves packets) from that client, which can be modeled as Geometric distribution. Then, for a client I with link quality pi, the success probability of any on-demand wakeup, denoted by θi, can be computed as

$$\theta i=1-(1-pi)di-B/mW \quad (1)$$

This is because any packet arriving di −B time before an on demand wakeup can be transmitted during the BI following that wakeup with a delay less than di. Therefore, the delay requirements of client I can be defined as

$$\delta i\leq(yiB-di+B)\theta i+(di-B)/ yiB \leq 1 \quad (2)$$

From Eq. (2),

We can solve yi and get $yi\geq di-B/B$ (3)

And $(\delta i-\theta i)yi\leq(1-\theta i)(di-B)/ B$ (4)

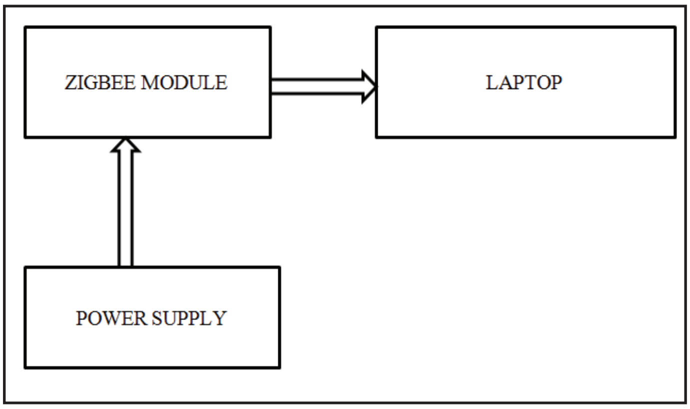

Fig. 2: Receiver Block Diagram

At the receiver side there is a zigbee module which is controlled by programming with keil software.

IV. Results and Analysis

As the microcontroller is programmed using Embedded C program, the programming is done using Keil software version 4.The hex code is dumped in an application called Flash Magic. Data can be monitored from mobile through wifi and can also be seen in Hyper terminal application for zigbee.

The baud rate setting is 9600bps and LPC 2148 is the micro controller used. The oscillation frequency is 12MHz. The temperature and humidity sensor reading are read from the sensors and are transmitted from the sensors to the clients. The clients are connected to the WiFi module. Zigbee module is used at both at transmitter and receiver to control the wifi status.

A number of clients can be connected to the wifi which is limited to 4 in this case. The wifi used is ESP8266 module.

Table 1: Power Consumption Readings Obtained

Parameters	Power Consumed
Modem-Sleep	15mA
Light-Sleep	0.9mA
Deep-Sleep	10uA
Power Off	0.5uA

The following current consumption is based on 3.3V supply. Maximum Driving Power IMAX is measured to be 12mA.Once connected by the clients the sensor data can be received to the application Term TCP. The sensor data is received to these 4 clients whenever required. Whenever the sensors data is required the data can be retrieved by sending a command, which is preprogrammed in the code itself. It can be observed that as the clients move far away the time taken to receive the data increases.

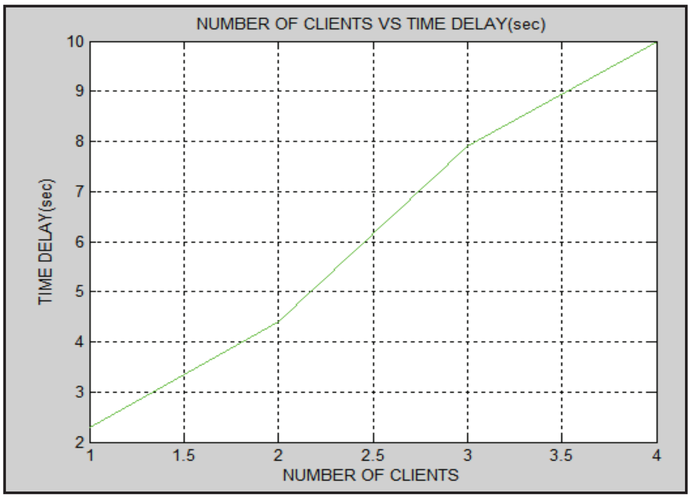

Fig. 3: Number of Clients Vs Time Delay

From the above graph we can infer that there are 4 clients connected to a single access point which is our wifi module. For the first client the data takes nearly 2 sec to receive the sensor data, the second client takes nearly 5 sec to receive the same data and the third and fourth clients take 8 and 10 sec approximately respectively. These above reading are calculated by placing client 1 nearer to AP when compared to client 4. Also as the number of clients increases the data is received slowly.

WiFi transferred 5.91 GB in download and 5.66 GB in upload in total. WiFi measurements were performed using 802.11g network with a link quality 54mbps and

With a maximum throughput of 20 Mbit/s in download and upload, while the measured throughput was 2.5 Mbit/s in download and 2.7 Mbit/s in upload.

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Table 2: Amount of Packets Transferred

Time elapsed	Transmitted packets	Received packets
16sec	1531	1840
56sec	3821	4705
1m 09sec	5661	6870
1m18sec	6290	7995
1hour 20 sec	41807	46189

The above table is for a client, as long as the client is connected to the access point the data is transmitted in the form of packets as tabulated above. Always the received packets are more than transmitted packets.

Below graph shows the WiFi upload and download with accordance to battery level. Using Wifi maximum of 7GB can be downloaded for a total battery level of 100% and 6.5GB can be uploaded. This is compared with the 3G data transfer.

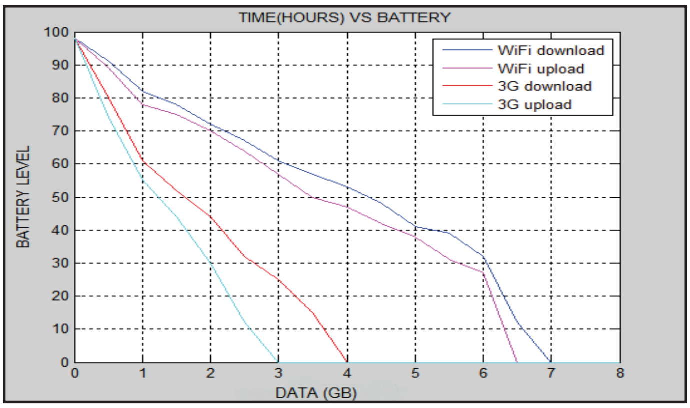

Fig. 4: Data Consumed vs Battery Level

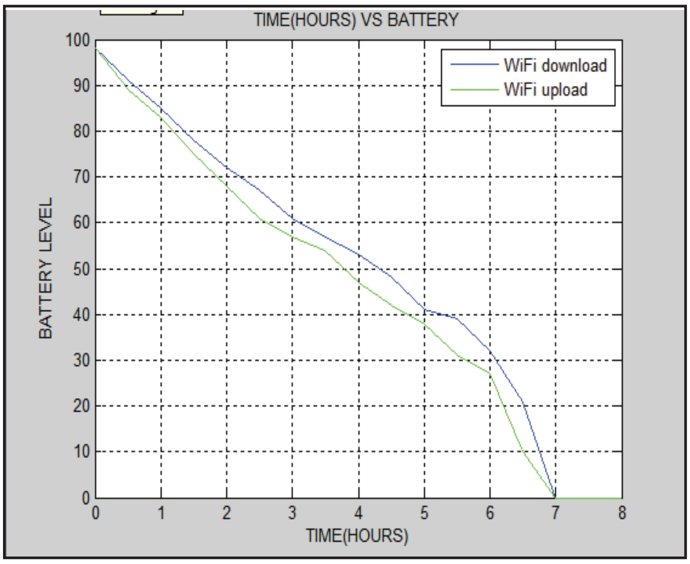

Fig. 5: Battery Level Vs Time Elapsed

In [6] Balasubramanian et al. showed that data transfer of 50 KB when using 3G needs 12.5 J, while when using WiFi the same data transfer consumes 7.6 J of energy indicating that WiFi communication technology is 39.2% more energy efficient than 3G communication technology

V. Conclusion

Hence from the above analysis we can observe that during wifi data transfer, the battery level falls gradually which indicates the power consumption. In fig. 4 we can conclude that Wifi uses more battery that 3G,giving a scope to download and upload more data. In Fig 5 Wifi can sustain upto 7 hours with continuous download and uploading of data. Our results confirmed the results obtained by previous studies. 3G communication technology is the largest consumer of energy, followed by WiFi. Although the data is retrieved from zigbee extensive study is not made in it. Hence the study can also be extended to analyze the behavior of the above parameters by transferring data through zigbee modules.

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