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Review: Power Management Schemes for WiFi Communication

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ABSTRACT: Now a days, power is a major constraint limiting wide applications of mobile and wireless sensor networks. WiFi communication consumes much energy for mobile devices where energy is limited. Power Saving Management (PSM) for mobiles have been applied in past, however, it may not deliver satisfactory energy efficiency as the wakeup strategy adopted by it cannot dynamically adapt to traffic pattern changes. Now-a-days it is very common for mobile devices to have both WiFi and other low-power wireless interfaces such as Bluetooth and ZigBee. Zigbee consumes much less energy as compared to the WiFi for communication at the same time both ZigBee and WiFi interfaces work on same band. Using these facts we propose a ZigBee-assisted Power Saving Management (ZPSM) where the ZigBee interface is used to wake up WiFi interface as required. In ZPSM the low power ZigBee radio is used to wake up asleep high-power WiFi radio for packet transmission between the AP and clients on demand thus saving energy significantly without violating delay requirements as compared to standard PSM systems in various scenarios.

KEYWORDS: WiFi, ZigBee, power saving management, energy efficiency, delay bound.

I.INTRODUCTION

For a battery-powered device, the wireless network is a significant contributor to the total energy consumption. Wireless network access is a fundamental enabling feature for many portable computers, but if not optimized for power consumption, wireless network interface can quickly drain a device's batteries. Wireless network interfaces consumes a significant amount of energy not only while sending and receiving data, but also when they are idle with their radios powered up and able to communicate. Mobile devices are increasingly equipped with multiple net- work interfaces with complementary characteristics. In particular, the Wi-Fi interface has high throughput and transfer power efficiency, but its idle power consumption is prohibitive. Among the typical network interfaces found in today's mobile devices, Wi-Fi provides arguably the best combination of throughout, range, and power efficiency for data transfers. On the downside, Wi-Fi is the least power efficient in idle state and incurs a high overhead when scanning for new networks. Thus, ideally, one should use Wi-Fi whenever it is available, switch it off when it is not, and avoid scanning whenever possible. As the ZigBee technology becomes more and more common, low-cost embedded ZigBee interfaces have been available off the shelf and their sizes are becoming smaller and smaller.

As both ZigBee and WiFi interfaces work on the 2.4 GHz frequency band their communication can severely interference if their working channels overlap. However, if their channels do not overlap, the interference becomes insignificant. Through various experiments it is seen that when ZigBee and WiFi interfaces use non-overlapping channels, the packet delivery ratio of ZigBee communication is high (> 95%)[1] and the WiFi communication is nearly not affected, which not only motivates but also supports the idea of the co-existed ZigBee interface to facilitate the WiFi power management. A ZigBee-assisted power saving management (ZPSM) for WiFi is a upcoming scheme, aiming to deliver energy efficiency with bounded packet delivery delay. The key idea is to use the low-power ZigBee radio to dynamically wake up asleep high-power WiFi radio for packet transmission between the AP and clients. Unlike the standard PSM, ZPSM system has a wakeup strategy which is adapted to both packet arrival rate and delay requirements in order to maximize energy efficiency. Moreover, ZPSM is built atop the standard PSM, and thereby, requires no change to the WiFi standard.

II. LITERATURE SURVEY

Numerous work has been conducted to improve WiFi energy efficiency in mobile devices, especially for web browsing applications. The systems proposed to minimize the energy consumption with bounded slowdown. To reduce the congestion at the AP and thus improve the performance of the standard PSM, an opportunistic PSM was proposed to allow one download at any time. One common shortcoming of these schemes lies in that, their savings largely depend on the accuracy in predicting client network usage patterns, because they are not able to wake up asleep clients at will without the assistance of additional interfaces. Thus, their performance is limited

1. Bounded Slowdown:- To overcome the problem of increasing fast round trip times (RTTs) and unnecessarily spending the energy waking up during long idle periods, this technique presents the Bounded- Slowdown (BSD) protocol, a PSM that dynamically adapts to network activity. BSD is an optimal solution to the problem of minimizing energy consumption while guaranteeing that a connection's RTT does not increase by more than a factor over its base RTT, where is a protocol parameter that exposes the trade-off between minimizing energy and reducing latency. As compared to a static PSM, the Bounded-Slowdown protocol reduces average Web page retrieval times by 5.64%, while simultaneously reducing energy consumption by 1.14% (and by compared to no power management) [2].

2. Blue-Fi:- Blue-Fi system predicts the availability of the Wi-Fi connectivity by using a combination of bluetooth contact-patterns and cell-tower information. This allows the device to intelligently switch the Wi-Fi interface on only when there is Wi-Fi connectivity available, thus avoiding the long periods in idle state and significantly reducing the number of scans for discovery. The prediction results on traces collected from real users show an average coverage of 94% and an average accuracy of 84%, a 47% accuracy improvement over pure cell-tower based prediction, and a 57% coverage improvement over the pure bluetooth based prediction. For the workload, Blue-Fi is up to 62% more energy efficient, which results in increasing our mobile device's lifetime by more than a day [3].

3. Cooperative Clustering Protocol:- It is a novel energy saving approach that exploits the multiradio feature of recent mobile devices equipped with WLAN and Bluetooth interfaces.It is based on clustering. Here, a cluster is a Bluetooth Personal Area Network (PAN), which consists of one cluster head and several regular nodes. The cluster head acts as a gateway between the PAN and the WLAN, enabling the regular nodes to access the WLAN infrastructure via low-power Bluetooth. Cooperative Networking protocol (CONET) is a distributed clustering protocol, which dynamically reforms clusters according to each node's bandwidth requirement, energy use, and application type. CONET does not require modifications of existing wireless infrastructures because clustering is performed independently of WLAN access points. CONET can be simulated for large networks of more than 100 mobile nodes. The approach is effective in reducing the power consumption of WLAN [4].

III.SYSTEM MODEL AND ASSUMPTIONS

The WiFi interface is for data transmission while the ZigBee interface is for power management. The WiFi and ZigBee interfaces of the AP are always awake, but the interfaces of clients are awake intermittently for energy conservation. In addition, each client can run 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 defaults to SPSM. Each client i has a desired delay bound for downlink packet transmission. Specifically, 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 $0 < \delta i < 1$.[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. As with the SPSM, we assume all clients are time synchronized with the AP. In addition, due to the unreliable link quality of ZigBee channel, ZigBee transmission may fail; also, as the ZigBee interface at a client may be used for other purposes, packets transmitted by the ZigBee interface at the AP may fail to reach the client occasionally. Some of the assumptions are made such as Uplink data traffic (i.e., data traffic from clients to the AP) and the data traffic to/from CAM clients are not considered. Downlink data packets for each client arrive at the AP following the Poisson process. Ideal WiFi channel conditions, meaning no packet loss, are assumed. The packet delay due to contention can be either negligible or constant. The size of all data packets is the same. The system is not saturated and no packet is dropped due to overflow of the queue. Thus, the buffered packets for clients will be eventually sent.

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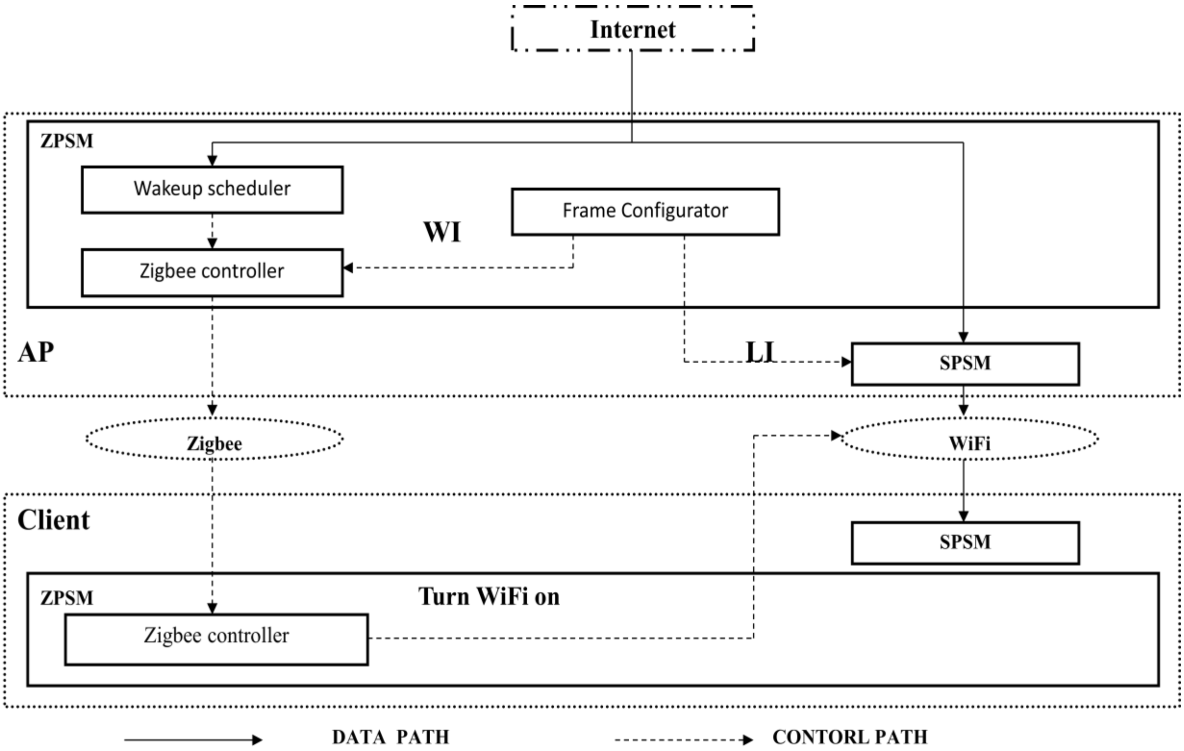

Fig. 1 System Structure

The fig.1 [1] shows the basic working of the proposed system. It contains following blocks that dynamically adjusts the regular and on demand wakeups of WiFi interfaces:-

1. FRAME WORK CONFIGURATOR:- The framework configurator periodically decides Listening Interval (LI) and Wakeup Interval (WI) for each client and the Access Point (AP) respectively.
2. WAKEUP SCHEDULER:- Based on the framework of frame work configurator, the wakeup scheduler dynamically schedules an on-demand wakeup (called wakeup dynamics) for minimizing energy consumption, if a client cannot meet the delay bound of its incoming data packets through regular wakeup.
3. ZIGBEE CONTROLLER**:-** Finally, the ZigBee controller component, implemented on both Access point (AP) and client sides, is responsible for exchanging control messages and waking up client at scheduled BIs.
4. STANDARD POWER SAVING MANAGEMENT (SPSM):- SPSM block works on a standard power management scheme by waking up the WiFi interface at regular interval.

IV. PERFORMANCE COMPARISON

A general study of the communication protocols shows that the WiFi interface consumes 20 to 30[1] times more energy than the ZigBee interface. The energy consumption of both WiFi and Zigbee increases as delay bound becomes smaller. Also if the link quality gets better the energy consumption for WiFi as well as ZigBee interfaces decreases. A basic comparision between the communication protocols; WiFi, Bluetooth, ZigBee is shown in the table 1 given below.

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Specifications	WiFi	Bluetooth	ZigBee
IEEE std.	802.11a/b/g	802.15.1	802.15.4
Frequency band	2.4 GHz; 5GHz	2.4 GHz	868/915 MHz; 2.4 GHz
Range	100m	10m	100m
Transmission power	15-20 dbm	0-10 dbm	0 dbm
Channel bandwidth	22 MHz	1 MHz	0.3/0.6 MHz; 2 MHz

Table 1 Comparison between communication protocols

As we can see in the table 1 WiFi has the highest range for communication. But also it has the highest transmission power. On the other hand Bluetooth and ZigBee both have less transmission power as compared to WiFi. The comparison shows that only ZigBee can match the range of WiFi since bluetooth range is only 10 m. Also WiFi and ZigBee work on the same frequency band which helps operating them in same device.

V. RESULT AND DISCUSSION

The block diagram shown in the Fig.1 shows a advanced power saving manegement scheme using ZigBee for assisting WiFi to saving power to a large extent. It basically removes the ideal waiting time of WiFi which consumes a lot of battery. Secondly the ZPSM adopts to the dynamic traffic pattern changes. So it is much smater than Standard Power Saving Management (SPSM). The comparison shown in table 1 concludes that ZigBee is more compatible in terms of range and power to WiFi as compared to Bluetooth. The graph shown below, Fig. 2 plots the portion of energy that WiFi and ZigBee interfaces consume. Generally, in our simulated scenarios, the WiFi interface consumes the energy that is 20~38 times more than the ZigBee interface does. As delay bound becomes smaller, both WiFi and ZigBee interfaces consume more energy due to increased wakeup overheads.

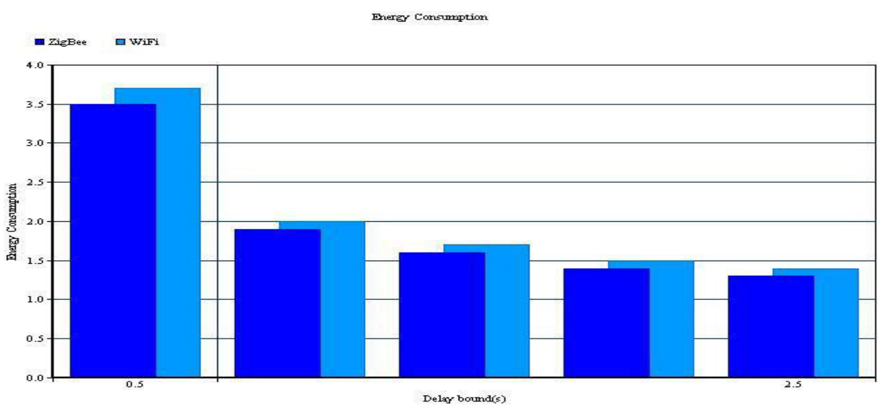

Fig 2 energy consumption WiFi vs ZigBee

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VI.CONCLUSION

The WiFi communication interface is good in terms of throughput and range but has a back drop in power utilization area. ZigBee on the other hand utilize less energy for its interface. So, ZPSM (ZigBee assisted power saving manegement) helps the device to save its power. ZPSM keeps WiFi awake for only data arrival for the rest of the time WiFi is off and ZigBee is on. Apart from saving power, ZPSM also meets the delay requirements of the device. ZigBee has a larger range than bluetooth and is also becoming available in the mobile devices. Also when ZigBee and WiFi interfaces use non- overlapping channels, the packet delivery ratio of ZigBee communication is high (> 95%) [1] and the WiFi communication is nearly not affected.

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