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EFFECTIVE ENERGY GAIN USING DETERMINISTIC POWER MODELING IN SMARTPHONE

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ABSTRACT

Despite the popularity of mobile applications, their performance and energy bottlenecks remain hidden due to a lack of visibility into the resource-constrained mobile execution environment. A collaborative relationship between the operating system and applications can be used to meet user-specified goals for battery duration. The novel profiling based approach is used for accurately measuring application and system energy consumption. By monitoring energy supply and by maintaining a history of application energy use, the approach can dynamically balance energy conservation and application quality. Wireless data transmission consumes a significant part of the overall energy consumption of smart phones, due to the popularity of Internet applications. The energy consumption characteristics of data transmission over Wi-Fi, focusing on the effect of Internet flow characteristics and network environment. The deterministic models can describe the energy consumption of Wi-Fi data transmission with traffic burstiness. Network performance metrics like throughput, retransmission rate and parameters of the power saving mechanisms are used to evaluate the battery life time. These models are practical because their inputs are easily available on mobile platforms without modifying low-level software or hardware components. The physical power measurement of applications including file transfer, web browsing, video streaming, and instant messaging are to evaluate the accuracy of energy consumption. Wireless data transmission consumes a significant part of the overall energy consumption.

Keywords : Power modeling, Wi-Fi, Smartphone, Deterministic Power Modeling, Data Transfer.

1 INTRODUCTION

Smartphones are widely used due to the popularity of Internet, and they are equipped with both Wi-Fi and cellular radio interfaces generally. In smartphone, although Wi-Fi interface is generally used for supporting higher rate data session of the smartphone itself, it can be also used to support connectivity to other nearby wireless devices with Wi-Fi interface only, such as laptop. This is achieved

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smartphone acts as an access point (AP) for nearby wireless devices using Wi-Fi interface. By using the Wi-Fi interface, nearby wireless devices transmit data to smartphone, and smartphone uses its cellular interface to deliver the data to wireless network. However, data transmission of nearby wireless devices using mobile hotspot application consumes significant battery energy of smartphone since Wi-Fi interface of the smartphone should be awaken always and data session of nearby wireless devices should be processed with both Wi-Fi and cellular interfaces of smartphone. The result of this work can be used to propose an enhanced mobile hotspot scheme by giving insight on the energy consumption. Recently, smartphones are widely used due to the popularity of Internet, and they are equipped with both Wi-Fi and cellular radio interfaces generally. Wi-Fi interface is used for supporting higher data rate services with cheap price, but the coverage of Wi-Fi is limited and no seamless handover is supported.On the other hand, cellular interface is used to provide continuous connectivity and seamless handover, although it has a higher access cost.

In smartphone, although Wi-Fi interface is generally used for supporting higher rate data session of the smartphone itself, it can be also use d to support connectivity to other nearby wireless devices with Wi-Fi interface only, such as laptop. This is achieved by mobile hotspot application of smartphones, where smartphone acts as an access point (AP) for nearby wireless devices using Wi-Fi interface. By using the Wi-Fi interface, nearby wireless devices transmit data to smartphone, and smartphone uses its cellular interface to deliver the data to wireless network. We will call the nearby wireless devices within the mobile hotspot area of a smartphone as mobile hotspot client in this paper. To act as an AP for nearby wireless devices, smartphone should awake its Wi-Fi interface always and power saving mode should not be enabled. Also, the data received from nearby wireless devices using the Wi-Fi interface of smartphone should be transmitted via its cellular interface of the smartphone, too. Therefore, significant battery energy is consumed to run mobile hotspot application. In order to reduce the energy consumption of smartphones running mobile hotspot application, a few works have been carried out recently. Although the works in analyzed the energy consumption of smartphone running mobile hotspot application, most works have been carried out via simulation and little work has been carried out for analytical modeling and performance analysis of energy consumption of smartphone supporting mobile hotspot application, to the best of our knowledge. However, the analytical mode ling on energy consumption of smartphone running mobile hotspot application is essential to analyze the effect of various parameters on the energy consumption of smartphone and propose an enhanced energy management scheme based on the performance analysis results. The result of this work can be used to propose an enhanced mobile hotspot scheme by giving insight on the energy consumption.

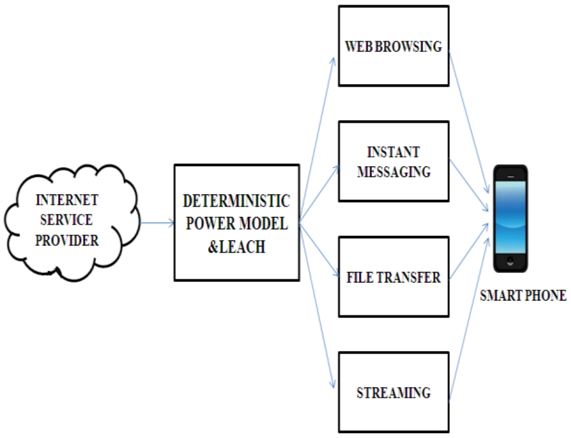

Fig 1.1 Architecture

II. Related Works

Multimedia streaming applications require continuous delivery of media traffic and they typically force a mobile device to keep its WNI or 3G interface most of the time in high power consuming *active* mode. According to Chandra et al, 802.11 power saving mode (PSM) as such is not suitable for reducing the energy consumption with multimedia streaming applications, as most of the media traffic tends to be delivered as a constant bit rate traffic which does not allow the network interface to efficiently enter the *sleep* state in between packets.

In case of 3G, there are so called inactivity timers which control the transition of the interface from high-power active states to lower-power idle states. These timers have usually rather long values which prohibit the interface from entering lower power states while receiving a multimedia stream. A simple proxy-based solution for reducing the energy consumption of mobile devices while using an audio streaming application which we call Internet radio from here on.

In order to develop energy-efficient networked applications on smart phones, the developers need to know the factors that affect the energy-efficiency in wireless data transmission and to be able to evaluate the joint effects of these factors on battery life. Only current samples alone are sufficient to determine the energy usage of the system. The battery is removed from the laptop while measurements are taken to avoid extraneous power drain caused by charging.

III. Scope and Outline of the Paper

The basic idea is to estimate the energy consumption of hardware components with the help of pre-defined state machines. The inputs of our models, mainly the traffic statistics such as the burst durations and sizes, are accessible without modifying low-level hardware or software components. Due to limited space, we use the more complex TCP transmission in model evaluation. Presenting simple and practical power models of Wi-Fi data transmission based on Internet flow characteristics and network environment context. Evaluating the proposed power models through thorough empirical experiments on various mobile platforms and in different network environments.

The newly proposed test cases cover the scenarios where the data is delivered in regularly repeated bursts as often seen in streaming applications, as well as the scenarios where the data is delivered in bursts with random sizes and intervals as seen in web browsing and instant messaging.

Build Power State Machine

The power state machine of a hardware component includes the state transitions defined by the power saving mechanisms in use. An 802.11 WNI has three default operating modes, namely, TRANSMIT, RECEIVE and IDLE. The 802.11 PSM introduces another operating mode called SLEEP. When the WNI stays in the SLEEP mode, the WNI only wakes up at a granularity of beacon intervals (e.g. 100ms) to check for incoming traffic. As a result, it costs much less energy than in any other mode. However, it may cause performance degradation, because the traffic that arrives between beacons is either buffered at the access point or simply dropped if the buffer overflows. To solve this issue, an adaptive version of PSM, also known as PSM Adaptive, has been proposed and widely adopted in commercial products. In PSM Adaptive, after receiving or transmitting a packet, the WNI will stay in the IDLE mode for a period of time before going to sleep. The length of this period is *PSM timeout*, in which the default value varies from device to device.

Build Power Models

Power models that define variables with burst size/duration, and data rate. An Internet flow can be considered as a train of packets. The definition of traffic burst is “a burst can be defined as a train of packets with a packet interval less than a threshold θ". An Internet flow can then be divided into bins with one burst in each bin. One burst includes one or more packets, depending on the distribution of packet intervals and the value of θ.

Due to the difference in power between the TRANSMIT and the RECEIVE modes, one constraint is added to the definition of “train of bursts". A burst is a train of packets with the same transmission direction and with each packet interval smaller than the threshold θ. The burst duration TB is “the time elapsed between the first and the last packets of a burst", and burst size SB is the amount of the data sent or received during TB.

Burst interval TI is the time elapsed between the last packet of a burst and the first packet of the following burst. Bin duration T includes the burst duration and the burst interval. The use of LEACH Protocol is to minimize the interference between power states and models, in which each mode uses a different set of CDMA codes.

Downlink and Uplink Power Consumption

A downlink or an uplink flow can be divided into bins. By evaluating and aggregating the energy spent in each bin, the transmission cost of a single flow will be determined. The threshold value θ is always smaller than the PSM timeout (Ttimeout) when the PSM is enabled. This means that the transition from the idle to the sleep mode may only happen during burst intervals. Tsleep is the duration spent in the sleep mode.

During a burst interval when the value of TI is greater than that of Ttimeout, the WNI switch to the sleep mode. Bin data rate can be declared as r. The threshold rc is the bin data rate when TI is equal to Ttimeout.

Tsleep = TI − Ttimeout, when TI > Ttimeout

rc = SB TB + Ttimeout

Download and Upload Power Consumption

The TCP transmissions can be modeled as a combination of separate downlink and uplink transmissions. Let rd be the downlink data rate and ru be the uplink data rate. Take TCP download as example, rd is the data rate of downloading the files, while ru is the data rate of sending acknowledgement message. A downlink burst includes n packets and uplink bursts consists of total message acknowledgements (mACKs). The downlink burst size be Sdb and the size of one acknowledgement be Sack.

A bin should include one downlink burst and all the uplink bursts sent before the beginning of the next downlink burst. The bin duration is the duration from the first packet in the downlink burst until the first packet of the next downlink burst. The downlink and uplink bursts should not overlap.

IV. Conclusion

The Deterministic Power Model (DPM) is used to construct the power state machines and power models in smart phones. By analyzing the network flow characteristics and traffic bursts the deterministic power modeling will evaluate the power consumption of various smart phones. This model quantifies the impact of traffic patterns and network performance on the transmission cost and energy consumption mainly caused by the operations of the WNI. This model can be used for estimating the power consumption of various network applications that are implemented with multiple TCP/UDP flows. In addition to deterministic power model, low energy adaptive clustering hierarchy protocol is used to reduce the total energy needed for using network based applications such as web browsing, instant messaging.

The future work is to improve the accuracy and energy efficiency of smart phones while using internet applications like file transfer (download or upload) and used.

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