Can we reduce Wi-Fi Energy Consumption during VoIP calls?

Vinod Namboodiri, Lixin Gao
Department of Electrical and Computer Engineering
University of Massachusetts, Amherst
{vnambood, lgao}@ ecs.umass.edu

ABSTRACT

In this paper we examine if any energy savings are possible by letting the Wireless LAN interface transition to sleep mode during a VoIP call considering the real time nature of voice. Using our proposed energy saving algorithm GreenCall, we show that it is possible, and quantify the possible savings through both empirical and trace based simulation experiments.

1. INTRODUCTION

Making Voice over IP (VoIP) calls over Wireless LANs (WLANs) is a common option provided by emerging dual mode phones/devices like the Apple iPhone and RIM Blackberry, among others. The main driving factors behind behind this shift from a single cellular mode to dual cellular/WLAN mode in these devices are (i) The cost-effectiveness of making VoIP calls over the Internet through WLANs compared to cellular networks, and (ii) The lack of coverage of the cellular network in many indoor and some outdoor areas, especially where users spend a significant amount of their time like in the office or home.

The caveat, however, with VoIP over WLANs is that now energy drain from the batteries of the devices used becomes an issue, and we require means to conserve it. An active or even idle wireless network interface (WNIC) is a significant drain on the typically energy constrained devices that will be used for VoIP calls over Wireless LANs. A good example is provided by the specifications of Apple's iPhone [1]. It has a talk time of 14 hours over the cellular network with WLAN interface off. When the WLAN interface is also on, the talk time is reduced to only 8 hours. With very light web browsing and accessing email over the WLAN once every hour, the talktime is reduced to 6 hours. If the iPhone were subjected to VoIP calls, it would further significantly reduce the talktime due to the much heavier workload imposed on the radio.

It is obvious that with applications like web browsing and NFS there is great potential to save energy by letting the WLAN radio sleep periodically due to high tolerable latencies (order of seconds) or infrequent traffic [2, 3]. However, it is not clear how much benefit this approach can provide with continuous, real time applications. VoIP has tolerable latencies of the order of only hundreds of milliseconds and any greater delay adversely affects the quality of the user's call. VoIP calls are characterized by continuous packet communication with small milli-second intervals. This constant communication of packets during these calls would also keep the radio awake. In this paper we explore if any savings are possible from a software perspective and address the issue of how to reduce energy consumption due to the WLAN interface during a VoIP call while preserving the quality within acceptable levels. Such a software solution would work with legacy hardware and complement any advances through hardware solutions.

2. APPROACH

Power Saving Strategy The IEEE 802.11 Power Save Mode (PSM) offers a simple way to save energy of the wireless interface without any additional hardware or software changes required. Using the Access Point (AP) for assistance obviates the need for any supplementary devices to reduce the energy consumption of the WNIC. The client (device that is running GreenCall to save energy) configures sleep periods to use with PSM through the call. Packets coming from the peer (device used on the other end of client) are buffered at AP until the client wakes up. This enables energy savings without packet losses.

Problem Statement Consider a user specified target loss rate LR for packet arrivals throughout the VoIP call. A packet is lost either in the network during traversal or if it misses the playout deadline. The playout deadline is based on a specified tolerable latency of voice to the user. Let $\Gamma = \{\gamma^1 \cdots \gamma^n\}$ be the set of sleep times

CoNEXT'07, December 10-13, 2007, New York, NY, U.S.A.

used by the client with PSM, with n being the number of times it transitions to sleep mode during the call. The constant parameters of the application like packet generation interval, encoding and packetization delay at sender and decoding and playout delay at the receiver are assumed known. The input variables of the problem are the network latencies of all packets from the peer to the client and all packets from client to the peer. At a certain instant during the algorithm's execution, only (estimated) latencies of those packets are known which have already been received by that time. Moreover, the client will need to rely on feedback from the peer to get information about latencies incurred by packets it sends and the loss rate at peer[1]. The problem we need to solve is:

Find Γ *that the client should use with PSM through the duration of call that minimizes energy consumption while keeping the total loss rate less than LR at each end of the session.*

Algorithm Overview GreenCall looks at each packet as it comes in, and calculates the spare time it has before its playout deadline expires based on the known tolerable latency. This known spare time of previous packets is then used to come up with sleep periods in the future to be used with PSM. Since, the latency of the network is typically variable, the sleep periods thus chosen take into account variability in the past through a sliding window of previous spare times. The size of this sliding window is chosen in relation to the current loss rate so that at higher loss rates more history information is used resulting in conservative sleep periods. This enables a smooth tradeoff between loss rate and energy savings and is the main feature of the algorithm. To ensure that the client's radio stays in sleep mode when its VoIP application is generating packets, we buffer these packets till the end of the sleep period and send them immediately thereafter.

3. EVALUATION

For our evaluations we use a tolerable latency for each packet to be 250 ms with other constants like encoding, decoding, packetization and playout taking 50 ms [4]. The target loss rate LR was specified as 3%. The nodes at remote locations were chosen from the PlanetLab network of nodes.

3.1 Empirical

For this experiment we exchange 160 byte UDP packets at both 30 ms intervals between the client and peer[2] equivalent to a 12 minute VoIP call. The GreenCall algorithm was run at the client side laptop and energy was measured using built-in instrumentation on linux

Empirical Savings through GreenCall

Avg. RTT (ms)	Energy %	Loss %	
		Client	Peer
99	51.7	0.10	0.26

distributions. The Intel PRO 2200 b/g card was used for this experiment. The IEEE 802.11 standard however mandates that the sleep period can be specified in multiples of the beacon interval (BI) only, which is usually 100 ms. That is, PSM sleep period cannot be configured to just any value. This restricts the algorithm to put the radio to sleep only if it deems packets have at least 100ms spare time before playout. This was the case for the two end points considered with the client situated at UMass Amherst and the peer at UC Berkeley, with a separation of 18 hops. Hence, we see significant energy savings with low loss rate as shown.

3.2 Trace Driven Simulations

Here we show the possible energy savings if the PSM sleep parameter were configurable to any value[3] through trace based simulations to nodes at different geographic points[4] from UMass Amherst. This opens up possibilities of energy savings between end points separated by larger network delays (for e.g. those separated by larger geographic distances) as well and not limited to those which can overcome the 100ms 'barrier' explained above. The algorithm delivered negligible savings only for trace no. 5 where the large network delay forced very small sleep periods to be used to avoid missing playout deadlines. The larger loss rate also forced GreenCall to be more conservative.

Possible Energy Savings with GreenCall

To	Avg. RTT (ms)	% Energy	% Loss	
		Client	Client	Peer
S1, USA	99	68	0.13	0.51
S2, Poland	127	70	0.03	0.10
S3, Brazil	179	67	0.01	0.27
S4, China	255	53	0.02	0.12
S5, India	320	4	2.88	1.85

4. REFERENCES

[1] Apple iPhone Technical Specifications. `http://www.apple.com/iphone/specs.html`

[2] M. Anand, E.B. Nightingale and J. Flinn. Self-Tuning Wireless Network Power Management, *ACM MOBICOM* 2003.

[3] R. Krashinsky and H. Balakrishnan. Minimizing Energy for Wireless Web Access with Bounded Slowdown *ACM MOBICOM* 2002.

[4] ITU-T Recommendation G.109. Definition of categories of speech transmission quality, 1999.

[1]It is assumed in this paper that the peer does not wish to save energy and is not running GreenCall.

[2]These are typical values for VoIP codecs

[3]This can be done with a simple modification to the existing standard by decoupling transition to sleep from the BI.

[4]S1 is planetlab4.millennium.berkeley.edu, S2 is planetlab1.ci.pwr.wroc.pl, S3 is planetlab2-saopaulo.lan.redclara.net, S4 is plab1.cs.ust.hk and S5 is planet1.cdacb.ernet.in