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David McMullin
Dublin City University, david.mcmullin@dcu.ie

Ramona Trestian
Dublin City University, ramona@eeng.dcu.ie

Gabriel-Miro Muntean
Dublin City University, munteang@eeng.dcu.ie

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Power Save-based Adaptive Multimedia Delivery Mechanism

David McMullin [1], Ramona Trestian [1], Gabriel-Miro Muntean [1]

[1] Performance Engineering Laboratory
School of Electronic Engineering,
Dublin City University, Ireland
david.mcmullin@dcu.ie, {ramona, munteang}@eeng.dcu.ie

Abstract

The use of mobile computing devices has become more and more common as such devices have become more and more affordable and powerful. With increases in throughput speed and decreases in device size, wireless multimedia streaming to battery powered mobile devices has become widespread. However, the battery power has not kept up with the advances in technology and has not increased so rapidly. This deficiency in battery power provides motivation for development of more energy efficient multimedia streaming methods and procedures. As such, an adaptive delivery mechanism is proposed to take into account the various drains on battery life and adjust rates appropriately when the battery is low. This paper proposes a Power Save-based Adaptive Multimedia Delivery Mechanism (PS-AMy) which makes a seamless multimedia adaptation based on the current energy level and packet loss, in order to enable the multimedia streaming to last longer while maintaining acceptable user-perceived quality levels. The proposed mechanism is evaluated by simulation using Network Simulator (NS-2).

Keywords: power, battery, energy-consumption, adaptive multimedia

1 Introduction

As the demand for multimedia streaming services increases, mobile users expect rich services at higher quality levels on their wireless devices. Currently on the market there are a multitude of mobile devices, from laptop computers to most PDAs to smart phones (like the iPhone), capable of receiving and playing high quality multimedia streams. As processor speed continues to increase and memory size and cost decrease, more and more mobile devices will have multimedia reception abilities. Mobile devices rely on batteries as a power source, however the energy costs of multimedia applications and their wireless reception are high and batteries have not advanced as quickly as processors and memory [1].

In this context (see Figure 1) the main challenge for this high volume real time service, is to enable the multimedia stream to last longer by reducing the battery power consumption and maintaining acceptable user-perceived quality levels.

In this paper we propose a novel **P**ower **S**ave-based **A**daptive **M**ultimedia Deliver**y** Mechanism (PS-AMy) which makes seamless multimedia adaptation based on the current energy level and packet loss. The aim of the new mechanism is to enable the multimedia streaming to last longer and at the same time to make efficient use of the wireless network resources. PS-AMy maintains acceptable user perceived quality levels for video streaming applications in wireless networks and reduces the battery power consumption.

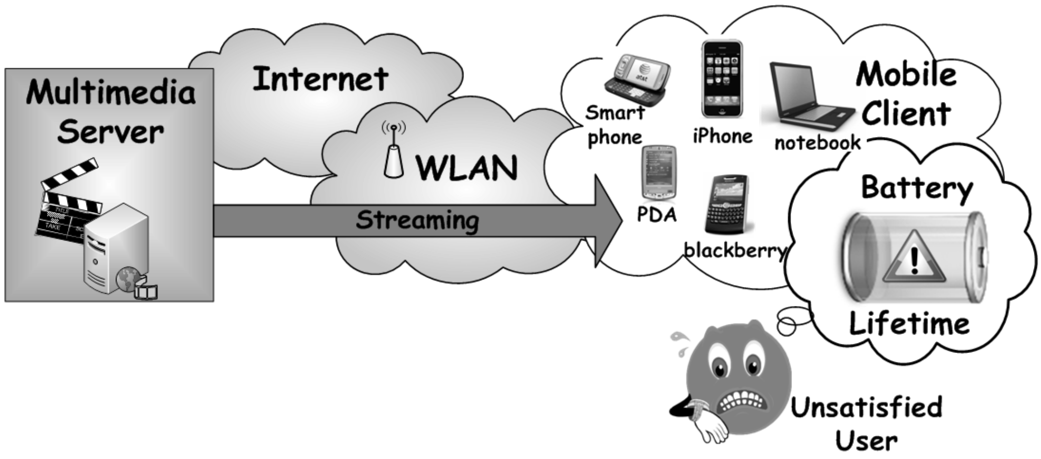

Figure 1. Example scenario: Existing Problem

The rest of the paper is structured as follows: in section 2 the related work is summarised, section 3 presents the proposed architecture, while section 4 explains the principle of PS-AMy. Section 5 details the simulation setup and presents testing results. Section 6 includes discussion and interpretation of the results and finally, concluding remarks and future work details are given in section 7.

2 Related Work

There is a variety of work available on the subject of energy consumption in mobile devices and energy efficiency for various applications including multimedia streaming.

2.1 Multiple Stage Savings

In terms of energy consumption in mobile devices, Adams and Muntean [2] document the energy costs incurred by reception, stream decoding, speakers and screen backlight. They propose an adaptive buffer mechanism for increasing time spent in the sleep state without changing the current IEEE 802.11 standard. Their algorithm incorporates savings at the reception, decoding and playback stages of multimedia streaming. They find that the greatest savings can be made at the reception stage and that considerable savings are possible with a comprehensive adaptation system controlling all elements including reception, encoding rate and playback.

2.2 Decoding Stage

Pakdeepaiboonol and Kittitomkun [3] present a solution for power saving in the decoding stage by reducing the number of memory/bus accesses through high level language optimization. However, this solution is limited to ARM (Advanced RISC Machines) devices and its high level nature makes adaptation and application specific rollout difficult.

2.3 Playback Stage

Not such a large amount of work has been done on saving energy at the playback stage. Shim et al. [4] propose a backlight management scheme for TFT LCD (Thin-Film Transistor Liquid Crystal Display) panels. Their scheme, called Extended DLS (Dynamic Luminance Scaling), compensates for loss of brightness or contrast respectively dependant upon the current energy budget. This makes for an energy saving when the power budget is low by adapting the contrast but not the backlight.

2.4 Energy Models and Energy Simulation

Palit et al. [5] discuss energy models and the use of energy states. In particular they examine the energy lost in transition between the idle and the sleep state. Due to this cost, there is a threshold sleep time, beneath which no energy saving and possibly even an energy loss is made by entering the sleep state.
Fujinami et al. [6] have developed an implementation of legacy power save functions defined within IEEE 802.11 for Network Simulator 2, allowing the user to test standard power save functions with the linear energy model implemented within NS2.

3 PS-AMy Architecture

PS-AMy bases its adaptation decision on energy level and packet loss. PS-AMy is distributed and consists of server-side and client-side components, as shown in Figure 2. On the Server side the multimedia streaming content can be encoded at five different quality levels, from lowest (level 1) to highest (level 5). The server adjusts the data rate dynamically based on the feedback received from the Client.

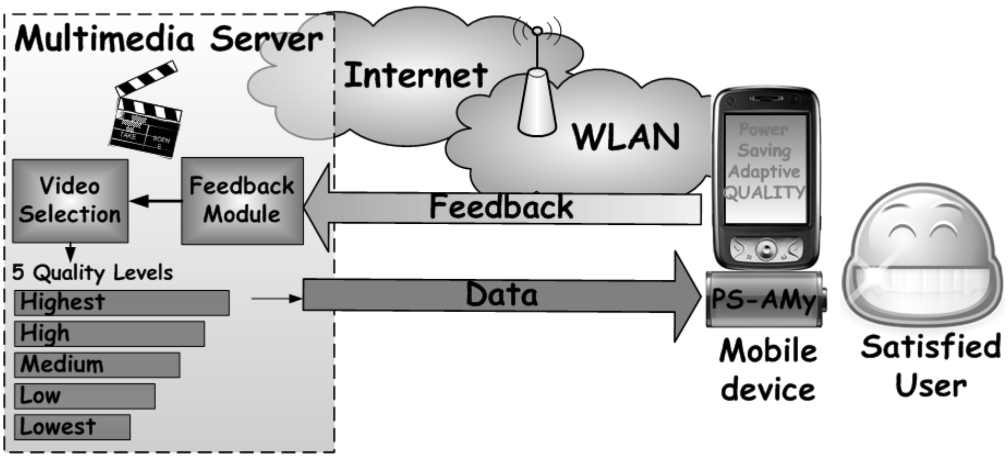

Figure 2. System Architecture

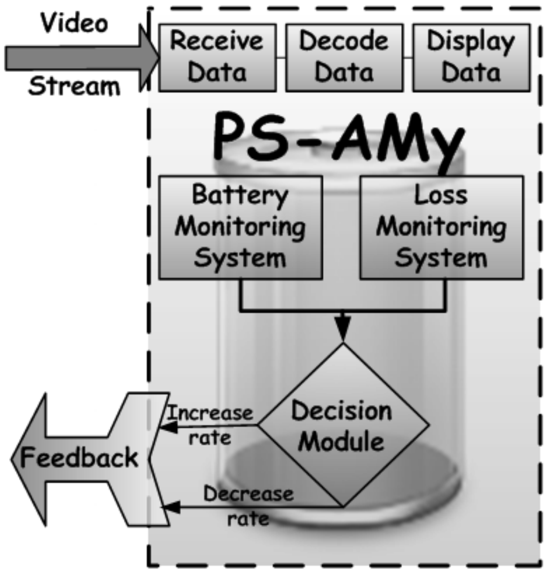

Figure 3. PS-AMy Architecture

The principle behind PS-AMy is illustrated in Figure 3. The role of the Battery Monitoring System is to measure the current energy level. The role of the Loss Monitoring System is to monitor the network traffic and to trigger the Decision Module on detection of packet loss. Based on this information, the Decision Module decides whether to increase or decrease the rate and sends feedback to the server.
At the Server side, the Feedback Module (see Figure 2), receives the feedback from the client and sends the new quality level to the Video Selection module which will change the quality level of the multimedia stream and streams the corresponding video back to the client. The client will receive, decode and display the new data.

4 Principle of PS-AMy

As stated before PS-AMy bases its adaptation mechanism on the energy consumption level and packet loss. The current energy level dictates the maximum encoding rate while the rate is adjusted between the minimum and the maximum based on loss. When no packet loss occurs, the encoding rate is increased, while packet loss results in a halving of the rate. The adaptive algorithm works as shown in Figure 4.

Initialization

- *request instantaneous measured energy level - El*
- *compute threshold: θ1, θ2, θ3, θ4*
- *monitor the network traffic*

Define Maximum

if *θ1 > El >= θ2* **then** *max = level 5*
if *θ 2 > El >=θ3* **then** *max = level 4*
if *θ3 > El >=θ4* **then** *max = level 3*
if *El < θ4* **then** *max = level 2*

Decision making

if *loss detected* **then**
decrease quality level by half
minimum quality level being 1
if *no loss detected* **then**
increase quality level by 1
maximum quality level being "max"

Figure 4. Energy-based Adaptive Algorithm

5 Simulation Setup and Test Results

In this section the simulation setup and the scenario used to evaluate the proposed PS-AMy are described. PS-AMy was implemented in NS-2 for testing purposes.

5.1 The Network Simulator NS-2

For the simulation, NS-2 version 2.33 [7] was used. NS-2 is a discrete event simulator targeted at networking research.
The NS-2 interface involves writing scripts in OTcl which define node positions, movements and wired connections; application and traffic type and when traffic should stop or start. PS-AMy is coded in C++ and integrated into the simulator. The trace output file was filtered for useful information such as throughput, loss and jitter. Another two patches were integrated in the simulator.

5.1.1 The Wireless Update Patch

The wireless update patch by Fiore et al. [8] groups several updates to NS-2 in order to improve the support for wireless networks, such as:
- a patch by Wu Xiuchao which implements realistic channel propagation by adding the effects of different thermal noises and accounting for the different Bit Error Rate (BER) to Signal to Noise plus Interference (SINR) curves for the various coding schemes employed.
- two patches by Fiore which implement multiple data transmission rates support and Adaptive Auto Rate Fallback (AARF). AARF allows each wireless node to adjust its rate of transmission toward each station it is transmitting to using a rate adaptation algorithm. This allows for simulation of different encoding rates and the implementation of a rate choosing algorithm.

5.1.2 No Ad-Hoc Patch

The No Ad-Hoc (NOAH) [9] routing agent is a wireless routing agent that allows infrastructure mode communication between nodes through the Access Point (AP).

5.2 Simulation Scenario and Test Results

The simulation evaluated in this experiment is illustrated in Figure 5. While on the move from Location A to Location B the user is watching a multimedia video stream on his/her mobile device. The video data is streamed from a Multimedia Server on the wired network to the user's mobile device through an Access Point (AP). At the Multimedia Server a five-minute long multimedia clip is stored at five difference encoding rates. The following encoding rates were considered:

- Rate1 – 0.5Mbps
- Rate2 – 0.75Mbps
- Rate3 – 1.0Mbps
- Rate4 – 1.5Mbps
- Rate5 – 2.0Mbps

The simulation is run in the 802.11b environment and the test runs for 330 seconds. The mobile user node moves at a walking speed of 0.9 m/s. An initial battery level of 30 kJ was used and the rates of energy spending in the idle, sleep, transmission and reception states are 40 W, 14 W, 280 W, 204 W respectively, modelled on the energy parameters of the Lucient WaveLan PC card [10].

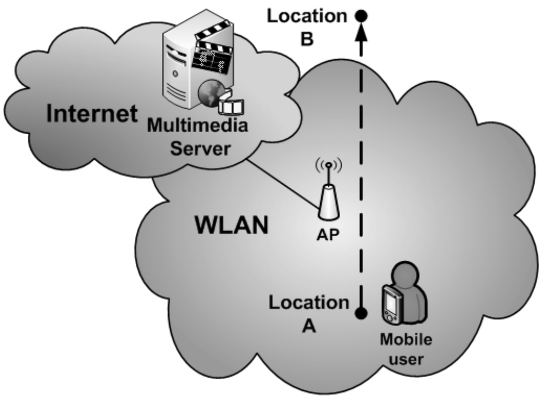

Figure 5. Simulated network topology

The mobile user is moving in a straight line towards, then further away and finally out of range of the AP. The results show that the energy spent on reception is greater at greater distances from the AP. Simulations showed that as energy was spent and the rate was lowered, energy spent on reception decreased while energy spent in the idle state increased, though to a much lesser extent, resulting in a net energy saving as illustrated in Figure 6.

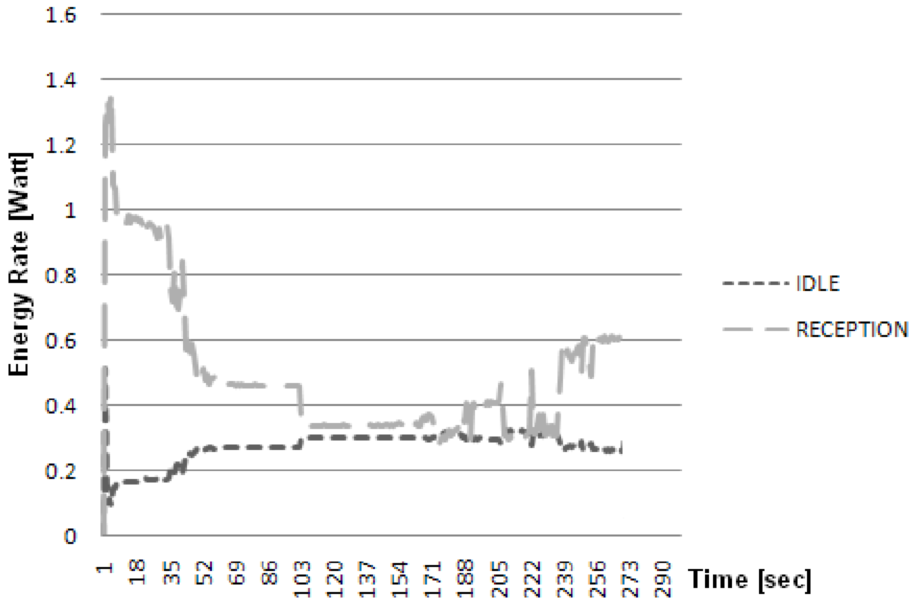

Figure 6. Energy rate spent in idle and reception states when using PS-AMy

The proposed mechanism was compared in terms of battery lifespan, average throughput and average loss with the simple streaming model and a Constant Bit Rate (CBR) stream. The simple MultiMedia streaming model (Standard MM) did not incorporate any adaptation. In both cases the encoding rate used was 2Mbps, the highest quality level considered by PS-AMy. The results are presented in Table 1 and Figure 6. The results show that although it yields a lower throughput, the proposed adaptive scheme is more energy efficient and gives a reduction in loss.

	CBR	Standard MM	PS-AMy	% of PS-AMy	
	Total	Total	Total	CBR	Std MM
Battery Lifespan (s)	239	262	312	76	84
Av. Throughput (Mbps)	0.6642	0.49954	0.446933	112	149
Av. Loss (%)	17.1	29.6	11.5	147	253

Table 1: Results when streaming over wireless network

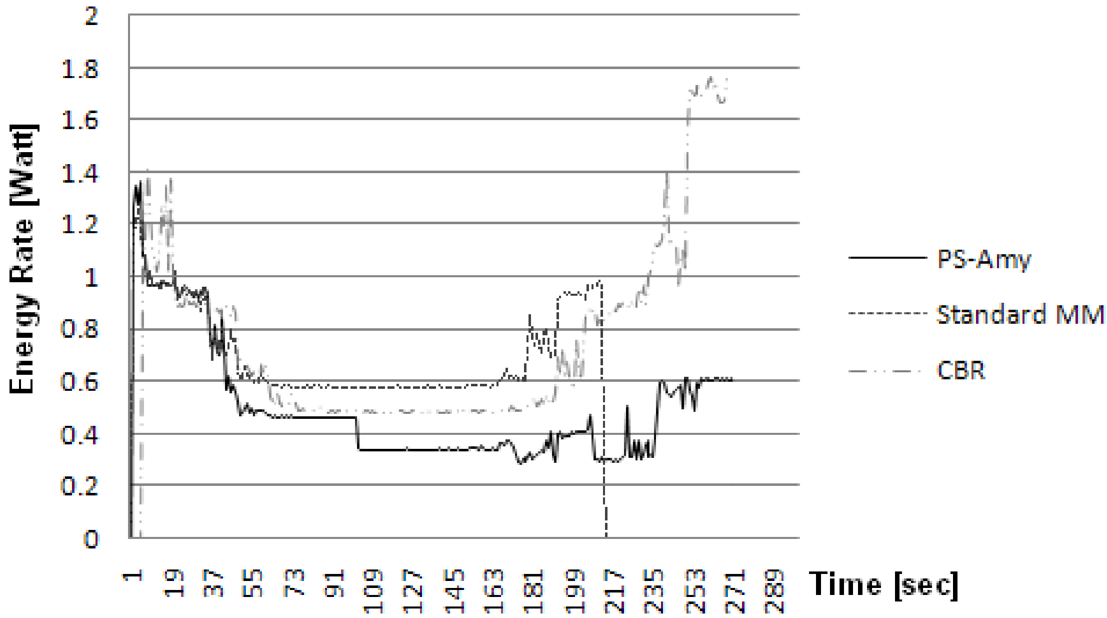

Figure 7. Energy rate spent on reception by CBR, Multimedia and PS-AMy traffic (Standard MM node ran out of energy at time 212)

6 Discussion and Reflection

The results in Figure 7 and Table 1 clearly show there are gains to be made using this system. In particular, the algorithms performance in delivering extra battery life and keeping loss to a minimum should be noted.

In Table 1 it can be seen that although PS-AMy delivers a lower throughput, it also suffers from loss considerably less than the other two systems. This can only result in an increase in user perceived quality. However further research should be performed to consider real world situations in order to complement modelling and simulations.

Figure 7 clearly shows PS-AMy consistently delivers a significantly lower rate of energy spending. In particular, PS-AMy succeeds in regulating energy consumption even as the node moves further away from the Access Point. In similar conditions the amount of energy needed to support communications increases when both other systems are used. It should be noted that this improvement is mainly due to lowering the encoding and delivery rates, resulting in possible reduction of multimedia quality (depending on device screen size).

7 Conclusions and Future Work

In this paper a novel Power Save-based Adaptive Multimedia Delivery Mechanism (PS-AMy) which bases decisions on the energy level and packet loss in order to enable the multimedia streaming to last longer, was proposed.

This project concentrated on adapting the encoding rate of multimedia streaming meaning less data to transmit and therefore resulting in lower energy costs incurred by reception and decoding, however there are many other energy costs which could be tied into an adaptive mechanism. Playback settings such as volume, brightness and colour depth could be adjusted to save energy, although care should be taken in this regard that the adjustment is within reasonable bounds and unlikely to disturb the user.

As the rate of energy loss in the idle state is generally not hugely less than that spent in reception, a sleep buffer could be introduced, and adjusted when necessary to maximise energy savings.

While this project showed promising results within simulations, further testing and work should be done with real world testing of the application.

Work in this area is highly relevant today as the energy costs of applications continue to rise while battery life struggles to keep up. As the solution explored in this project is software based, it could be easily deployed and tested, as opposed to a hardware solution.

8 Acknowledgements

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