Energy-Aware Adaptation for Mobile Applications

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Outline

- PowerScope
- Odyssey
- Energy Savings Through Adaptation
- Display-Energy Usage Reduction
- Achieving Desired Battery Life
PowerScope

- Provides procedure-level energy-consumption measurement
- Uses digital multimeter for current measurement.
- Log (PC,PID) samples.
- Processing done off-line.
The Odyssey Platform

- Supports *application-aware adaptation*.
- Monitors resource levels, notifies applications of relevant changes, and controls resource allocation decisions.
- Involves trading data-quality for resource consumption.
Odyssey

• Each application independently decides how best to adapt when notified of resource changes.

• *Fidelity* – Measure of the degree to which data at a client matches the reference copy at a server.

• Each application specifies the fidelity level it currently supports.
Odyssey Architecture
Odyssey Architecture

- Conceptually part of the OS.
- *Viceroy* – Monitors availability of resources and controls their use.
- *Warden* – Encapsulates type-specific functionality; one warden per data type in the system.
- Integrated with Linux as a new VFS layer.
Odyssey Architecture

• When resource-levels change beyond an application’s expectation, Odyssey sends it a notification via an up-call.

• Application changes its fidelity to match the new resource level and communicates its new set of expectations to Odyssey.
The Big Question

- Does operating at lower fidelity levels offer significant energy savings?
- Applications considered – video player, speech recognizer, map viewer, Web browser.
Experimental Setup

• 233 MHz Pentium IDM ThinkPad 560X Laptop with 64MB RAM, running Linux 2.2.
• Configured as an Odyssey client; communicates with Odyssey servers via 2 Mb/s wireless WaveLAN network.
• Servers – 200 MHz Pentium Pro desktops with 64 MB RAM.
Experimental Setup

• PowerScope sampling frequency – 600 times/s.
• Baseline – Highest fidelity with hardware power management.
• Hardware-Only Power Management -> No BIOS-level power management.
• Lower fidelities with hardware power management.
Video Player

- Fidelity – 1. Amount of lossy compression.
- Size of the display window.
Energy Impact of Fidelity
Speech Recognizer

Remote Janus Server

Speech Front-End

Local Janus Server

Viceroy
Speech Recognizer

• Fidelity – 1. Vocabulary size
  2. Complexity of the acoustic model

• Recognition – Local, Remote, Hybrid
  Hybrid – First pass of recognition done locally; the compact representation thus obtained is shipped to the remote server.
Energy Impact of Fidelity
Map Viewer

- Fidelity – 1. Filtering
  2. Cropping

- Filtering – Eliminates fine details and less important features
- Cropping – Preserves detail but restricts to a lesser geographic area.
Map Viewer

- Client annotates map request with desired amount of filtering and cropping.
- Server performs required operations before transmitting map to client.
- *Think Time* – Time taken by the user to absorb the contents of the map after it has been displayed.
Energy Impact of Fidelity; 5 sec
Think Time
Web Browser
Web Browser

• Fidelity – 1. Aggressiveness of lossy JPEG compression (performed by the distillation server)

• Again need to consider think time.
Energy Impact of Fidelity
Zoned Backlighting

• Backlight – Largest energy consumer

• Zoned Backlighting – Selectively control illumination in different parts of the screen.

• Can be used in conjunction with image size reduction.
Zoned Backlighting

• Screen is viewed as a grid of zones.
• Each zone can be independently controlled by the X server.
• Fidelity – No. of zones spanned by an image.
• Zoned backlighting with lower fidelity can provide 29% energy savings.
Goal-Directed Energy Adaptation

• User specifies the amount of time for which the battery is to last eg., the duration of a flight or a meeting.

• Odyssey monitors the battery energy and directs application adaptation to meet the specified duration.
Issues

• Odyssey should determine the feasibility of the specified duration and inform the user if it is infeasible.
• User should be provided with the highest fidelity possible and still be achieve the specified duration.
• The frequency of adaptations.
Steps to be Taken

- Determine the available residual energy.
- Predict future energy demand.
- Decide if applications should change fidelity and notify them accordingly.
Steps to be Taken

• Uses on-line version of PowerScope that communicates with Odyssey servers.
• Can also use ACPI calls for determining residual energy.
• Future energy demand can be calculated by using prediction algorithms like PAST and LONG_SHORT; Odyssey uses an exponential smoothing function.
Steps to be Taken

• If predicted demand exceeds residual energy, Odyssey up-calls the application to lower fidelity and vice-versa.

• When multiple applications are executing concurrently, fidelities are degraded based on user-specified priorities.