CS 525M – Mobile and Ubiquitous Computing Seminar

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Software Strategies for Portable Computer Energy Management

- Paper by Jacob R. Lorch and Alan J. Smith at the University of California
- In mobile computing, power consumption is an obvious concern
  - Battery life is not improving at the same rate as computational power.
- Computer hardware often has built in power saving features.
  - Must have software that takes advantage of the power saving modes available in hardware, and minimizes power use while making the experience as pleasant as possible for the user.
  - Three main strategy types for energy conservation:
    - Transition strategy
    - Load Change strategy
    - Adaptation strategy

Transition

- Transition strategy: The strategy used for when you switch to a low power mode.
- Need to balance performance and the needs of the rest of the system
  - Other components still use power when waiting for component to return to an “on” state
  - Don’t want to harm the users perception of the performance.

Inactivity Threshold

- Assumes the longer the period on inactivity has been, the more likely that there will be a long period of inactivity following it.
- Uses this assumption to put the device in a low power mode.
  - Example: Screen savers

Load Balancing

- Load Balancing Strategy: Changing how a device operates so that it uses less power
  - Examples: Caching data from a hard drive so that the hard drive motor can be shut down more often
  - Another Example: Storing data locally so that wireless networking card can be used less often, broadcasting common data so that the portable device does not have to broadcast a request.

Adaptation Strategy

- Adaptation Strategy: Using software to allow novel, power saving use of components
  - Example: Using a broadcast disc so that a mobile device does not need to have it’s own permanent storage.

Energy Considerations

- Need to balance the energy concerns of the entire system.
  - If other components must stay on longer to allow one component to be put in a low power state, it could cost more power
  - Different components take different amounts of power.
    - Can only save as much power as a component uses
    - Saving power with some components gives a greater gain than others.

Power Budget

Component	Hyp. 386	Duo 230	Duo 270c	Duo 280c	Avg.
Processor	4%	17%	9%	25%	14%
Hard disk	12%	9%	4%	8%	8%
Backlight	17%	25%	26%	25%	23%
Display	4%	4%	17%	10%	9%
Modem	n/a	1%	0%	5%	2%
FPU	1%	n/a	3%	n/a	2%
Video	26%	8%	10%	6%	13%
Memory	3%	1%	1%	1%	2%
Other	33%	35%	28%	22%	30%
Total	6 W	5 W	4 W	8 W	6 W

Table 2. *For various portable computers, percentage of total power used by each component when power-saving techniques are used [4, 5].*

Hard Drives

- Primary power saving mode is to stop the rotation of the hard disk platter
  - Best power saving with frequent stops
  - Problems:
    - Restarting the hard drive causes an annoying wait as the hard drive begins spinning again
    - Frequently stopping a hard drive increases the wear on the hard drive, causing the hard drive to last a much shorter time.

Hard Drive Power Consumption

Hard disk	Maxtor Mobile Max 251350	Road Warrior 815 Mbyte Slimline	Toshiba MK2720	WD Portfolio
Capacity	1.35 Gbyte	815 Mbyte	1.35 Gbyte	1.0 Gbyte
Idle power	0.9 W	0.9 W	1.4 W	0.95 W
Standby power	0.73 W	0.5 W	0.35 W	0.20 W
Sleep power	0.025 W	0.15 W	0.15 W	0.095 W
Spin-up time	1 s	5 s	5 s	6 s
Spin-up energy	4.4 J	17.5 J	19.5 J	30 J

Table 3. *Characteristics of various hard disks [12–15].*

Hard Drive Power Saving Strategies

- Most common approach: Hard drive spins down after fixed inactivity period
  - Simple to implement
- Another strategy is to keep track of how effective various intervals have been.
  - Attempt to use intervals that have been successful before
- Strategy 3: Weight strategy to strategies that would be effective for recent data
  - Assumes data use changes over time

More Hard Drive Strategies

- Another strategy: Use a random interval
  - Good worse case performance
  - Other algorithms can defeat it in the average case.
- Some attempts have been made to predict when hard drive accesses will be made.
  - In theory could result in performance improvement over using an inactivity interval.
  - None have been made to work well in a real life application as of this paper.

Alternatives to Hard Drives

- Flash memory can be used instead of a hard drive.
  - Positives:
    - Fast in retrieving data
    - Lower power usage
  - Downside:
    - More expensive than a hard drive
    - Writes take a longer amount of time.
    - Can only make a limited number of writes.

Wireless Networking as Hard Drive Alternative

- Can use Network as a Disk, broadcasting necessary data
  - Positives:
    - Low power usage
    - Requires less hardware for the mobile device
  - Negatives:
    - Much slower than a hard drive
    - Susceptible to network failures
    - Need to be in range of a central server.

Processor Power Savings

- Processor uses much less power if it gets turned off.
  - Modern operating systems have the ability to turn off the processor when all the processes are blocked.
  - Operating System can be tuned to prevent processes from busy waiting.

Regulate Processor Speed

- If it corresponds to being able to reduce core voltage, reducing processor clock speed can lead to power savings
  - Frequent changes in speed can cost more power than a higher overall clock rate.
  - Need to change gradually change speed.
    - React too slowly and the device can have trouble dealing with peak workloads
    - React too quickly and power savings are lost.

Networking Devices

- Can save power using Network devices in several ways.
  - Can enter sleep mode to save power
    - Can enable device to enter sleep mode more often by reducing network usage, such as compressing TCP packets
    - Devices can be put into listen mode more often by having a central server broadcast frequently used data such as in broadcast discs.

More Networking Information

- Can reduce power by reducing broadcast power
  - Advantages
    - Uses less power
    - Improves the ability of other devices to broadcast
  - Disadvantages
    - Increases bit error rate
      - May require more error bits
      - May require it to transmit more often

Strategies to Lower Broadcast Power

- Can communicate with other devices about the observed quality of service and level of interference
  - Use information to adjust broadcast power
- Device can also make adjustments based on its observed interference and adjust power accordingly
  - Can provide reasonable efficiency while simpler to implement.

Display Power Savings

- Display devices are among the most expensive devices power wise.
- Most common power saving strategy is to turn off the monitor.
  - Can not turn it off too quickly or it can be annoying to the user
- Other strategies include lowering the refresh rate, dimming the display, or switching to black and white

Overall Strategies

- Can also implement power savings system wide.
  - Advantages:
    - Simple to implement
    - More tolerable to the user
  - Disadvantages:
    - Save power less efficiently than component by component strategies.