

# Outline - Energy Management

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- ECOSystem: Managing Energy as a First Class Operating System Resource
- Energy Aware Adaptation for Mobile Applications
  - Jason Flinn and M. Satyanarayanan
- Software Strategies for Portable Computer Energy Management
  - Jacob Lorch and Alan Jay Smith



# Software strategies

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- Energy consumption is a major concern
  - Obvious for mobile devices
  - Heat dissipation issues for data centers
- Devices can operate in multiple power levels
  - Full, sleep, idle, suspend, standby etc.
- Choosing the right mix of power states can allow software to exploit the hardware mechanisms to effect energy conservation



# Categorization

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- Transition
  - When should a component switch between modes?
- Load-change
  - How can a components functionality needs be modified so that it can be put in low-power modes more often?
- Adaptation
  - How can software permit novel, power-saving uses of components?



# Power conservation

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- Conserving energy for system components may not offer overall energy savings
  - Running the CPU slower = takes longer to finish computation while the display, disk and other components are also powered up longer
- Have to make sure that the system component being optimized contributes to the overall energy
  - Modem consumes 2% energy. Optimizing this may not matter
  - As components change, relative energy consumption can change



# Battery Technology

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- Improvements are slower
  - “Eveready” law - 30 years (as compared to 18 months for Moore’s laws)
  - Few fundamental change in technology
- Hard drive
  - Idle/Standby/Sleep states
  - Disk spin-up adds to the switching cost
  - Switching based on past performance
  - Flash memory as backups



# Processor

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- Reducing Voltage and Frequency can offer savings
  - Processors are already running at lower voltages and so we may not have much leeway
  - Intel Xscale : 0.7 through 1.75V?
- Wireless Communications
  - For a given range, they consume enormous power
- Backlight
  - Light sensors, inactivity intervals
  - Newer display technologies



# Main memory

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- Memory banks that can be turned off independently
  - RDRAM memory



## Energy-aware adaptation

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- This is an off-shoot of Odyssey, which was an offshoot of Coda ....
- The Operating system measures the system constraints, applications register adaptation policies using call backs. Whenever significant changes occur in the system, the OS notifies the clients using call backs. The clients are expected to adapt the computation using application specific logic
  - Transcoding to reduce data fidelity
  - OS performs the operations, applications participate in the adaptation policy
  - Again, where does the functionality belong: OS, Application, Hybrid





# Energy Management Systems

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- Manage energy for the device/component
  - Disk, wireless device
- Cooperative application/OS mechanism
  - Odyssey
- Have the OS manage energy as a resource
  - ECOSystem



# ECOSystem

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- Utilize resource containers to charge applications with energy consumption across subsystems (file, network devices etc.)
- Allocate currency similar to lottery scheduling
- Modify kernel to charge applications with energy costs
  - Spinning up disks is charged to all processes that utilized this spin-up operation



# Discussion

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- If the application knew that there would a disk spinup just for itself, maybe it would've changed/delayed its disk request.

