Apprehending Joule Thieves With Cinder

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Handheld Linux
Desktop Resource Management

If it's slow
add more resources
The State of Mobile Devices

• Complex
  • Running full UNIX stacks
  • Multiprogrammed
  • Software from many sources
  • Hard to trace resource consumption to individual tasks

• Users care about
  • Energy
  • Network
The Future of Mobile Devices

• Need new OS mechanisms
  • Make resource accounting a first class OS primitive
• This talk: energy
  • Same mechanism applies to networking, which is easier
• Cinder OS
  • Simple kernel
    – Easy to reason about
    – Familiar UNIX userland
Cinder Goals

- Energy as a first class resource
  - Track it
  - Ration it
  - Delegate it

- In terms the user understands
  - Talk time/Standby time rationing
    - Phone calls (total talk time, 911)
    - “Games & Widgets” folder
    - E-mail (composing versus polling)
Capacitors

• First-class abstraction
  • Can be named and manipulated
  • Protected by permissions
• All threads run in the context of one or more
  • Track and ration resources for all actions
    - CPU usage
    - Flash writes
    - Network transmissions
Capacitors
Capacitors

- **Input rate**
  - Throttles consumption

1 W
Capacitors

- Input rate
  - Throttles consumption
- Energy storage
  - Allows for burstiness

maps

1 W
Capacitors

- Input rate
  - Throttles consumption
- Stored energy
  - Allows for burstiness
- Half-life
  - Acts as a ceiling
  - Prevents hoarding/starvation

1 W maps
Capacitors

- Input rate
  - Throttles consumption
- Stored energy
  - Allows for burstiness
- Half-life
  - Acts as a ceiling
  - Prevents hoarding/starvation
- Form a hierarchy

maps
Hierarchy

- Allows composition of policies
- Actions debited upward
  - To the battery
- Block on any empty ancestor
  - Can't perform actions
  - Effectively rate limited
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Downloaded Apps

• Include resource declarations
  • Background / Foreground
• Hold them to it
  • 1 MB/mo ($0.40)
    - about 3 bps
  • 24 hrs active life
    - about 250 mW

20 KJ
250 mW
0 J
iFoo

200 MB
3 bps
0 B
Composition

20 KJ

1 W

0 J

spacewar
wumpus
rogue

250 mW

0 J

iFoo
Limits on Background Apps

• User's expectations
  • Driven from interaction
  • Not visible not using energy
• “Foreground” Capacitor
  • Increased responsiveness/fidelity
  • Matches user's expectations
  • Driven from specification for downloaded apps
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Capacitors

- Fine-grained
  - Tracking
  - Rationing
    - Limits
    - Reservations
  - Delegation
- Composable

- Can represent
  - Users
  - Applications
  - Classes of Apps
  - Vendors
  - Web-application Origins

**Easily expresses real-world policies**
Initial Results

- OS running on the HTC Dream
  - AKA T-Mobile G1 with Google
  - Keyboard, Display, Serial port
  - Incoming and outgoing phone calls work!
    - No audio
  - Text messaging works
  - GPS works for 45 seconds
- Also runs on x86_64 desktops/laptops
Initial Results

- Capacitors implemented
  - *All* threads are accounted for using capacitors
- Only accounts for the CPU
Remaining Work

• Create a rich energy model for a device
  • Hopefully the HTC Dream
• Craft interesting policies
  • Validate the approach
• Experiment with user involvement
  • Allow the user to specify policies easily
Q&A
Example
Example
Permissions

- **Ownership** allows a thread to
  - Change the capacitor's parameters
  - Grant other threads *Ownership*

- **Consumption** allows a thread to
  - Use energy of the capacitor
  - Read energy levels of the capacitor
  - Attach child capacitors
  - Grant other threads *Consumption*
Current Mechanisms

• Users
  • Disk quotas
    – No delegation

• Processes
  • nice
    – Priorities
    – Can't reason about
  • setrlimit
    – Kill switch
    – Child processes inherit same limits

Neither address energy or networking
State-of-the-art accounting

- Profile device-state consumption
  - Statically or dynamically
- Account to tasks
  - Bill for device-state changes
- Difficulties
  - Ambiguity
  - Lack of fine-grained sensors
- Prior control systems limited
Subdivision

gui-shell

maps

route

gps-sense

render
Cgroups

- Cinder
  - Energy
  - Application controlled

- Linux Cgroups
  - No energy yet
    - Pluggable
  - Large kernel → High baseline
setrlimit

- Capacitors
  - Energy
  - Network
  - Limits
    - Blocks on violation
  - Reservations
- For use in the general case

- setrlimit
  - No energy
  - No network
  - “Kill” limits
    - Sends signal or aborts
  - No Reservations
  - Intended for runaways
ECOsystem/Currentcy

- Cinder
  - Hierarchical
  - Network

- ECOsystem
  - “Task” Containers
  - Energy specific
Over-committing

- Contention for resources
  - First-come-first-served
Reservations

• No Over-committing
  • Act as a reservation
  • Guaranteed and set aside

• Works
  • As a rate
  • As a quantity
Reservations

- No Over-committing
  - Act as a reservation
  - Guaranteed and set aside
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Guarantee a 5-minute 911 call
Throttle Games

20 KJ

1 W

0 J

spacewar  wumpus  rogue
Composition

20 KJ

0 W

250 J

0 J

1 W

911

spacewar

wumpus

rogue
Amortizing GPS Costs

GPSd

maps
Amortizing GPS Costs

GPSd

maps
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GPSd

maps
Amortizing GPS Costs
Amortizing GPS Costs

GPSd

loc-share
Amortizing GPS Costs
Amortizing GPS Costs
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