

Apprehending Joule Thieves With Cinder

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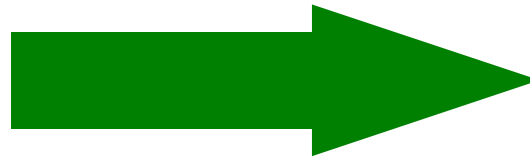
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MIT

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

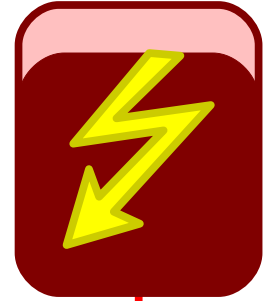
Cinder Goals

- 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



maps

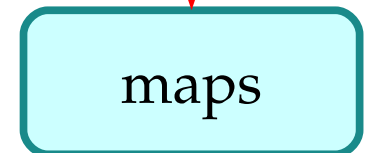
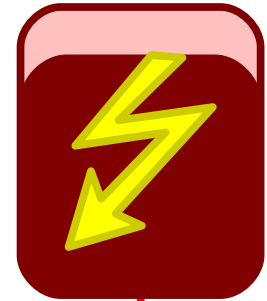
Capacitors

- **Input rate**



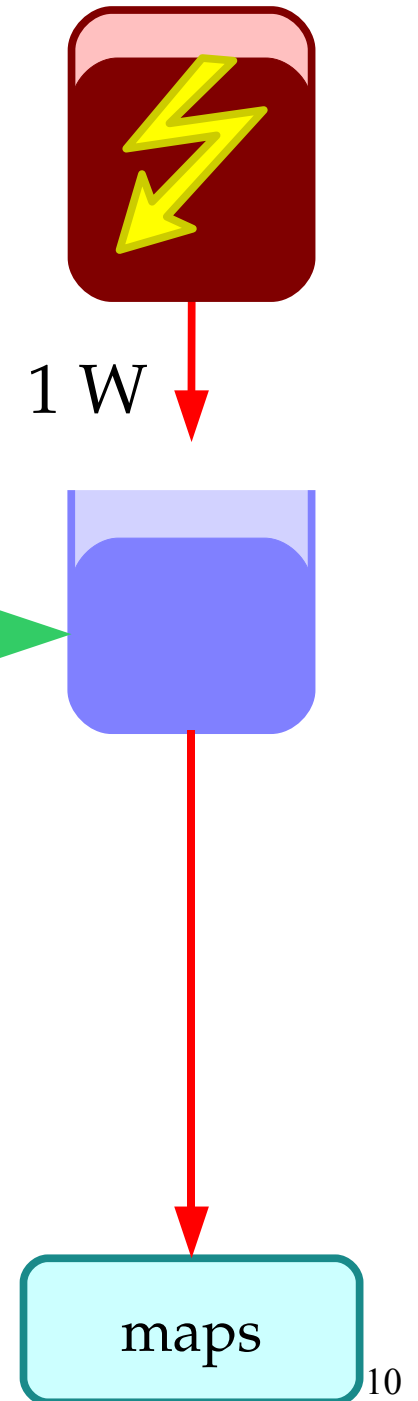
1 W

- Throttles consumption



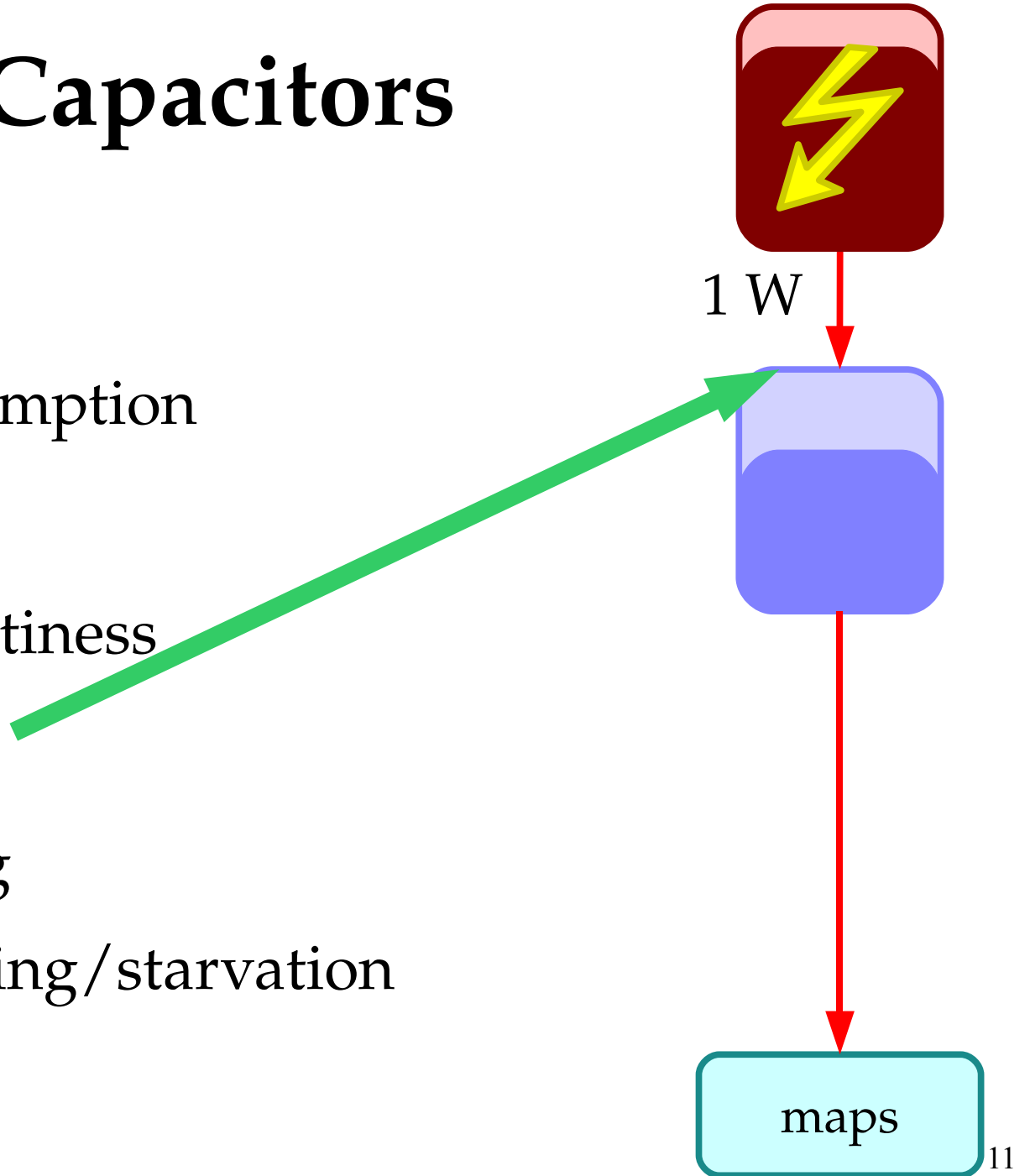
Capacitors

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



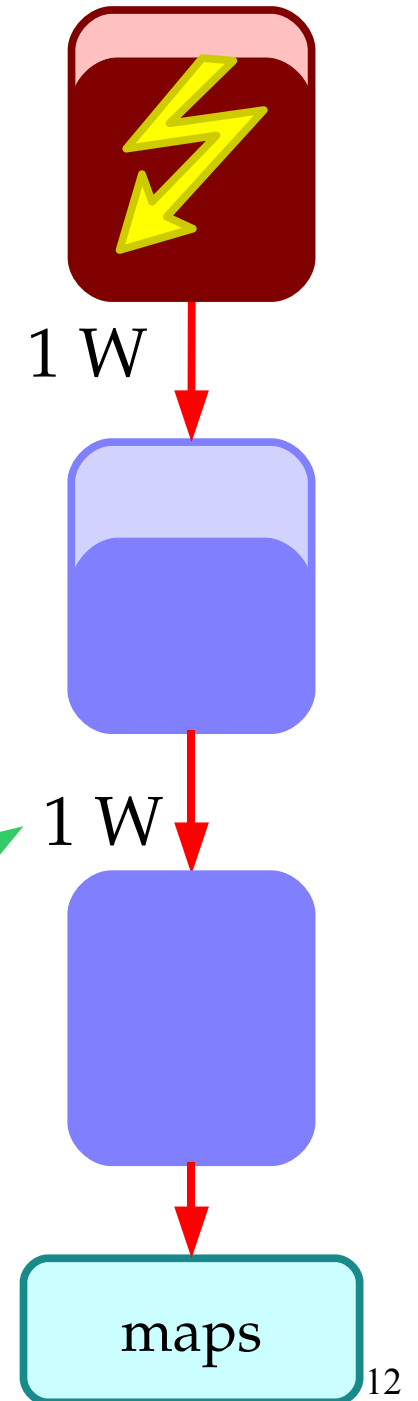
Capacitors

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



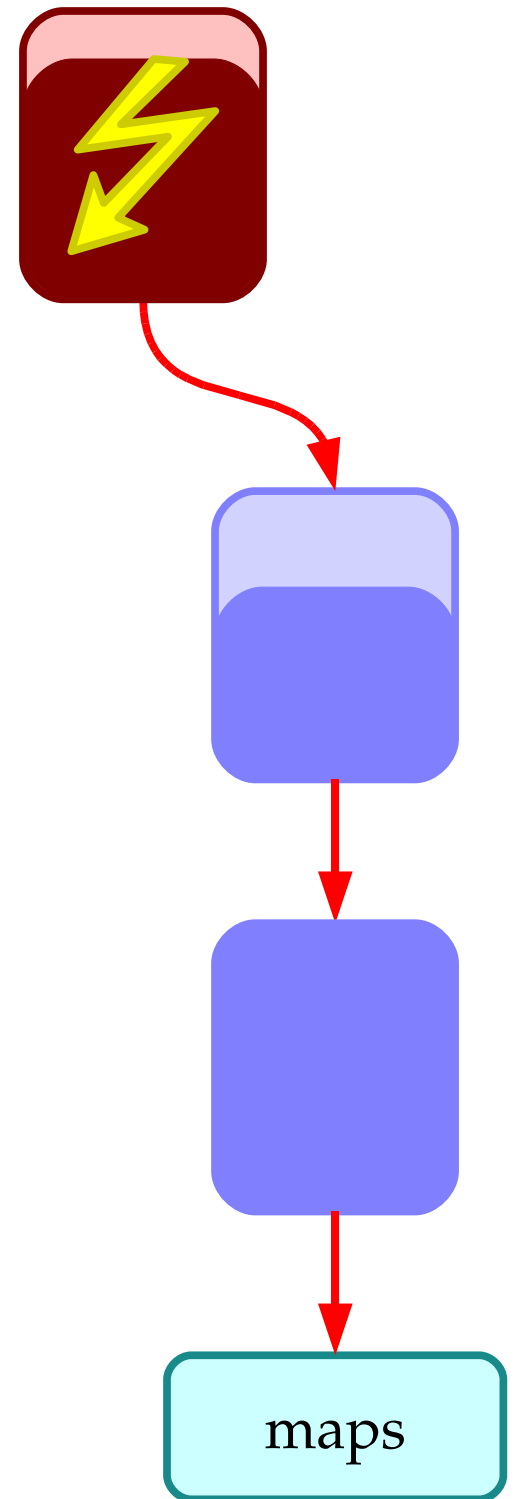
Capacitors

- Input rate
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- Stored energy
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- Half-life
 - Acts as a ceiling
 - Prevents hoarding/starvation
- **Form a hierarchy**



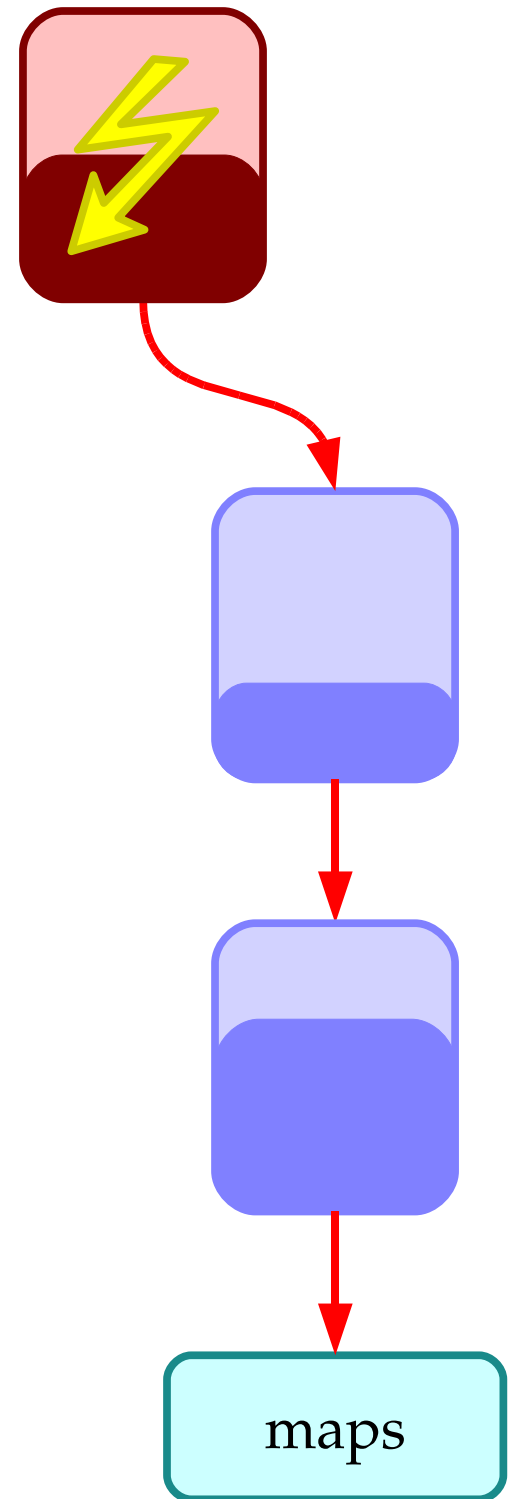
Hierarchy

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



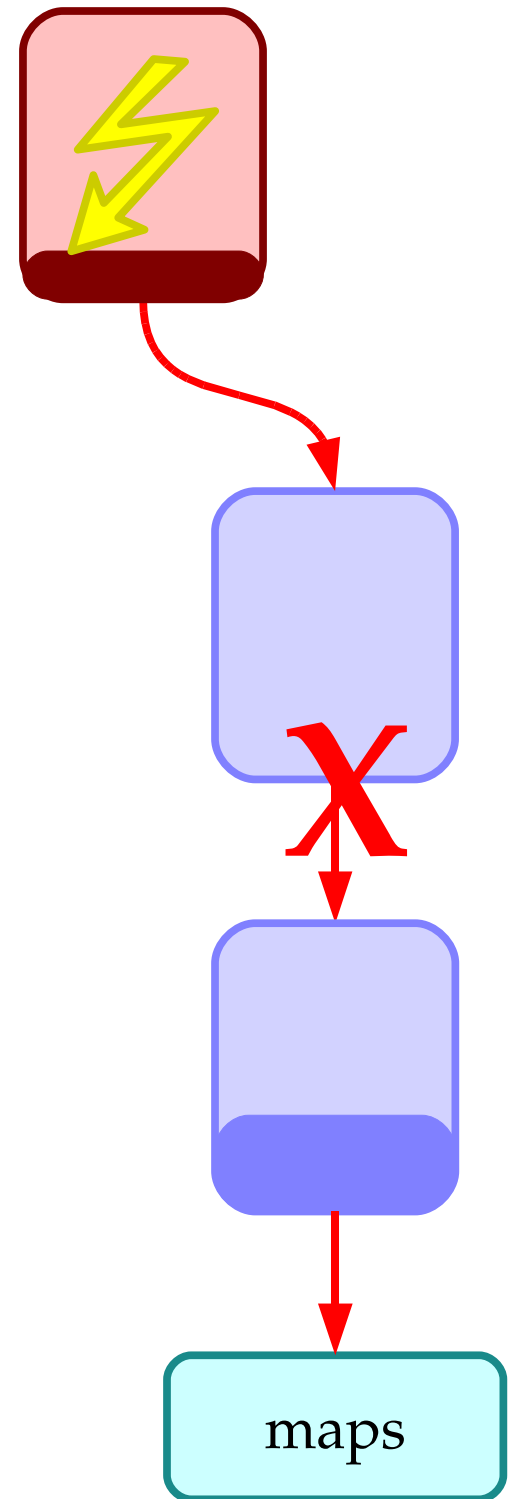
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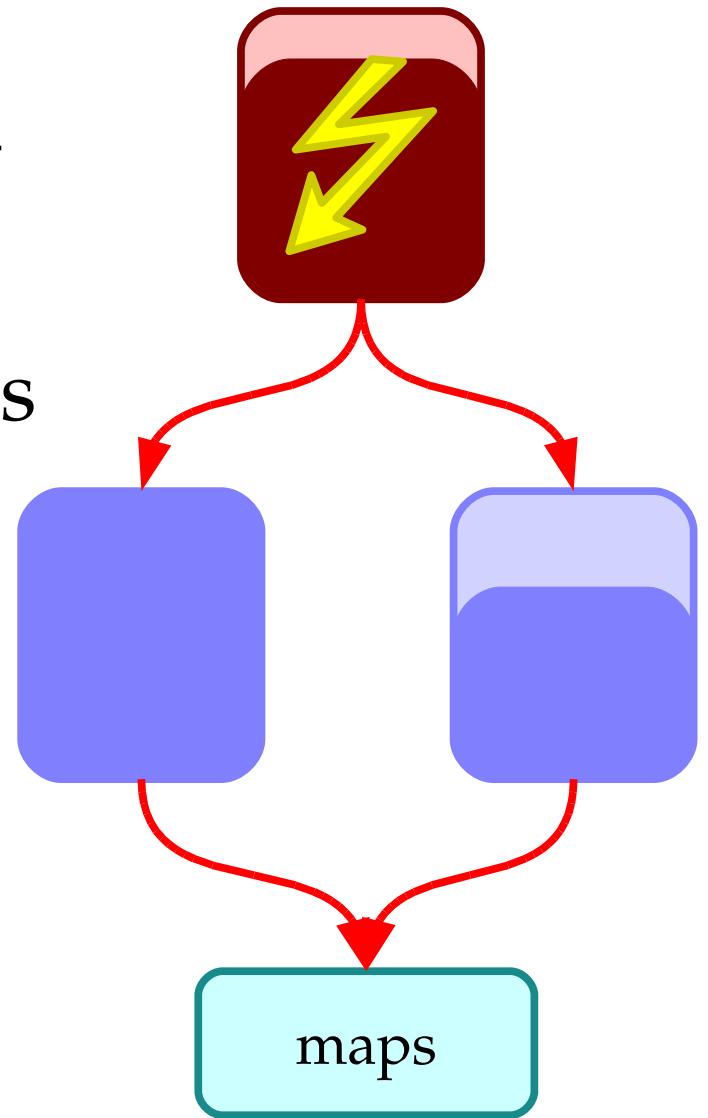
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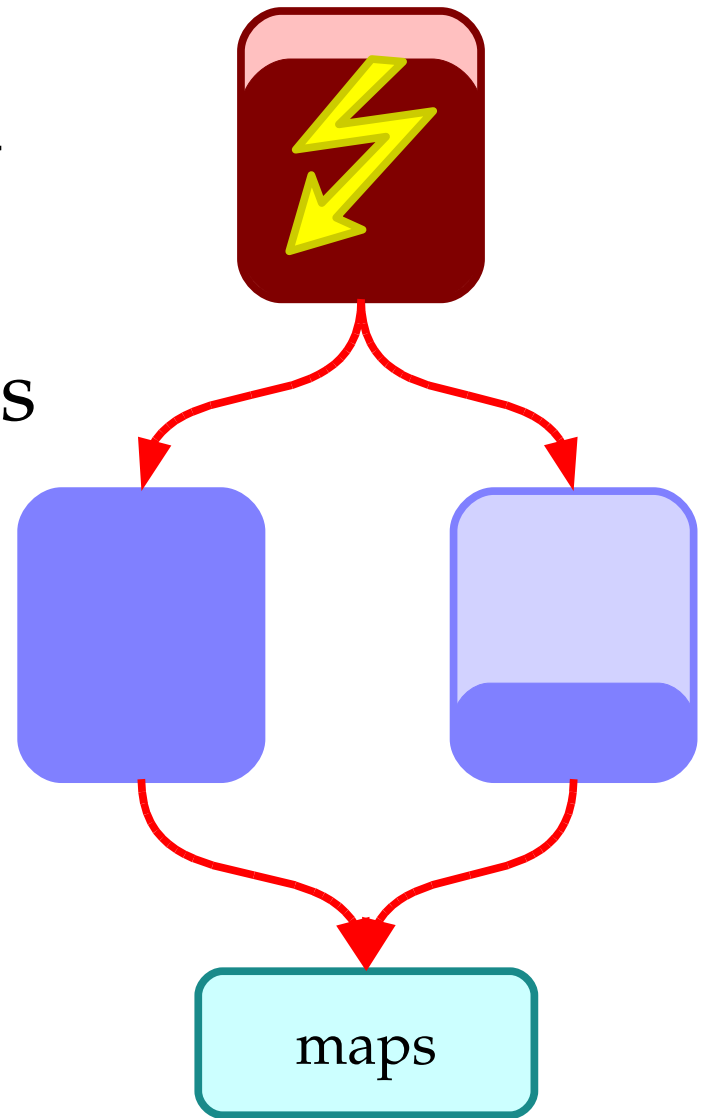
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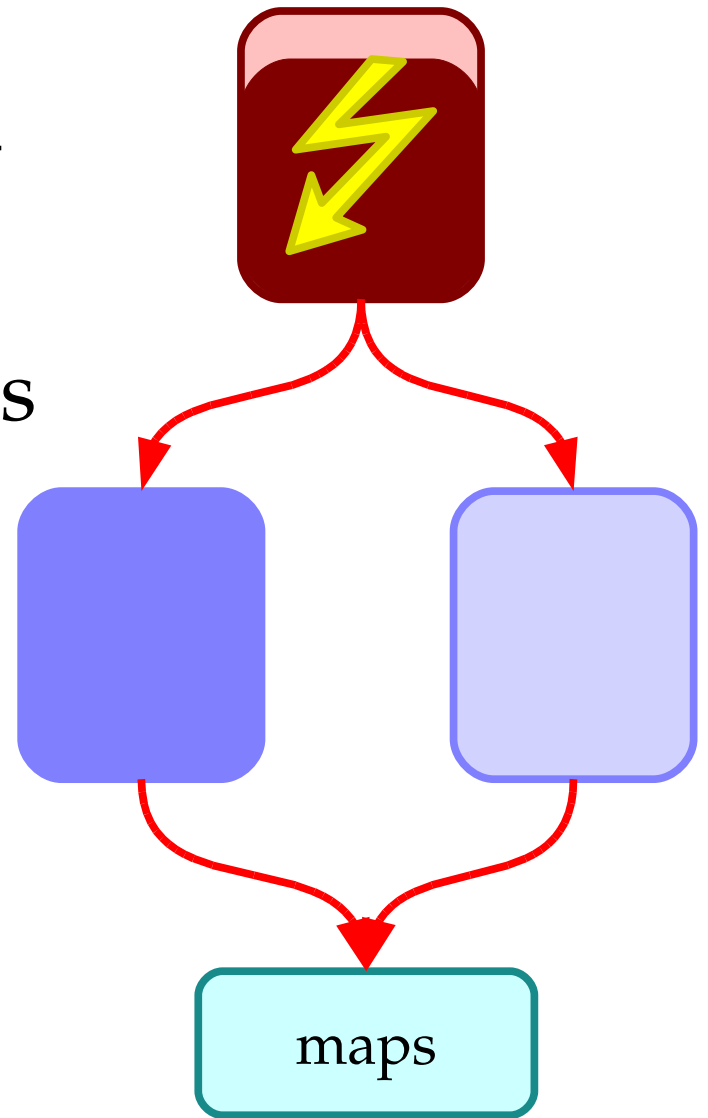
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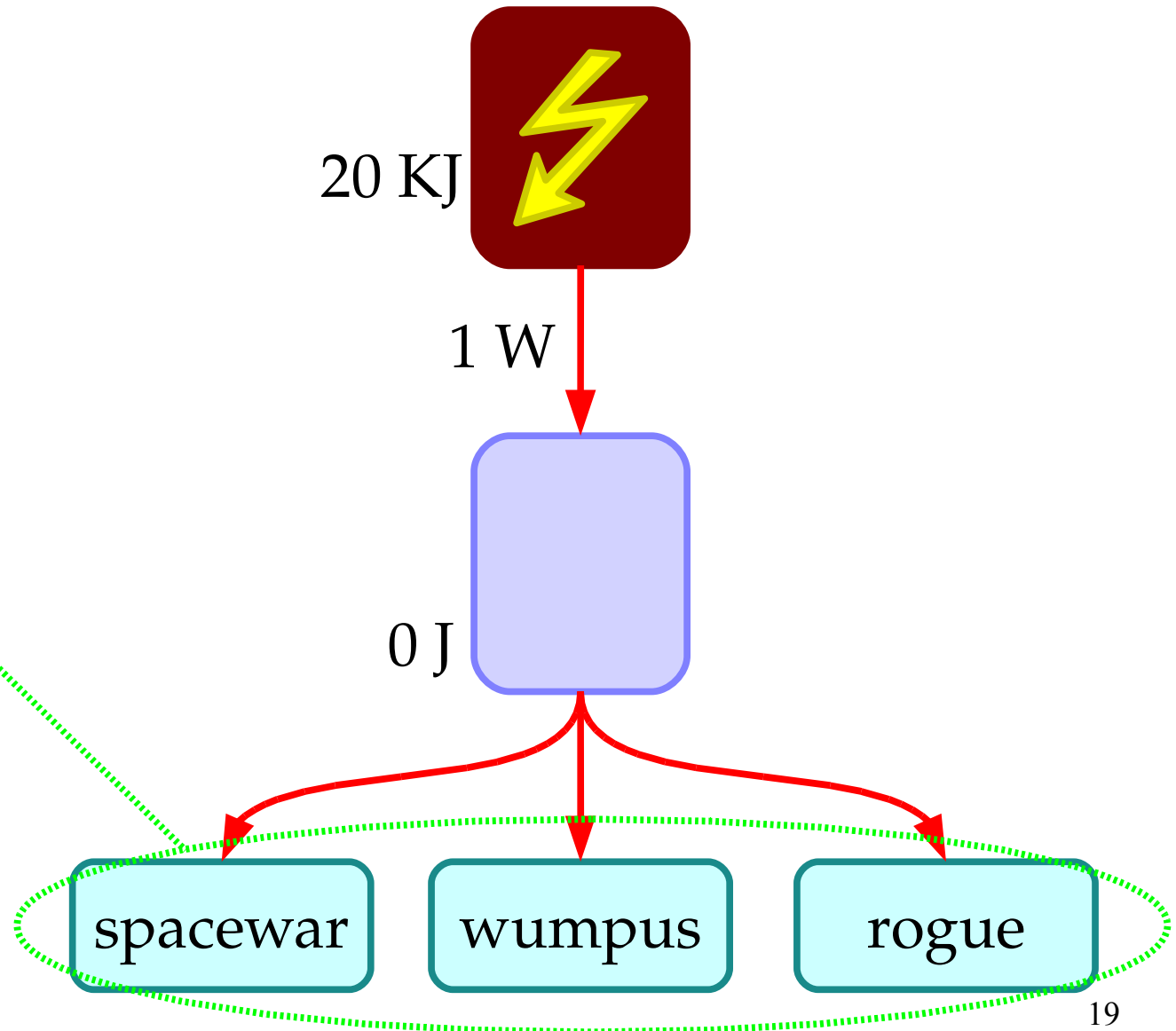
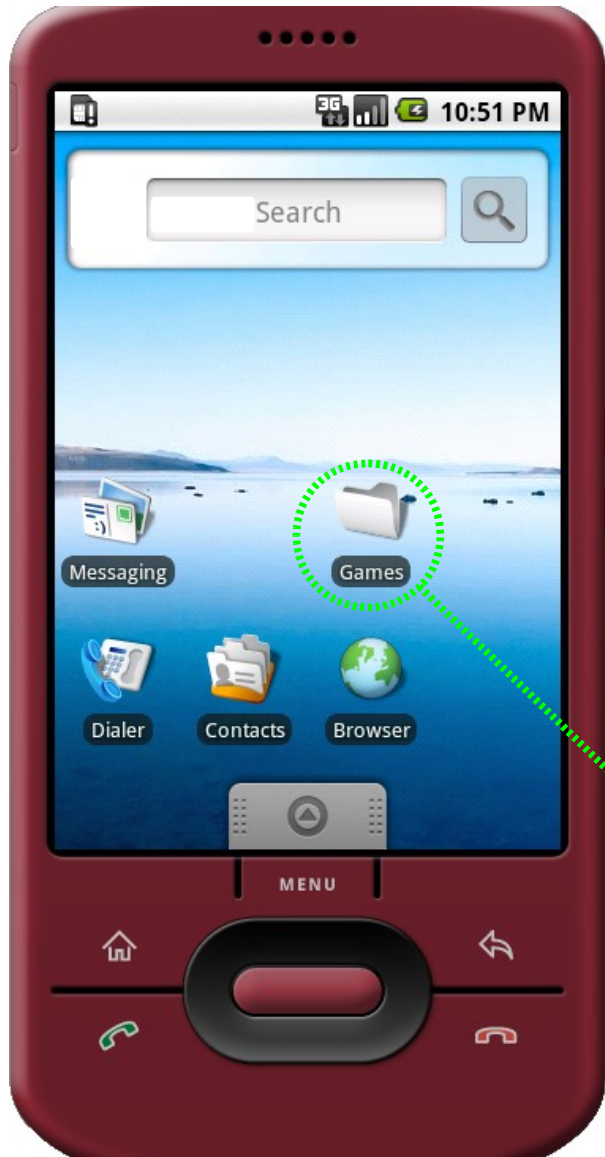


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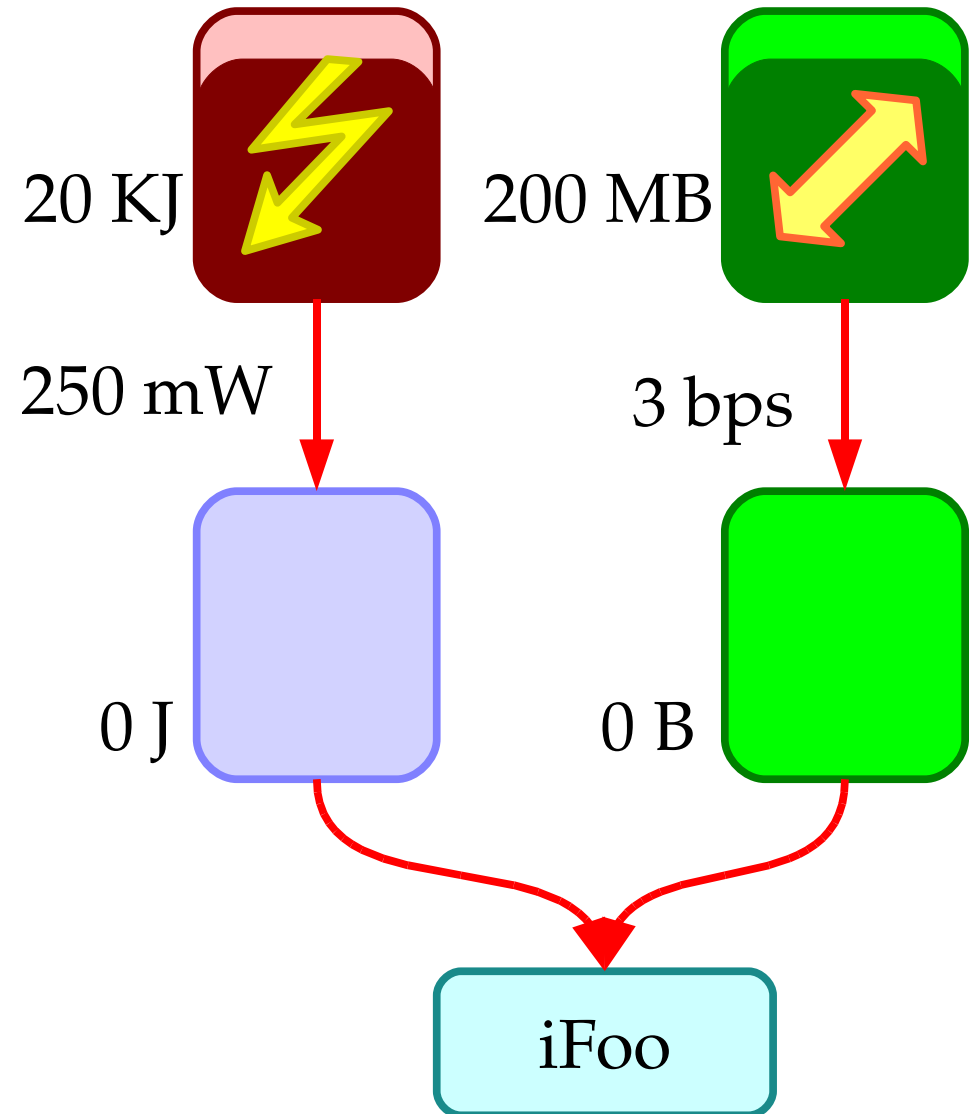


Throttle Games

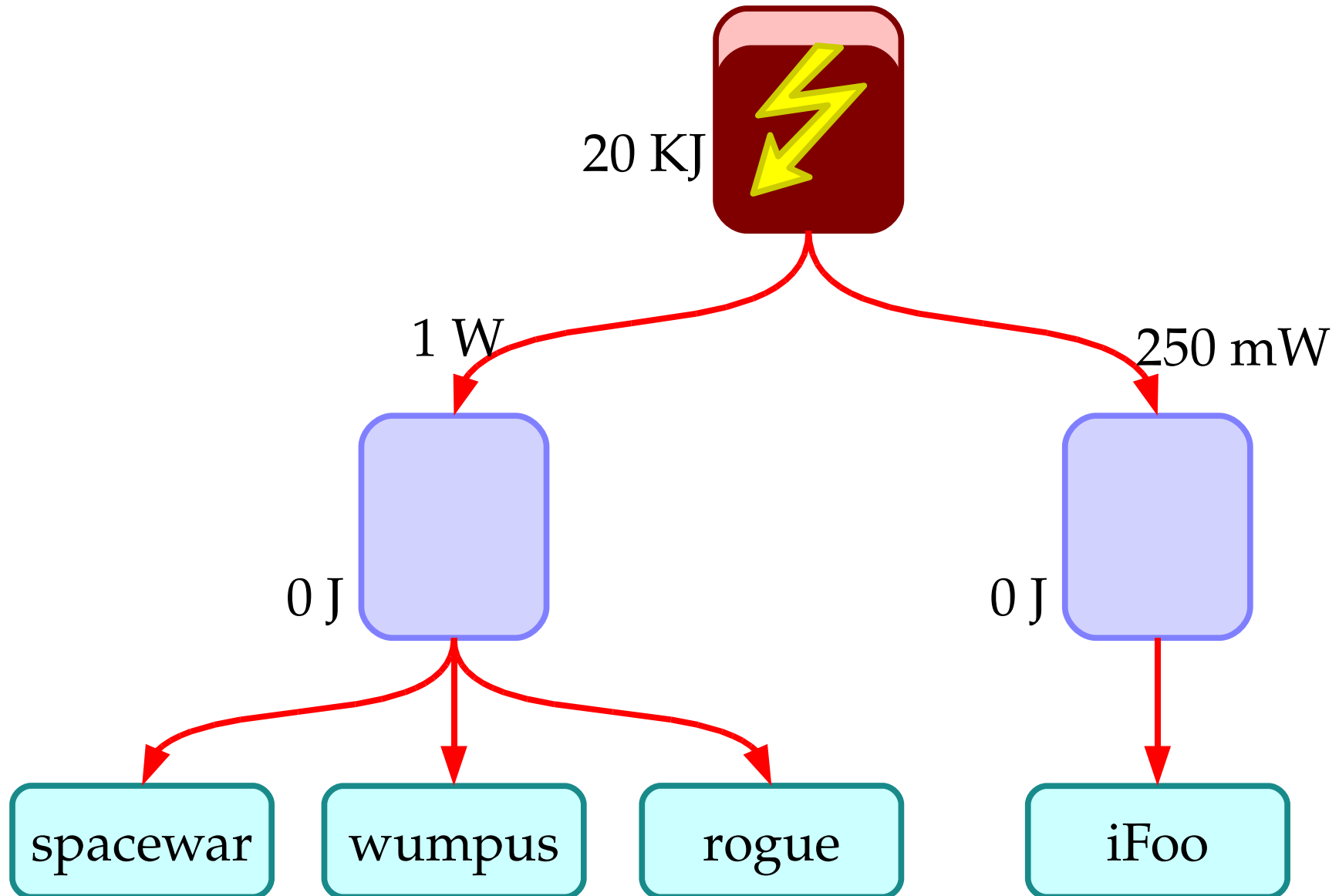


Downloaded Apps

- Include resource declarations
 - Background / Foreground
- Hold them to it
 - 1 MB/mo (\$.40)
 - about 3 bps
 - 24 hrs active life
 - about 250 mW

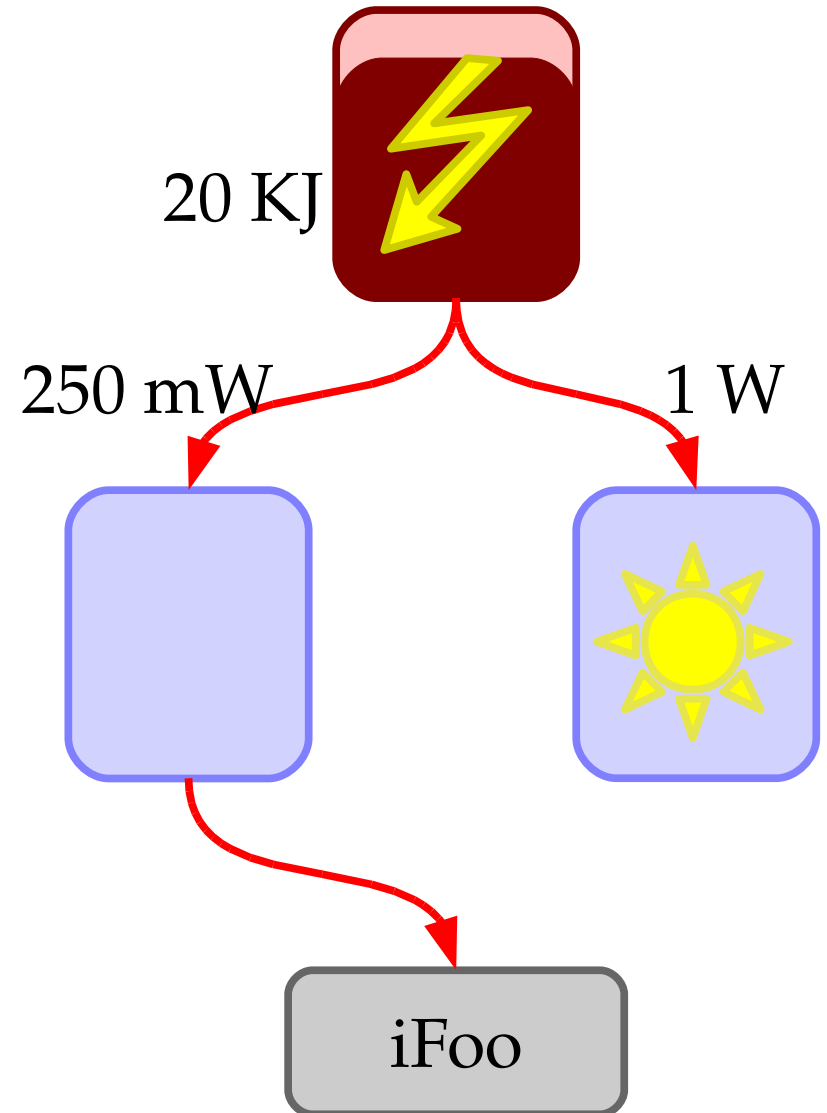


Composition



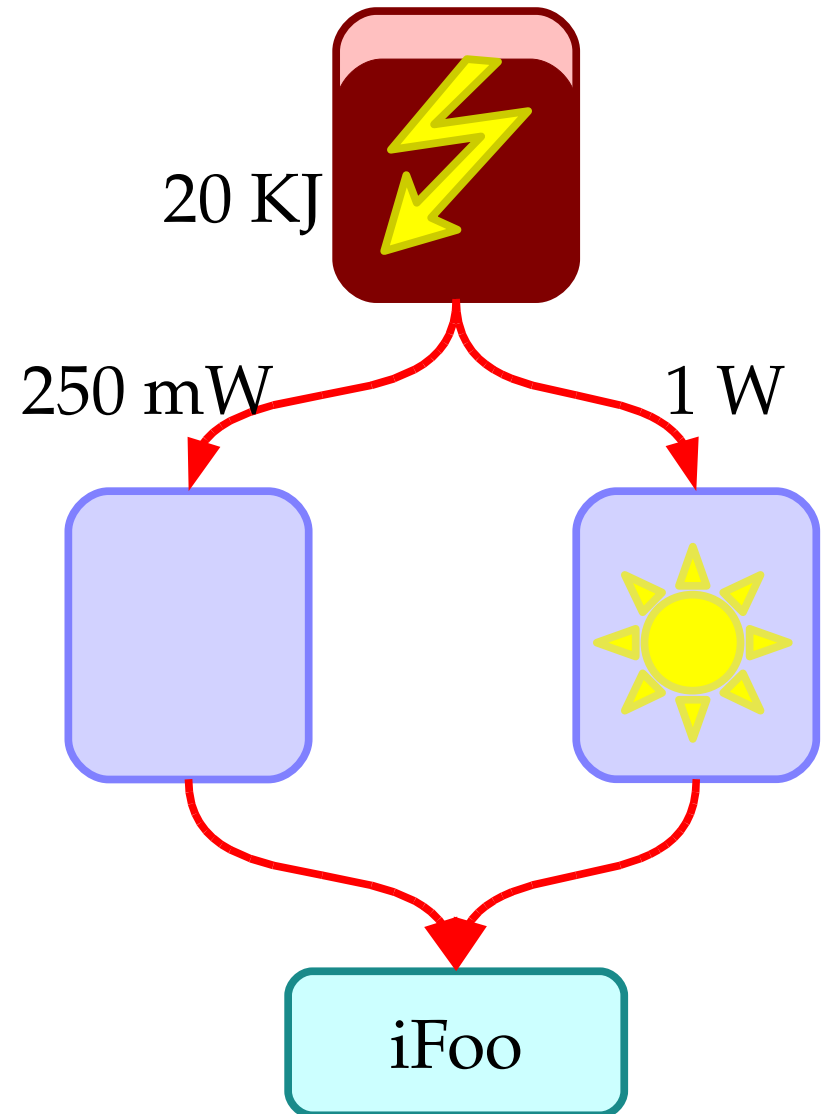
Limits on Background Apps

- 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

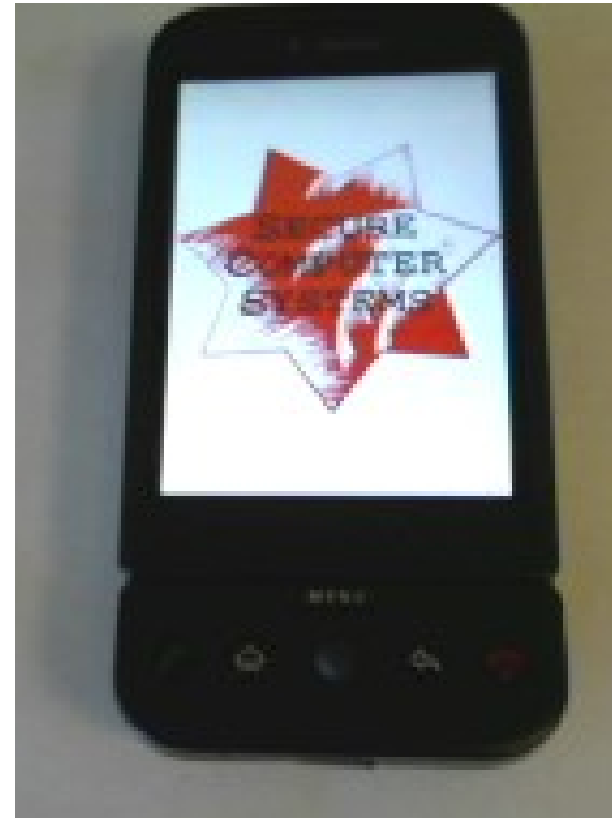
Initial Results

- 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

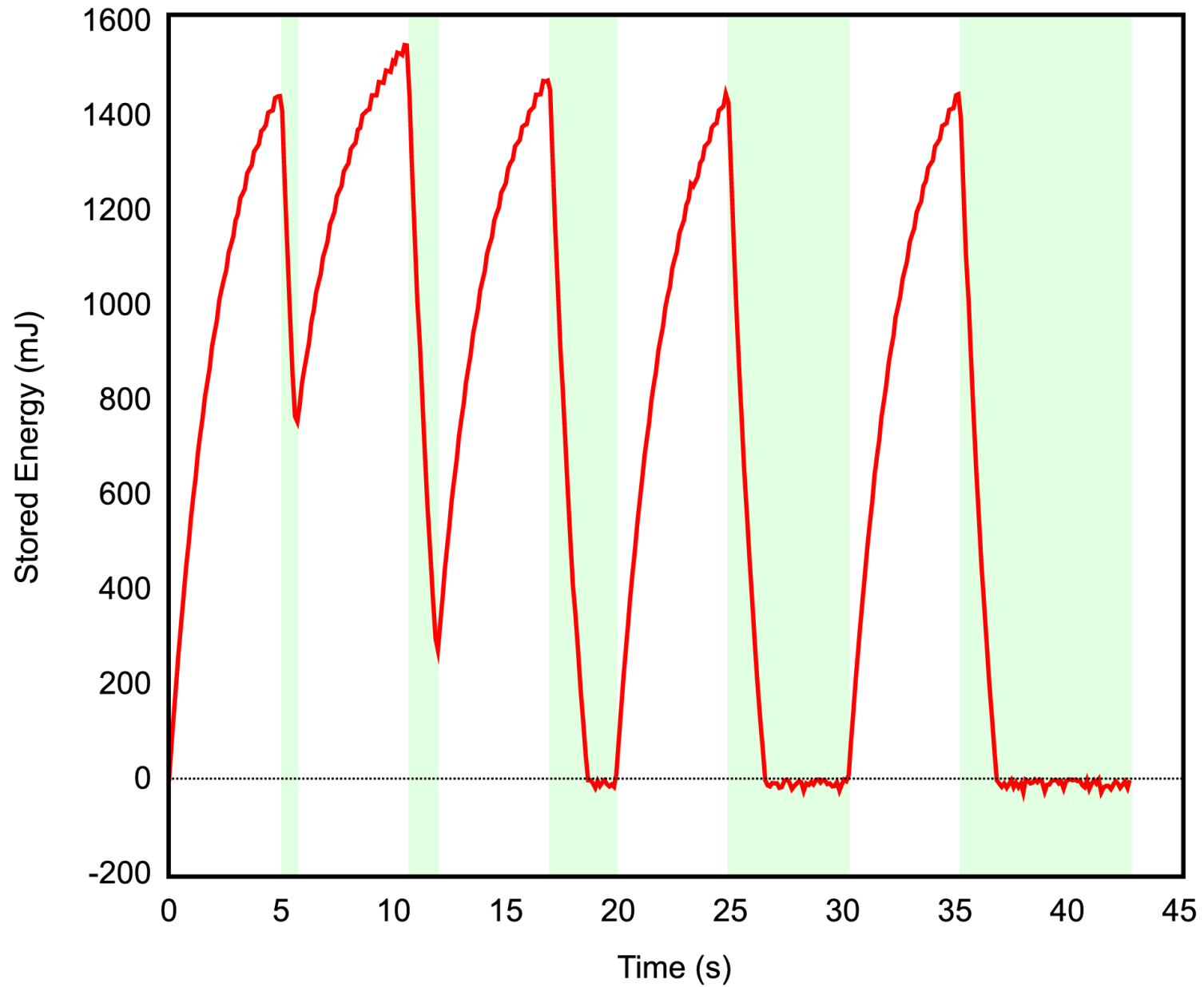


Remaining Work

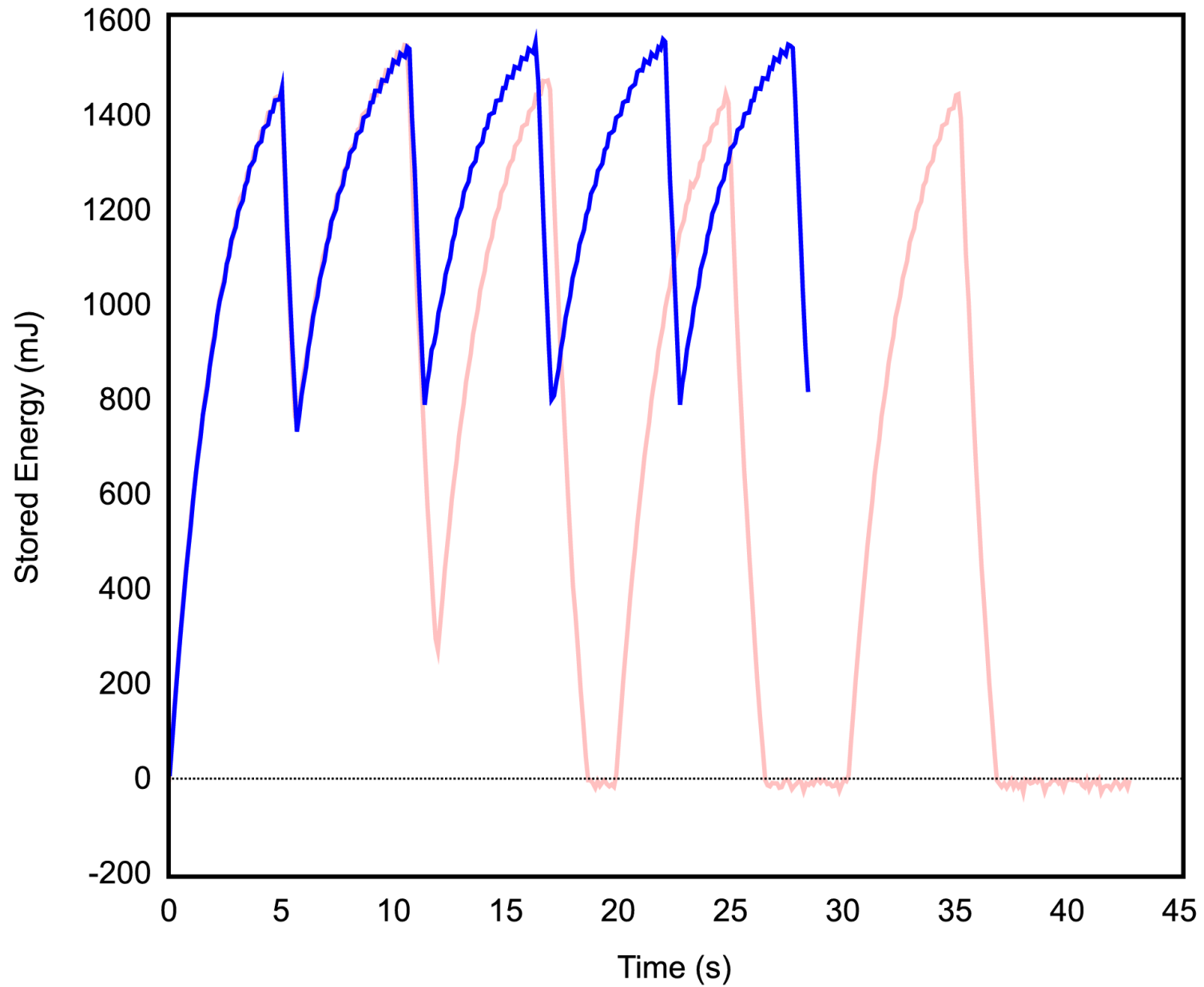
- Create a rich energy model for a device
 - Hopefully the HTC Dream
- Craft interesting policies
 - Validate the approach
- Experiment with user involvement
 - Allow the user to specify policies easily

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

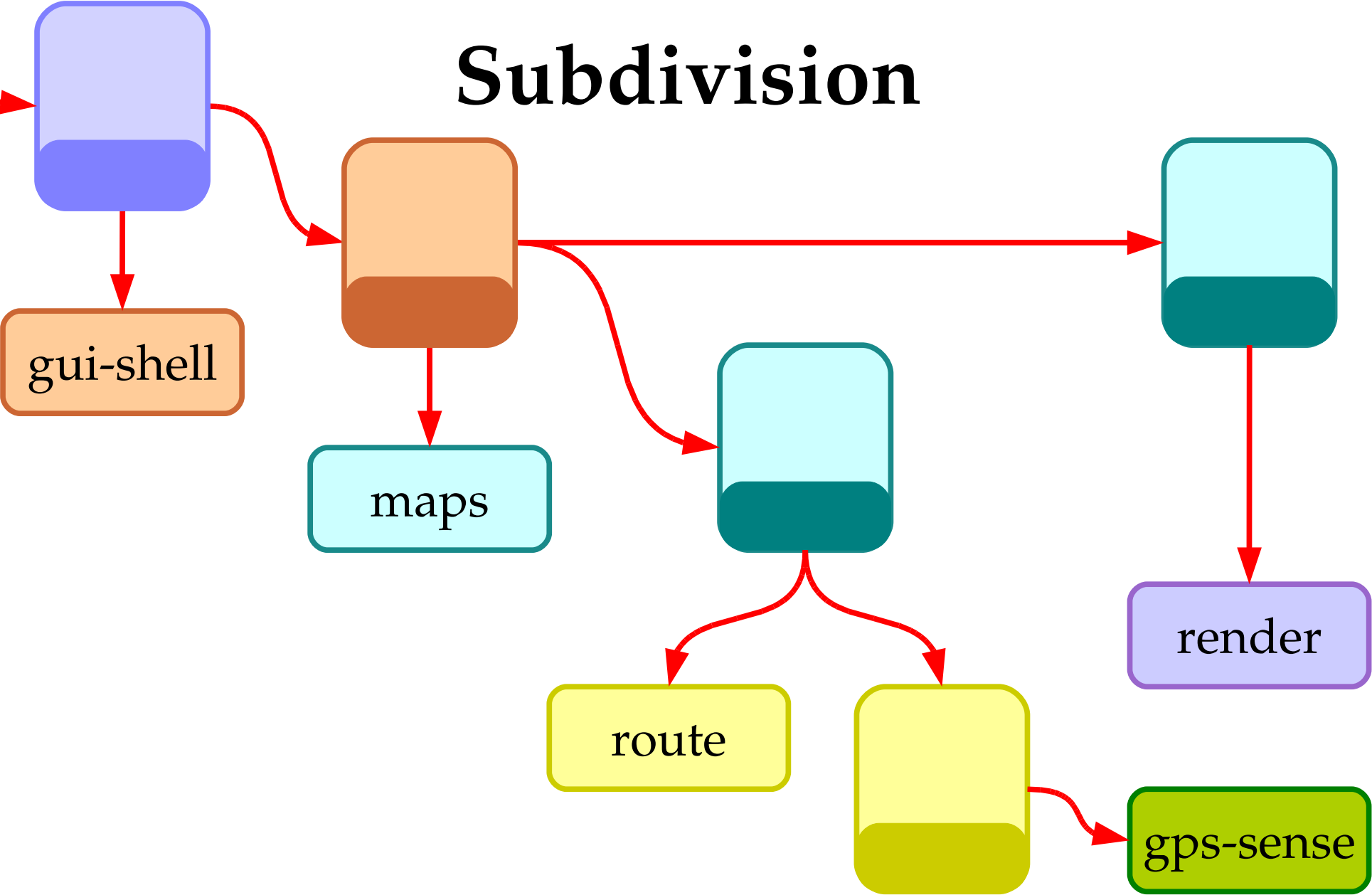
- Users
 - Disk quotas
 - No delegation
- Processes
 - **nice**
 - Priorities
 - Can't reason about
 - **setrlimit**
 - Kill switch
 - Child processes inherit same limits

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



Cgroups

- Cinder
 - Energy
 - Application controlled
- Linux Cgroups
 - No energy yet
 - Pluggable
 - Large kernel → High baseline

setrlimit

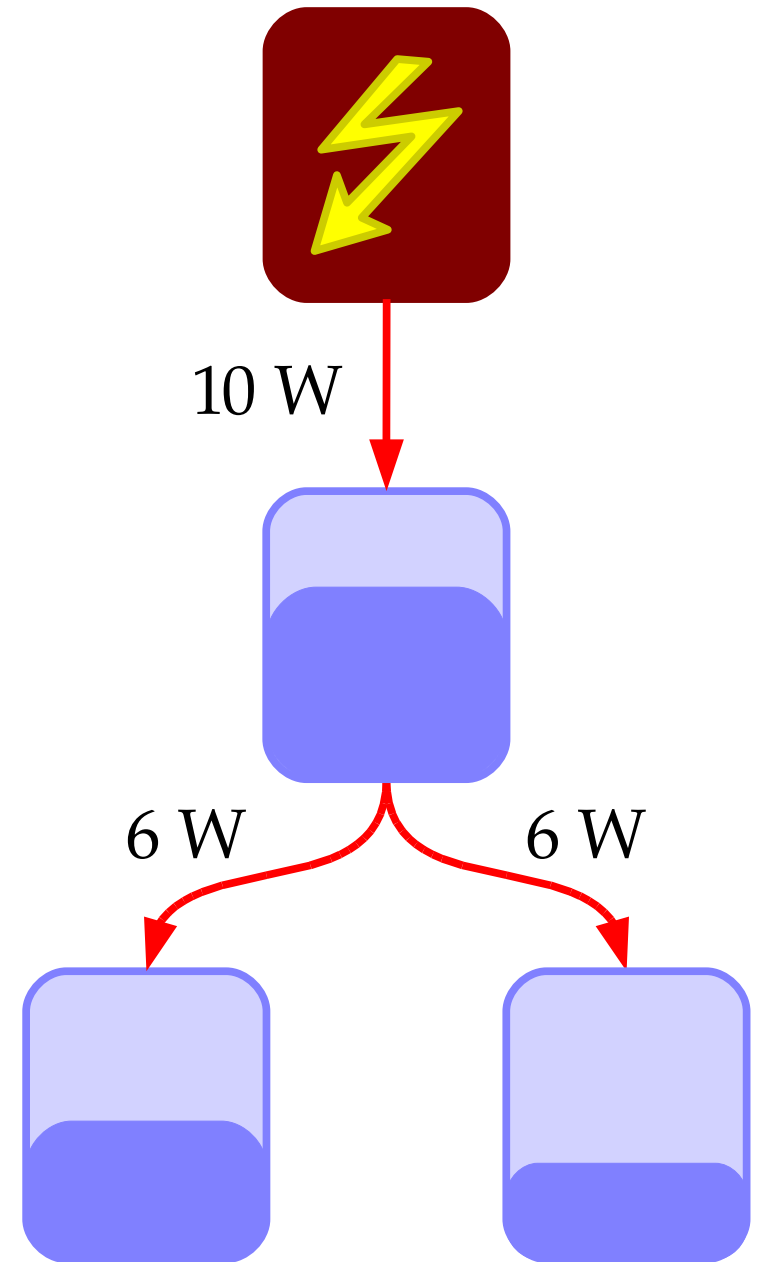
- Capacitors
 - Energy
 - Network
 - Limits
 - Blocks on violation
 - Reservations
 - For use in the general case
- setrlimit
 - No energy
 - No network
 - “Kill” limits
 - Sends signal or aborts
 - No Reservations
 - Intended for runaways

ECOsystem/Currentcy

- Cinder
 - Hierarchical
 - Network
- ECOsystem
 - “Task” Containers
 - Energy specific

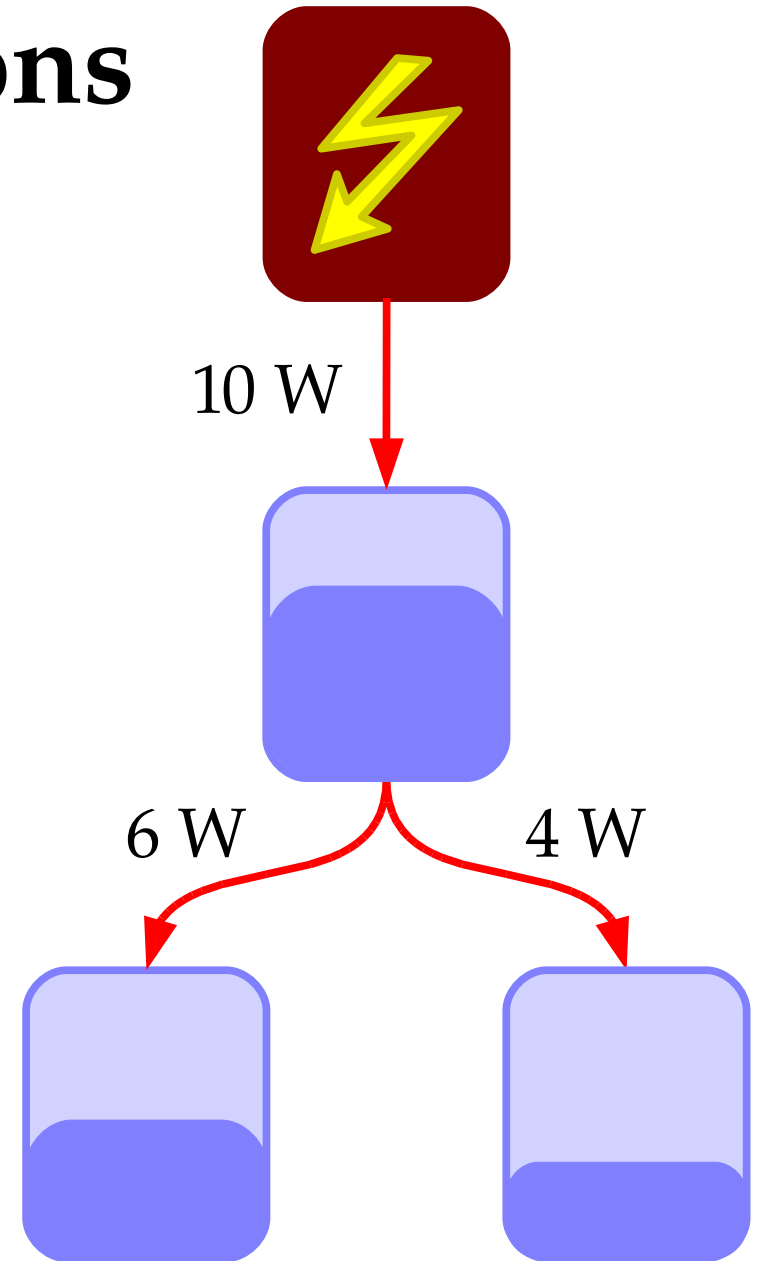
Over-committing

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



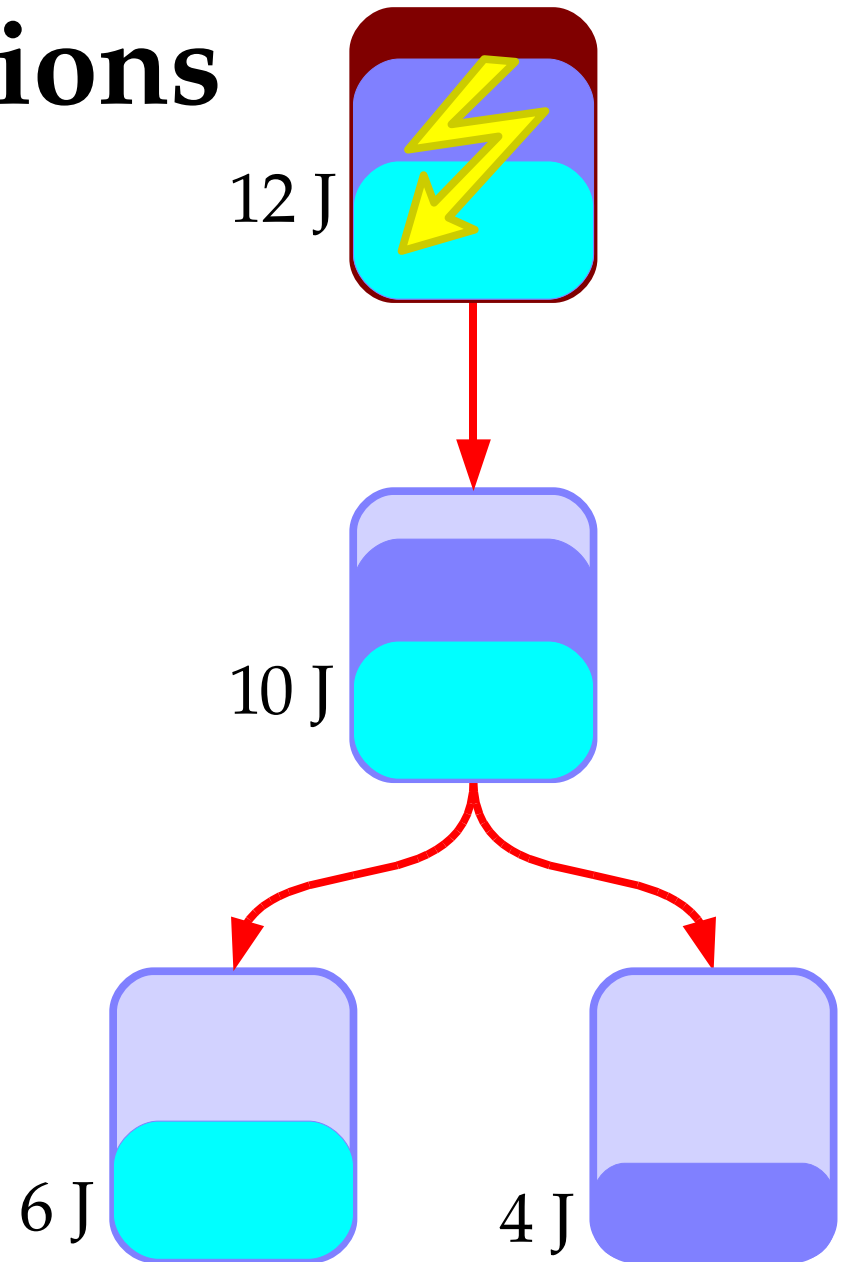
Reservations

- No Over-committing
 - Act as a reservation
 - Guaranteed and set aside
- Works
 - As a rate
 - As a quantity

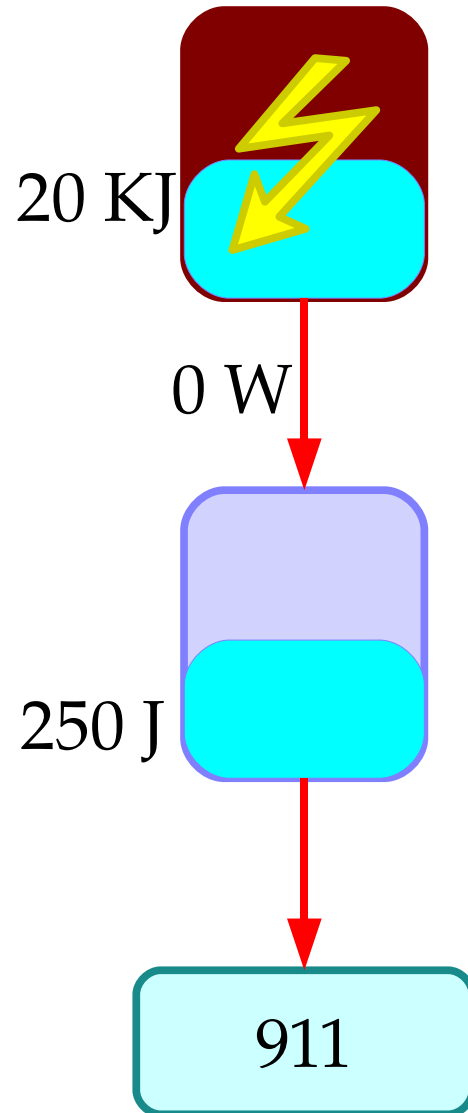


Reservations

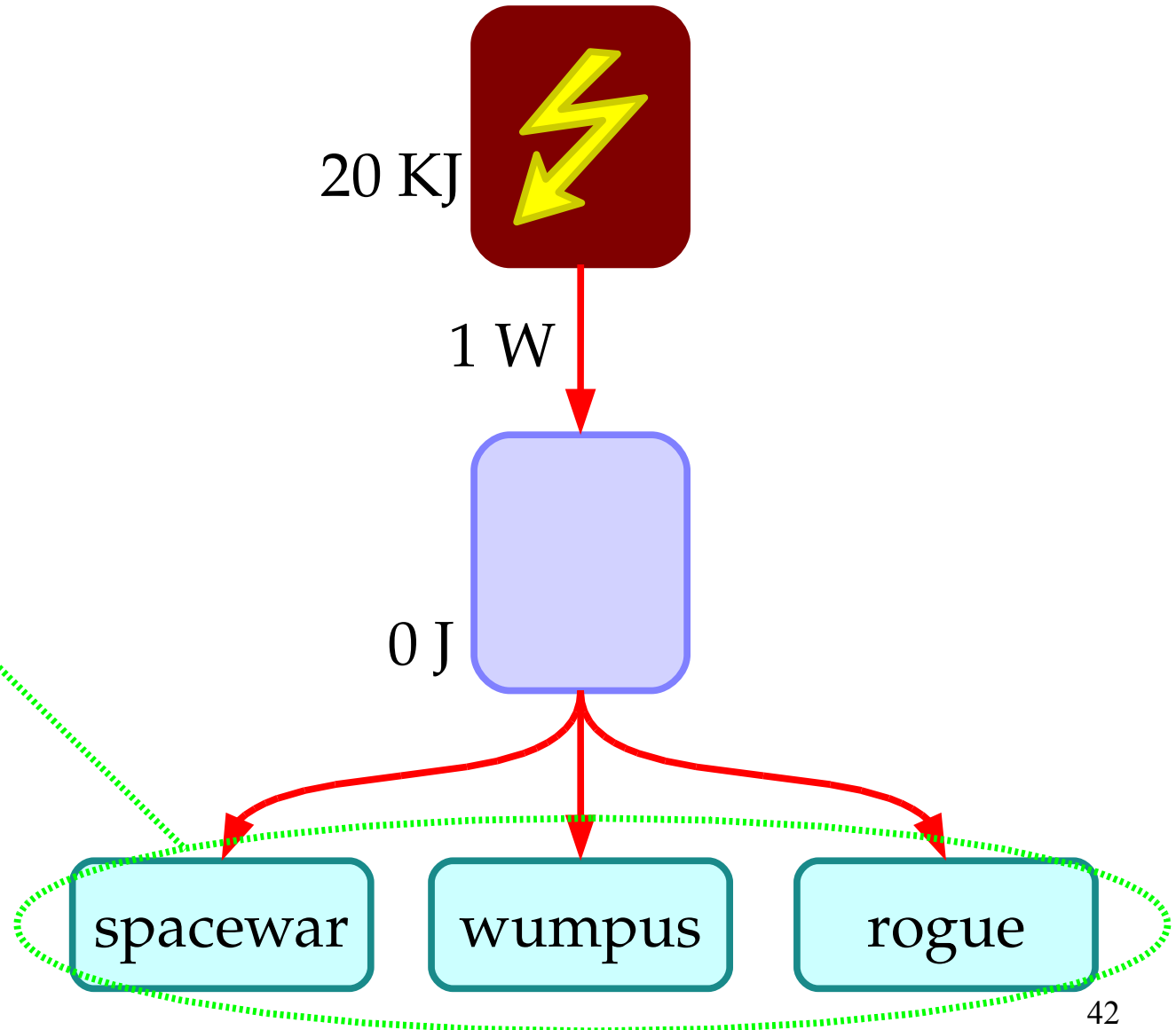
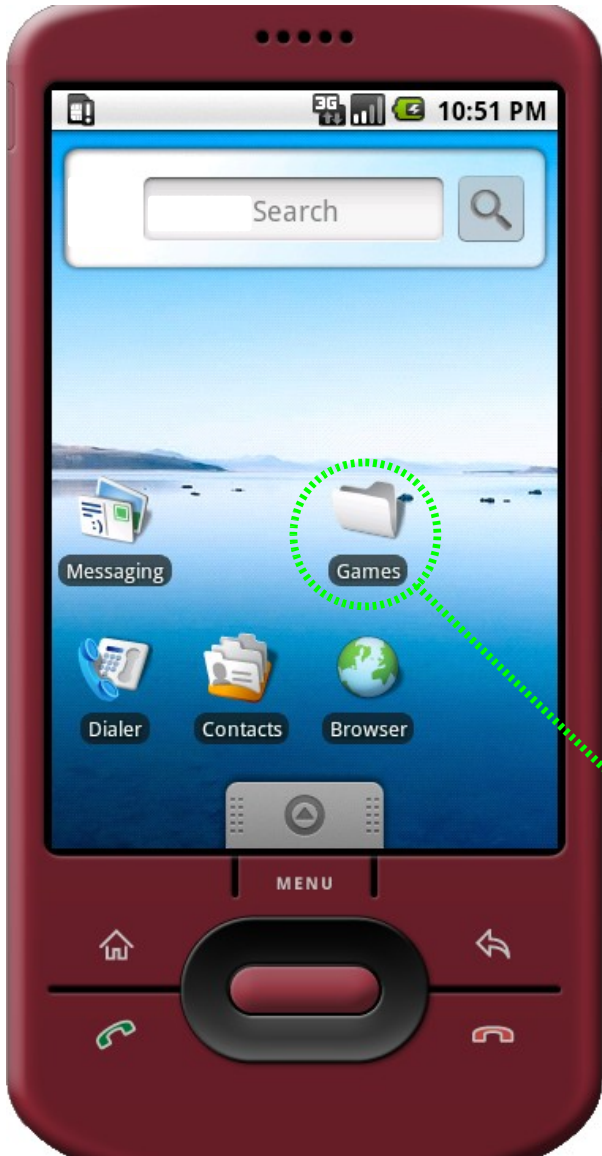
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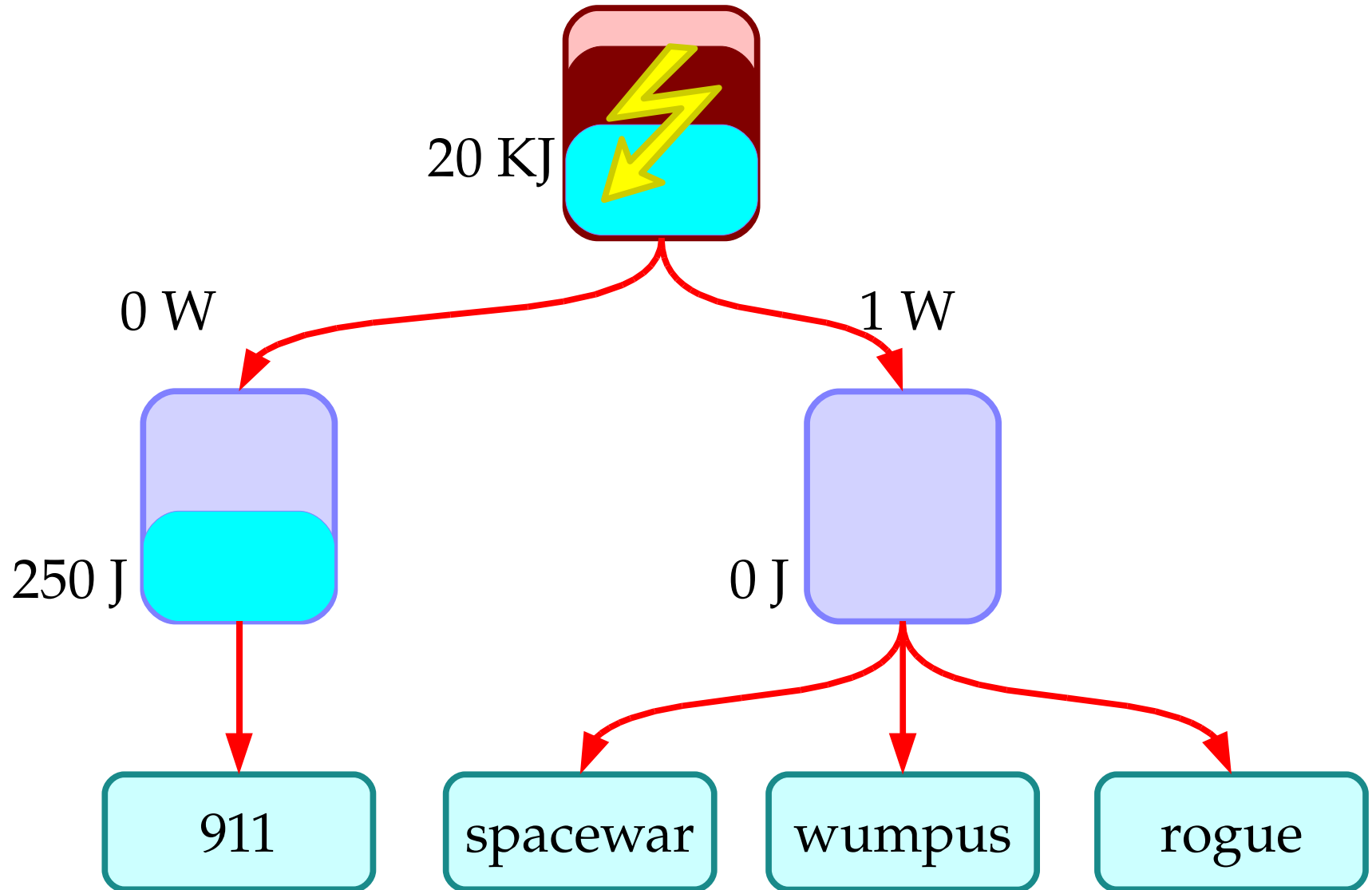
Guarantee a 5-minute 911 call



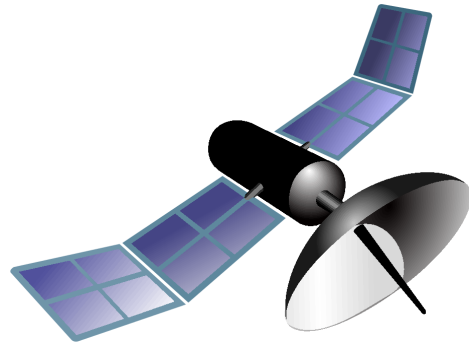
Throttle Games



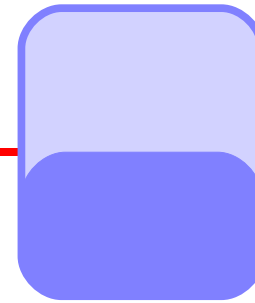
Composition



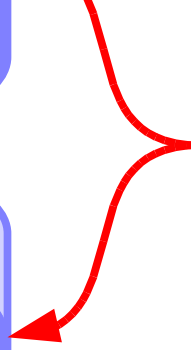
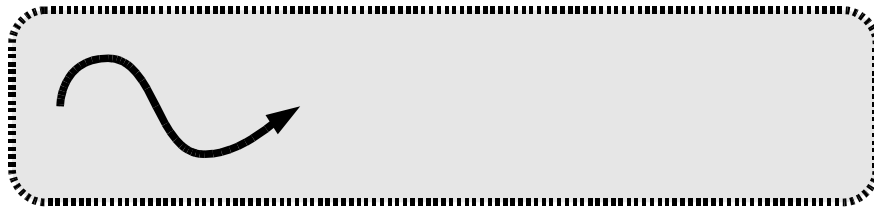
Amortizing GPS Costs



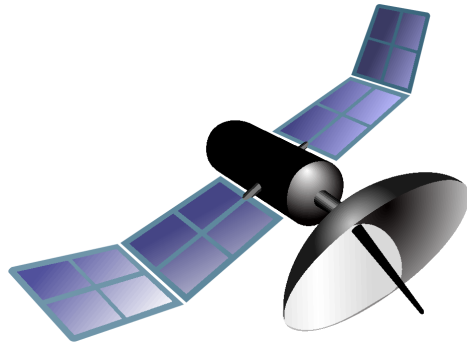
GPSd



maps



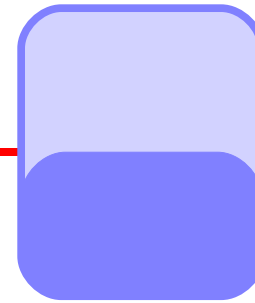
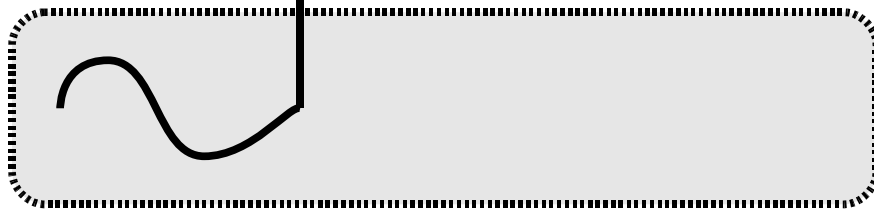
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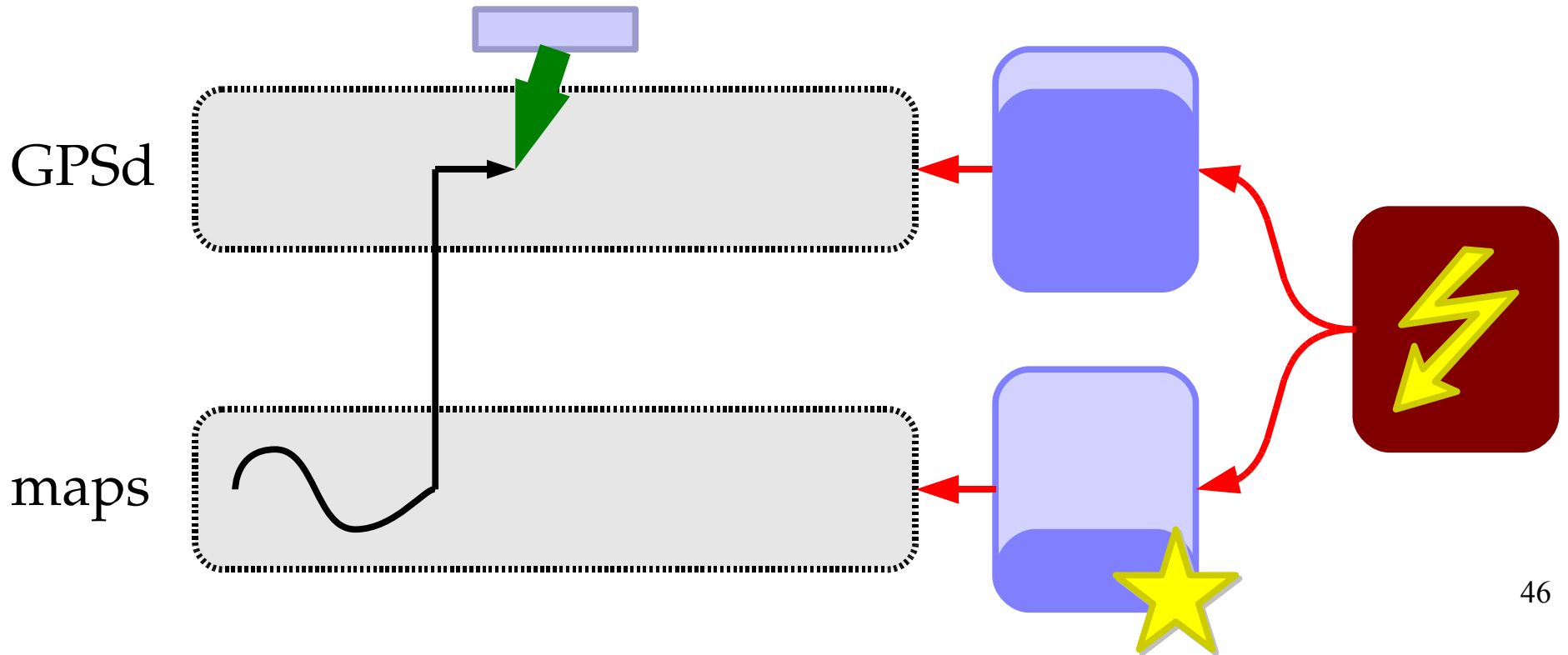
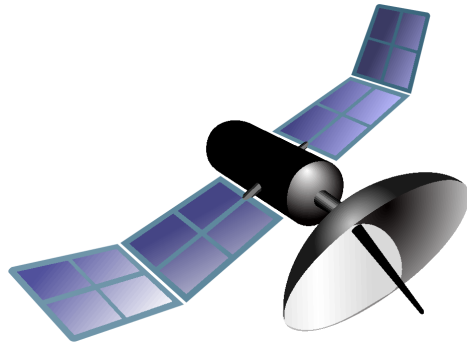
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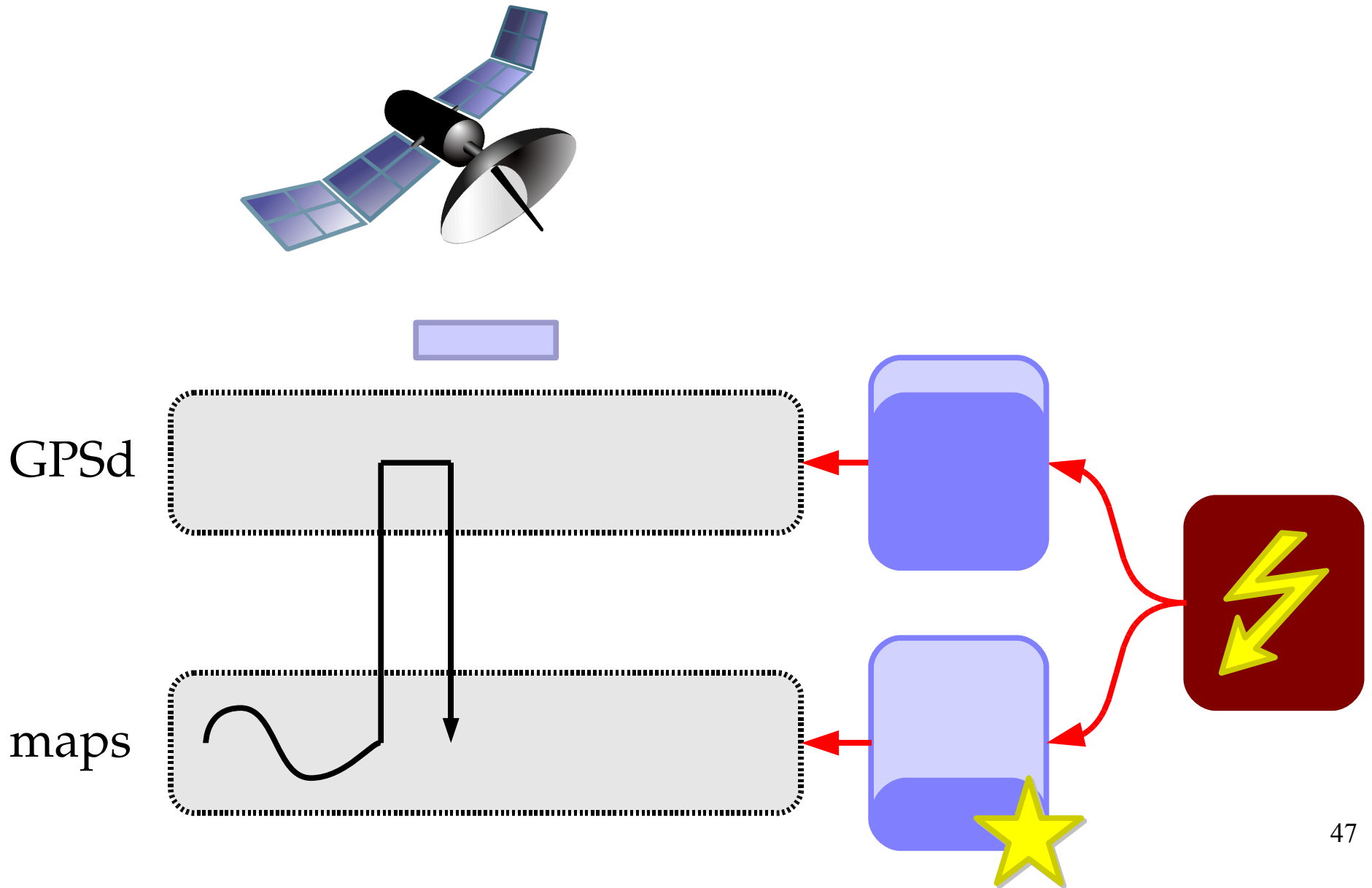
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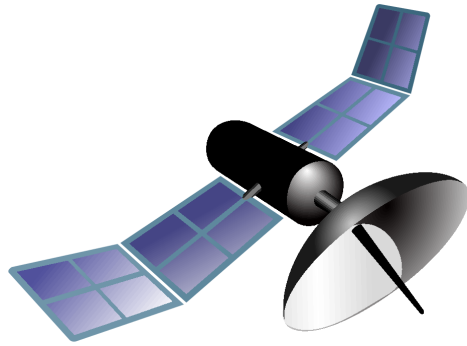
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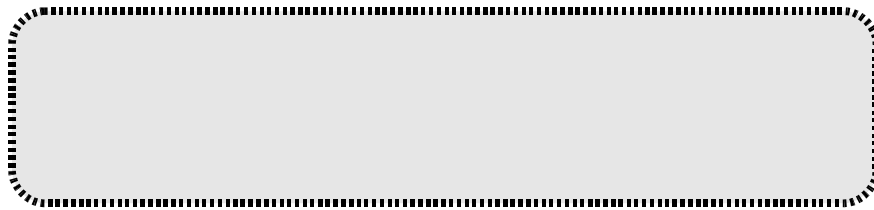
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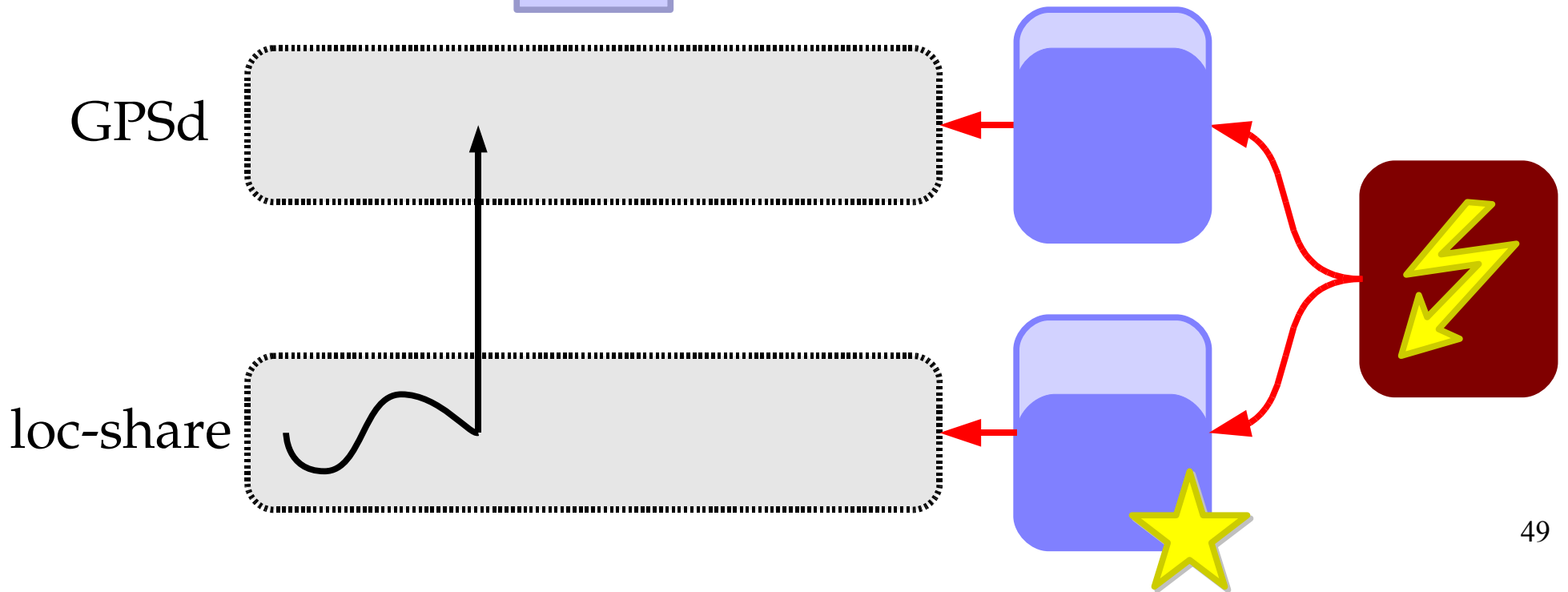
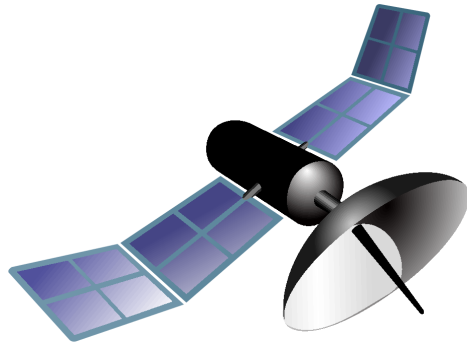
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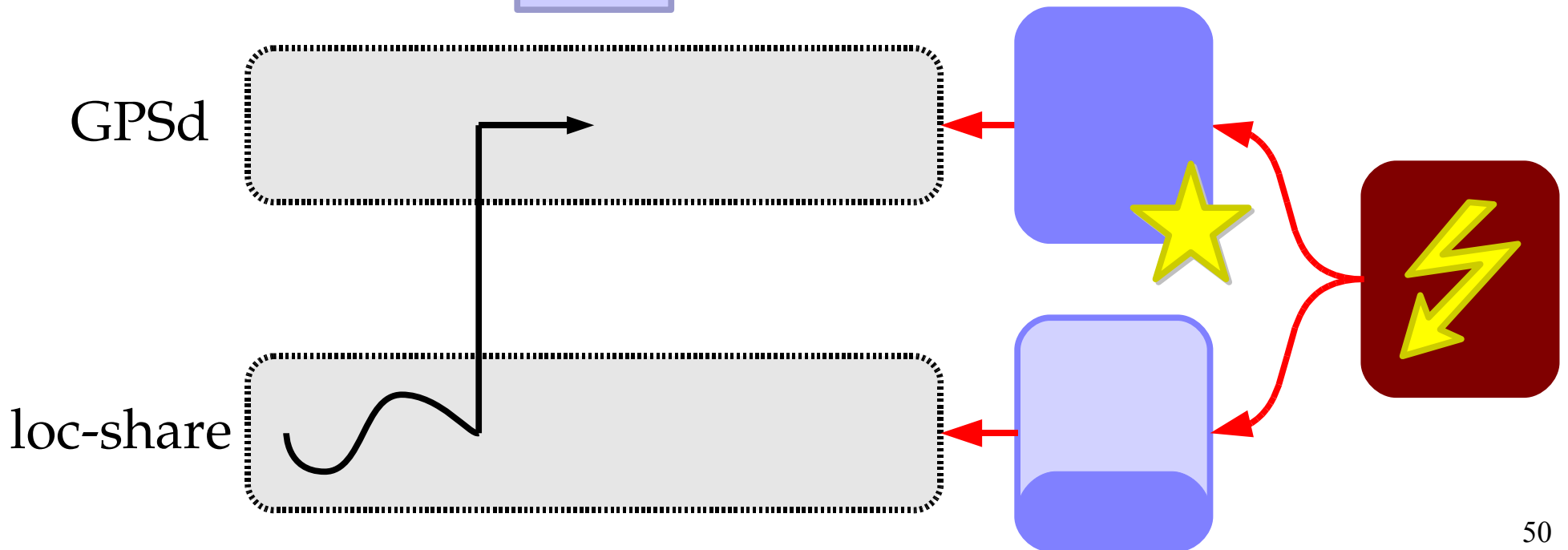
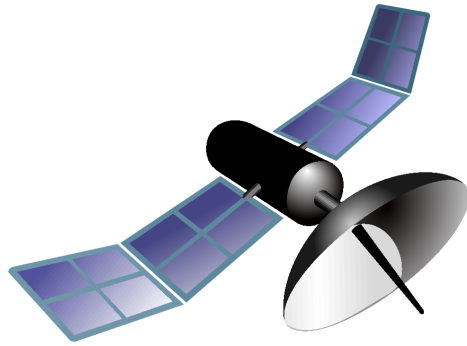
loc-share



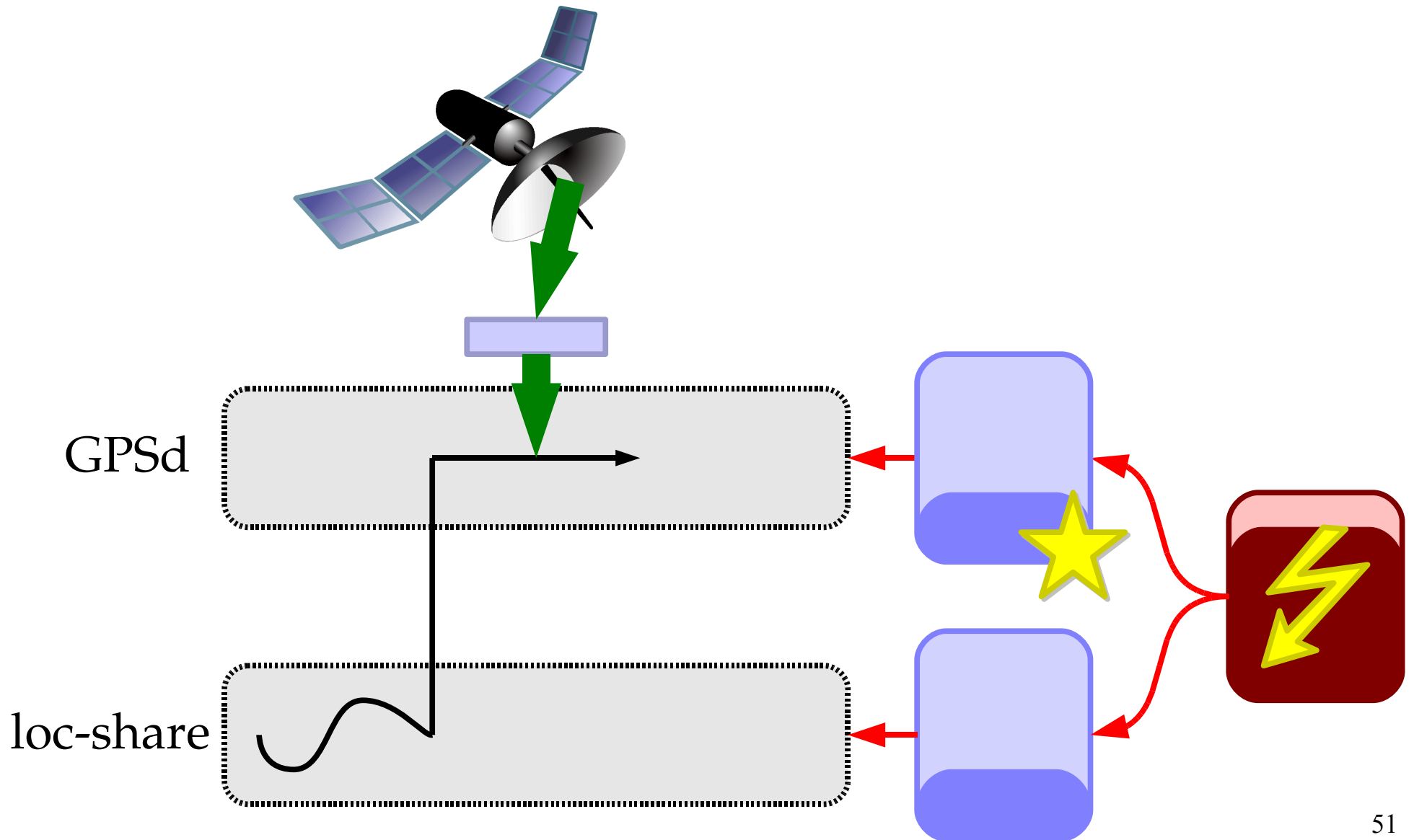
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