ENERGY MANAGEMENT IN MOBILE DEVICES WITH THE CINDER OPERATING SYSTEM

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PROBLEM

- memory and CPU time treated as first-class resources
- mobile devices are „the dominant end-user computing platform of the decade“
- **energy is the new speed**
- energy is not controllable at all
- (at least not like memory and CPU time)

MECHANISM

Reserve

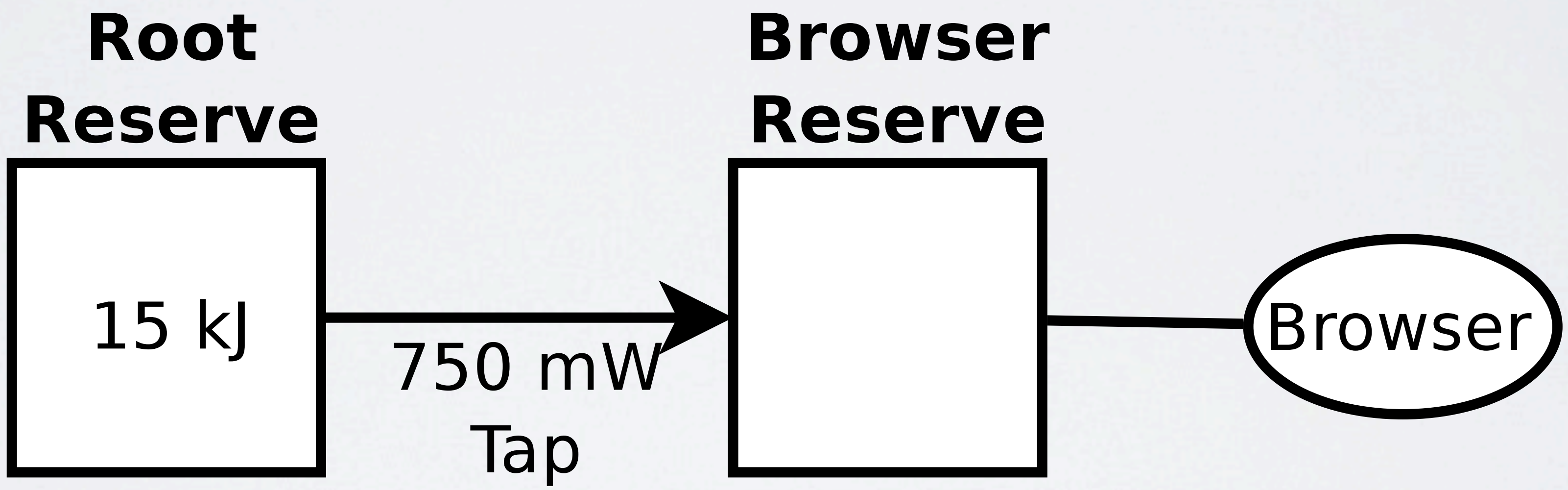
- right to use a given quantity of a resource
- when the resource is used, the reserve is consumed

Tap

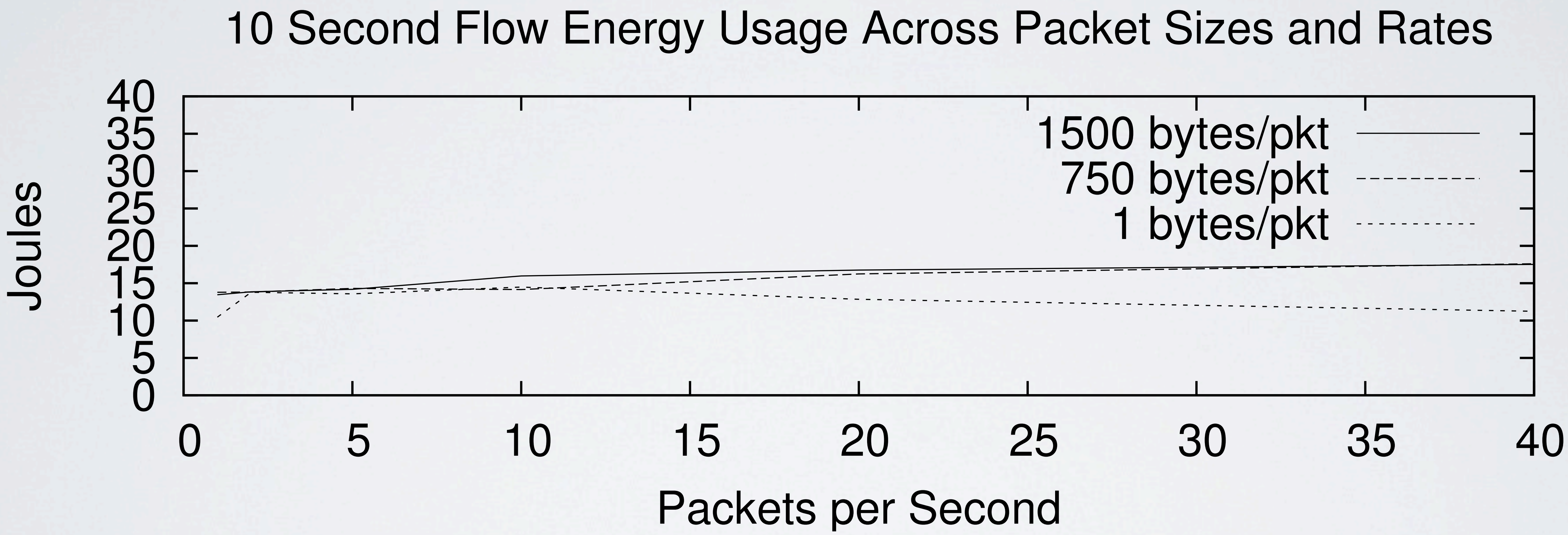
- conduit between a source and a sink reserve
- transfers specific rate of resource allowance

QUOTAS

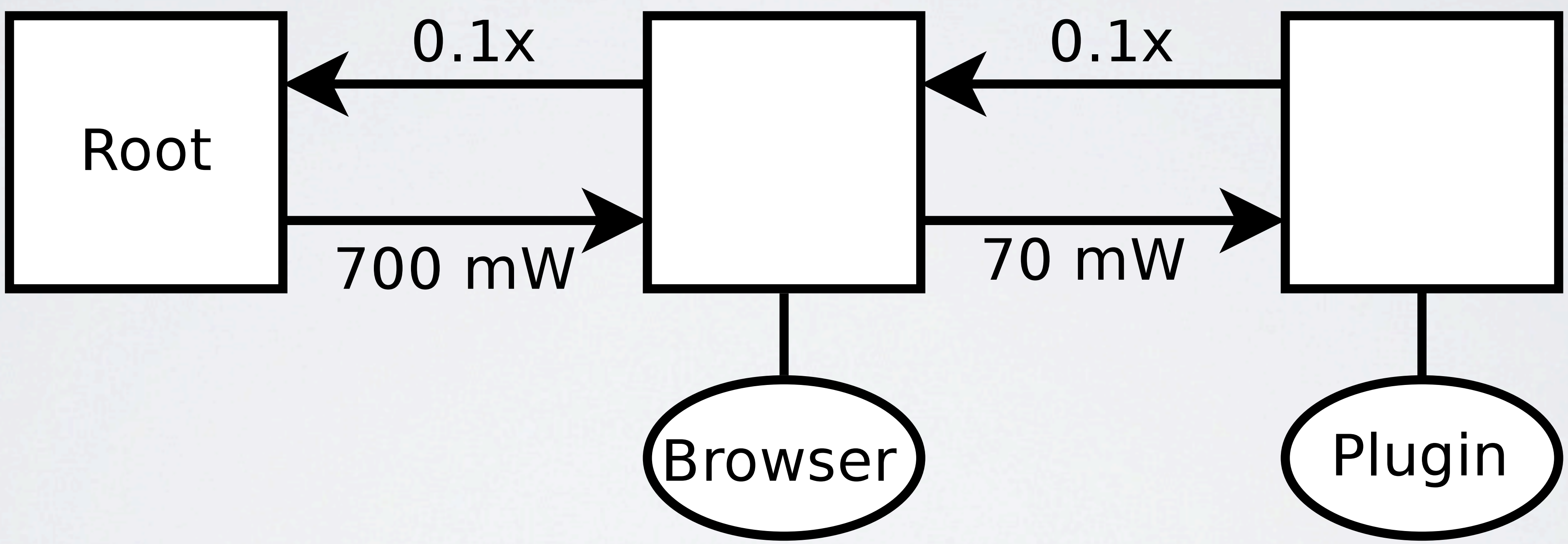
energy isolation, subdivision and delegation



SAVING ENERGY



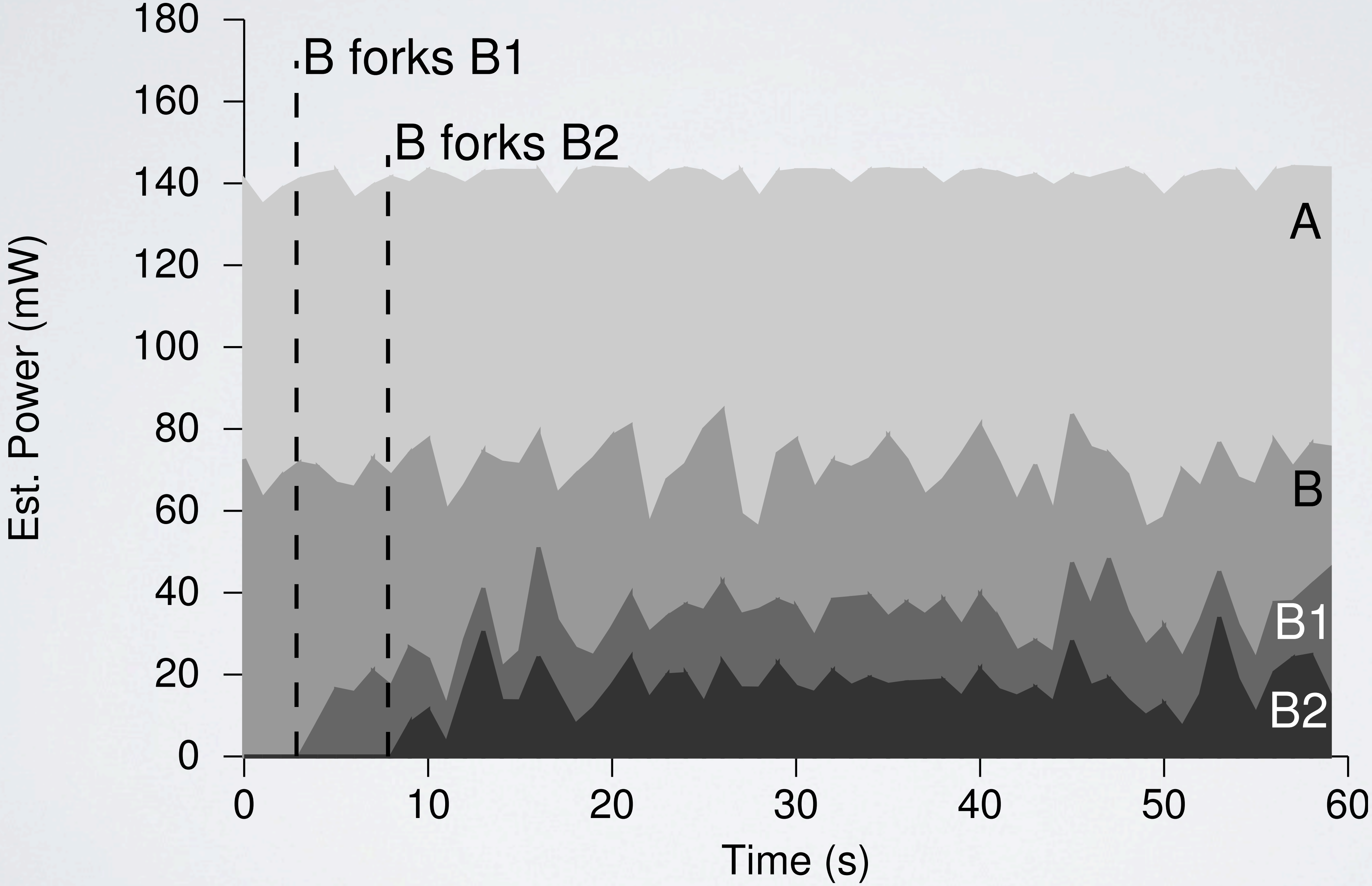
LIMIT ENERGY HOARDING



TIDBITS

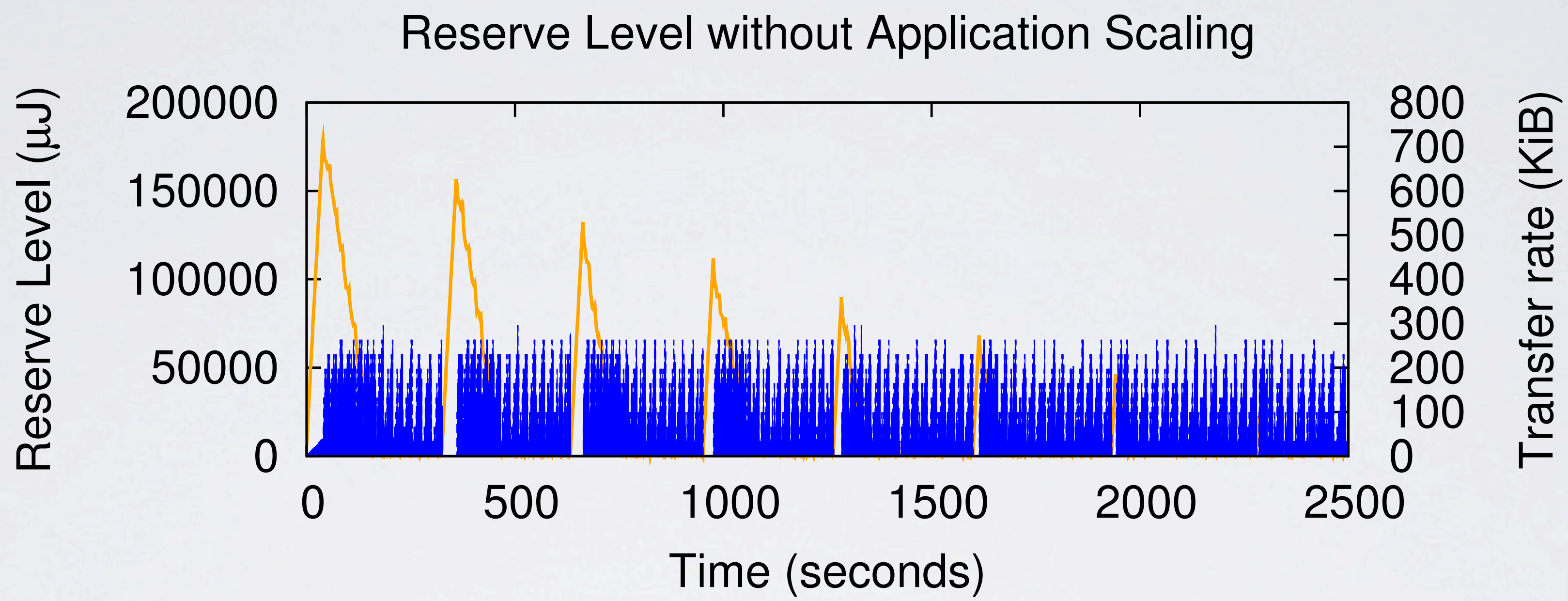
- applications can inspect their reserve and adapt
- different reserves for foreground and background operation
- executing a service depletes the caller's reserve
- multiple caller's can pool reserves to pay device startup cost
- *netd* short-sales reserve when receiving

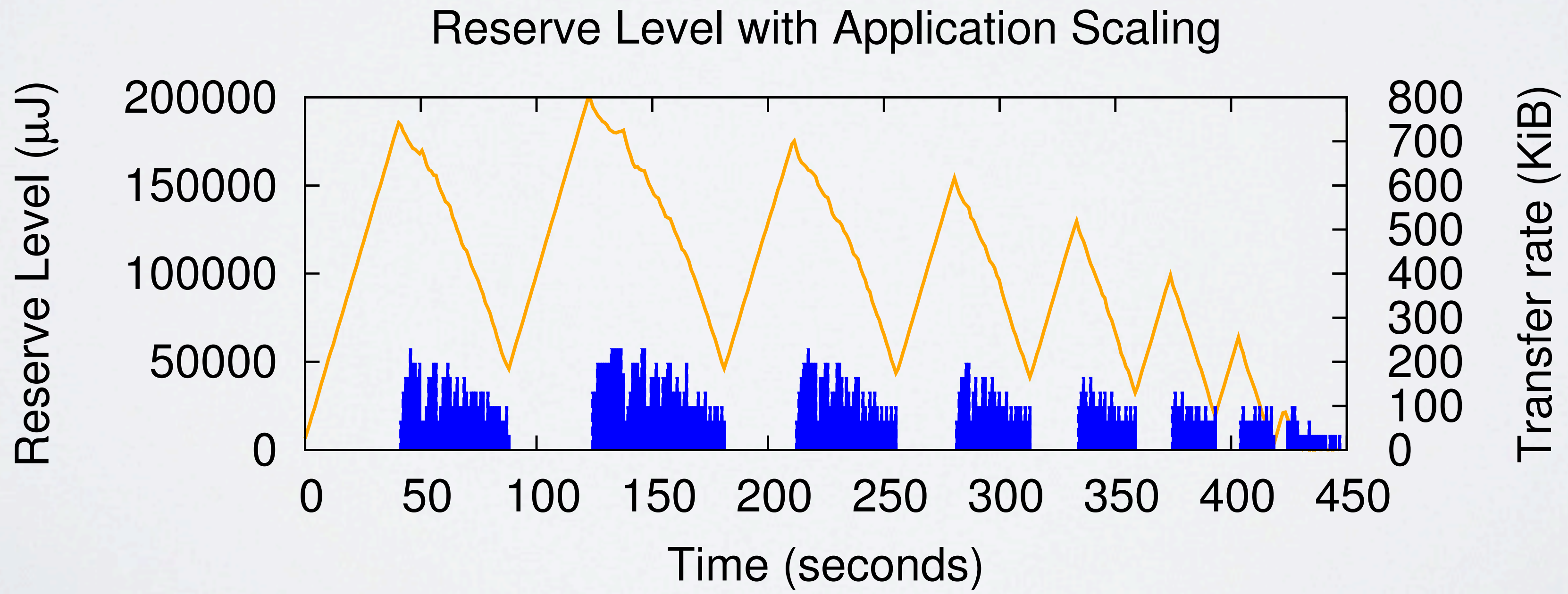
EVALUATION



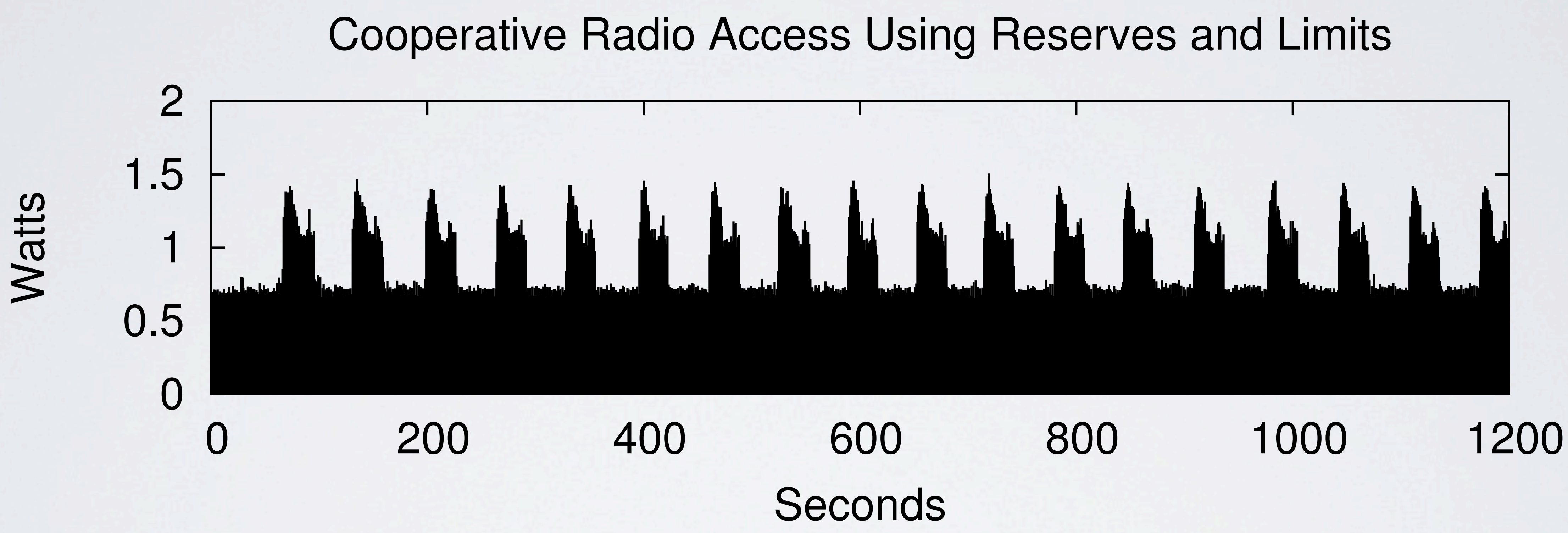
180
160
140
120
100
80
60
40
20
0
Est. Power (mW)
B forks B1
B forks B2
A
B
B1
B2
0
10
20
30
40
50
60
Time (s)

ADAPTIVE APPLICATION



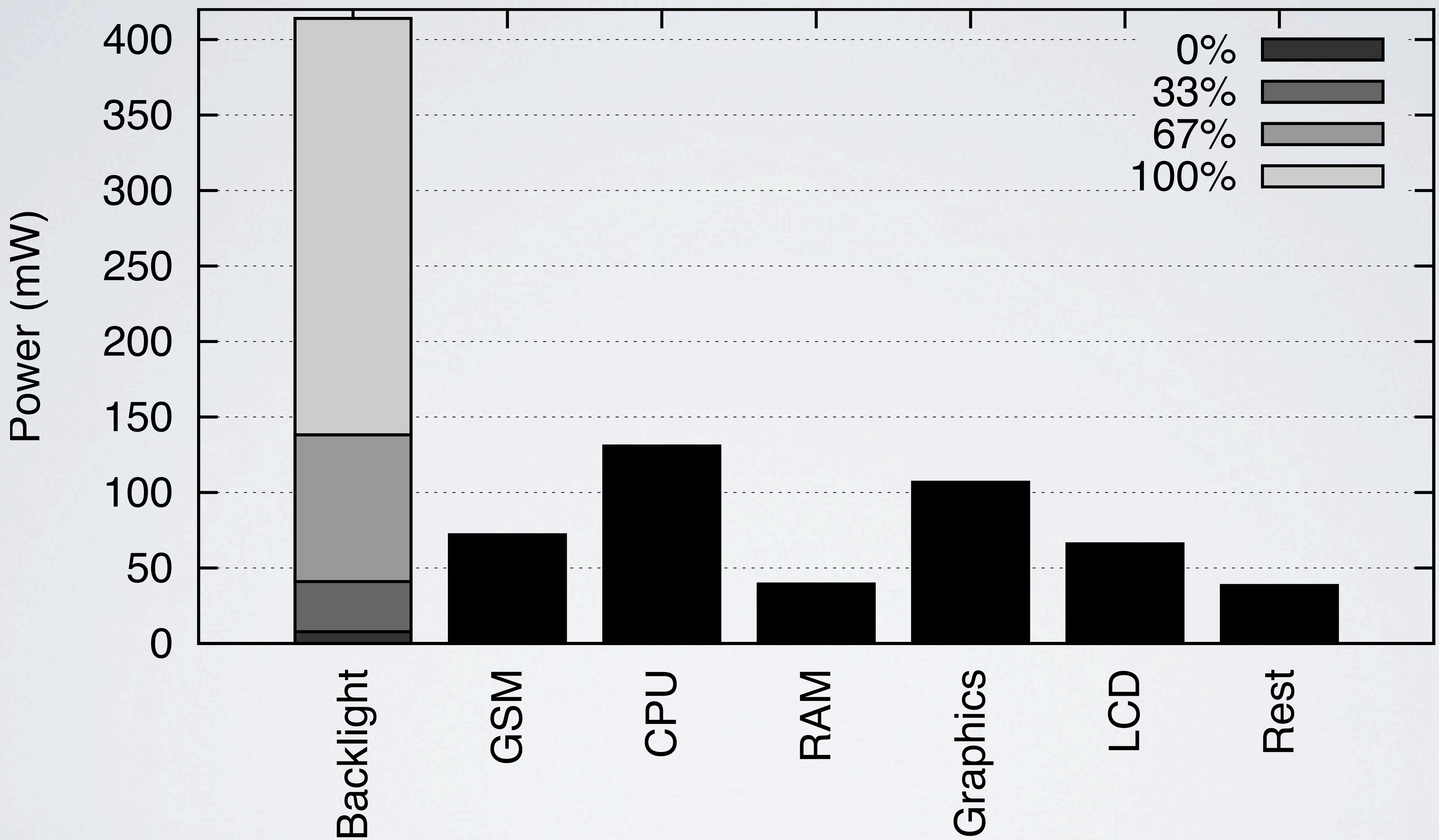


POOLING

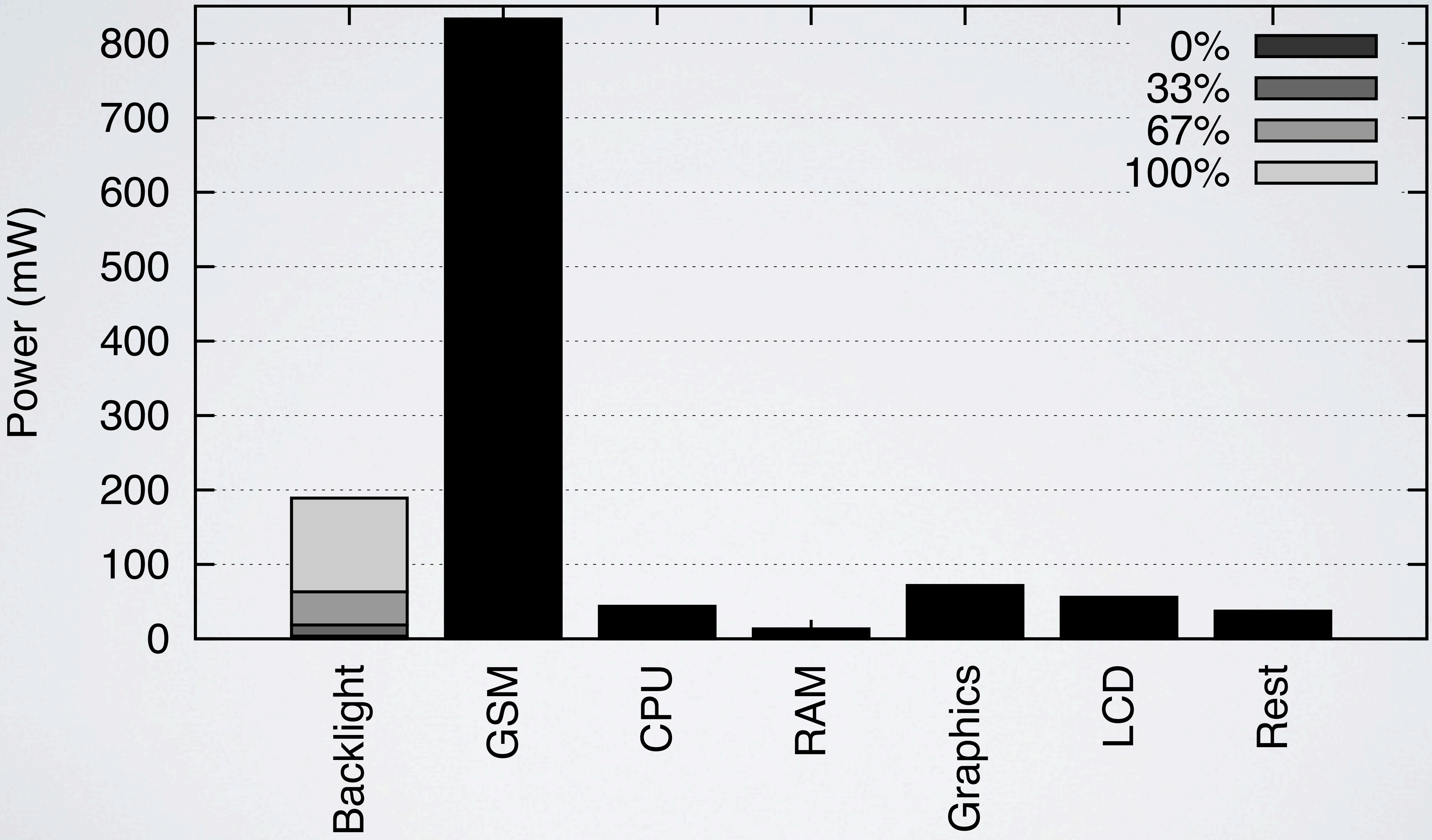

Cooperative Radio Access Using Reserves and Limits
Watts
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
Seconds

SUMMARY

- token-bucket shaping for energy use
- throttling threads when energy reserve is depleted
- enables energy isolation and controlled delegation
- applications can adapt and pool



Power (mW)
0
50
100
150
200
250
300
350
400
0%
33%
67%
100%
Backlight
GSM
CPU
RAM
Graphics
LCD
Rest



Power (mW)
800
700
600
500
400
300
200
100
0
0%
33%
67%
100%
Backlight
GSM
CPU
RAM
Graphics
LCD
Rest

DISCUSSION

- interesting mechanism, but does it allow useful management?
- thinking inside the box: energy should be like CPU time
  - hard: deadlines are inherent, energy cap is not
- thinking outside the box: system does only useful work
  - efficiency: order requests to use resource better
  - adaptivity: quality-resource tradeoff