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An Analysis of Power Consumption in a Smartphone

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Motivation

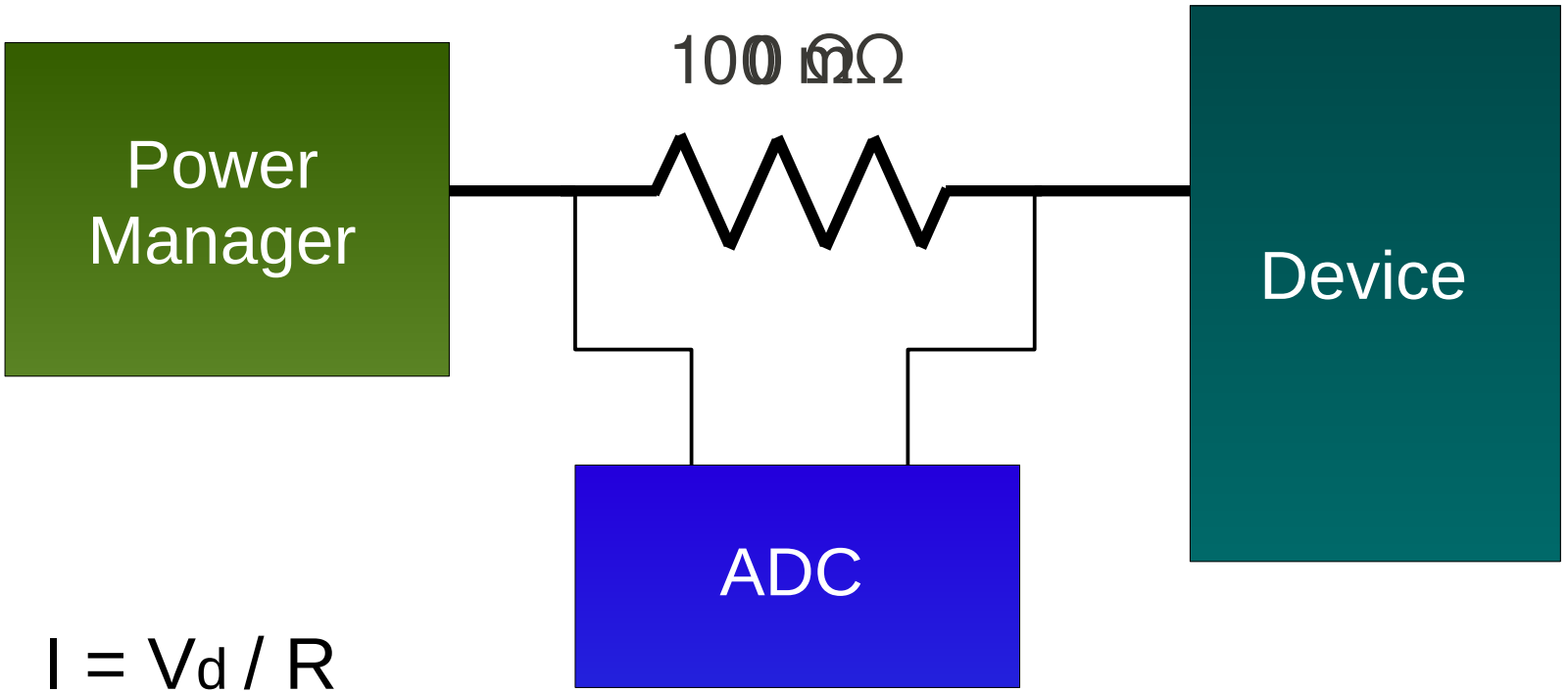
Problem

- Where and how is power consumed in a smartphone?
- Approach: fine-grained instrumentation of a real device

Methodology

- OpenMoko Freerunner
  - 2.5G smartphone, c. 2008
  - 400 MHz ARM9
  - Lacking camera, 3G modem
  - Open design
  - Amenable to power instrumentation

Methodology



$I = V_d / R$

$P = IV$

Methodology

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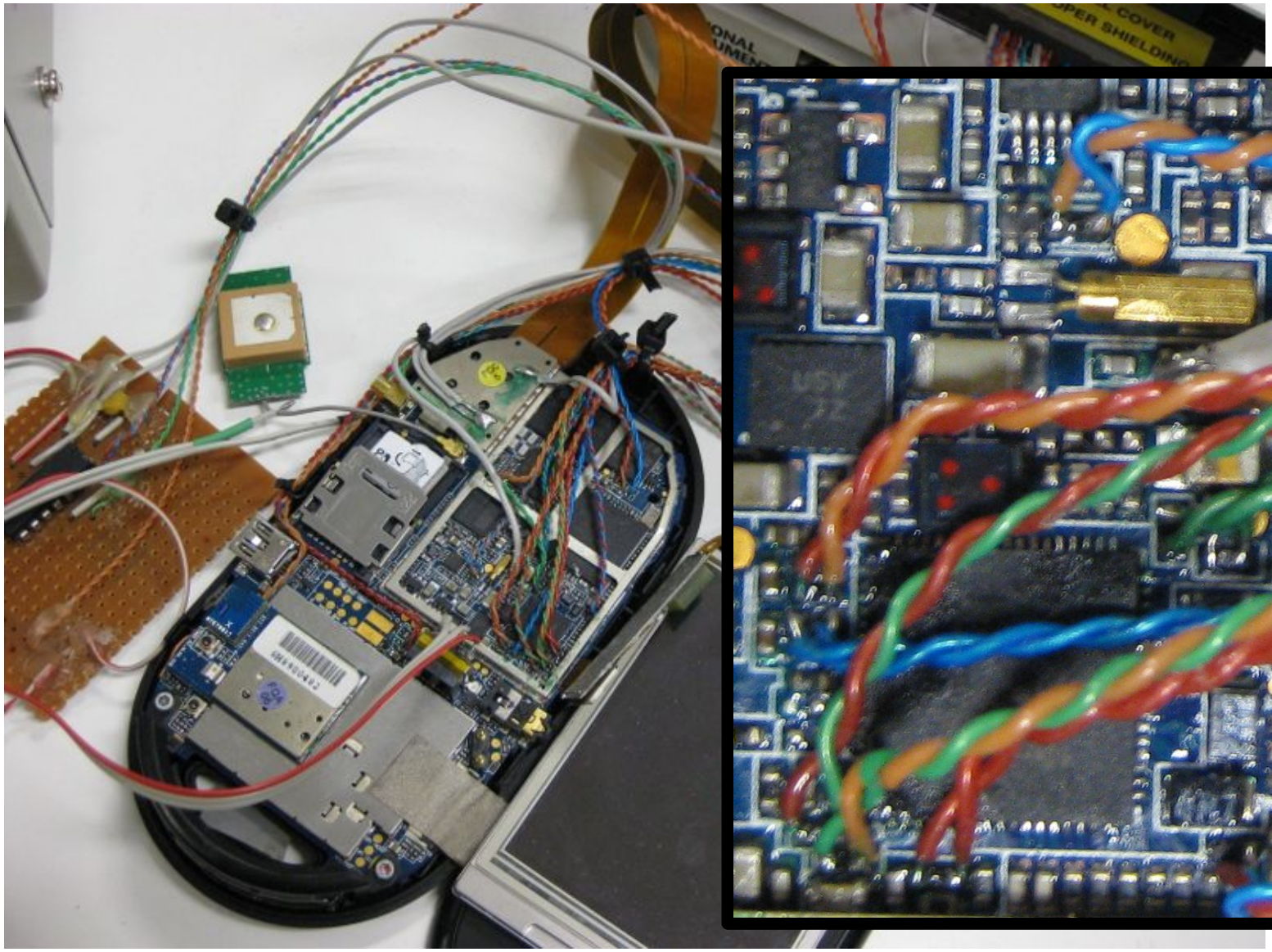


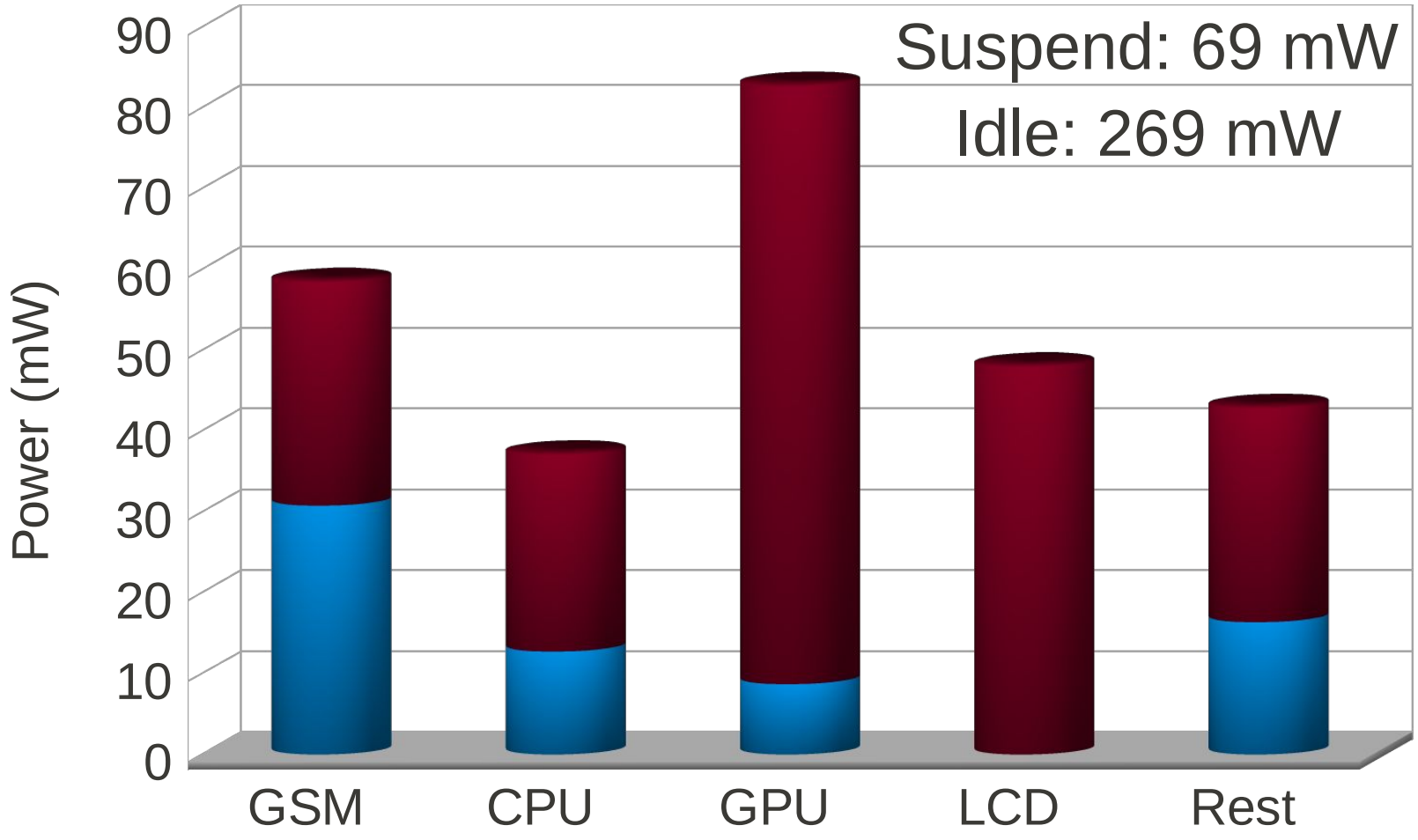
Methodology

- Instrumented components
  - CPU
  - RAM
  - GSM
  - GPS
  - Bluetooth
  - LCD panel
  - WiFi
  - Backlight
  - Audio codec
  - Amplifier
  - NAND flash
  - SD card

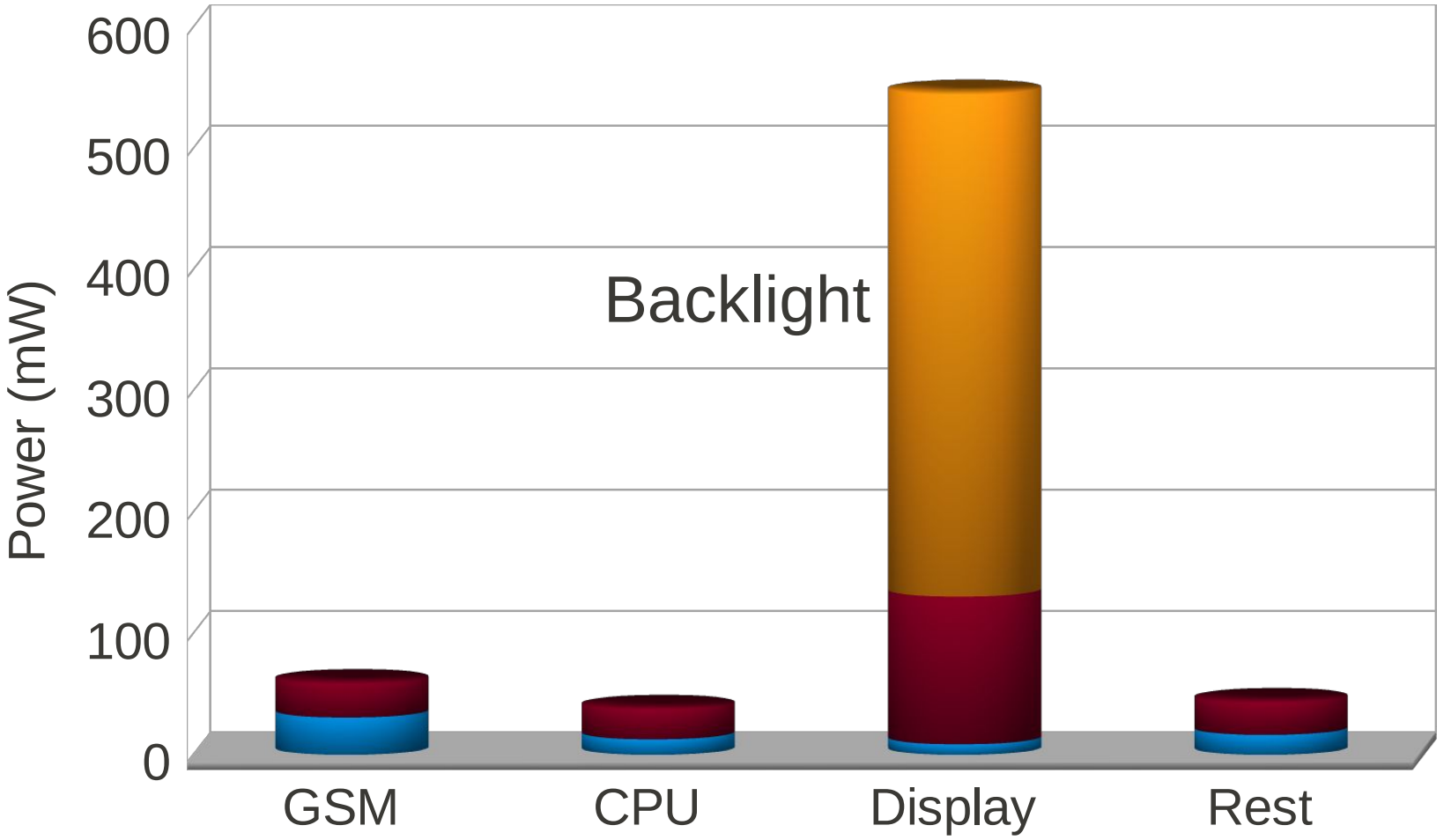
Benchmarks

- Micro-benchmarks
  - Suspend
  - Idle
  - Backlight
  - CPU/RAM
  - Flash storage
  - Network
  - GPS
- Usage scenarios
  - Audio
  - Video
  - SMS
  - Email
  - Web
  - Call

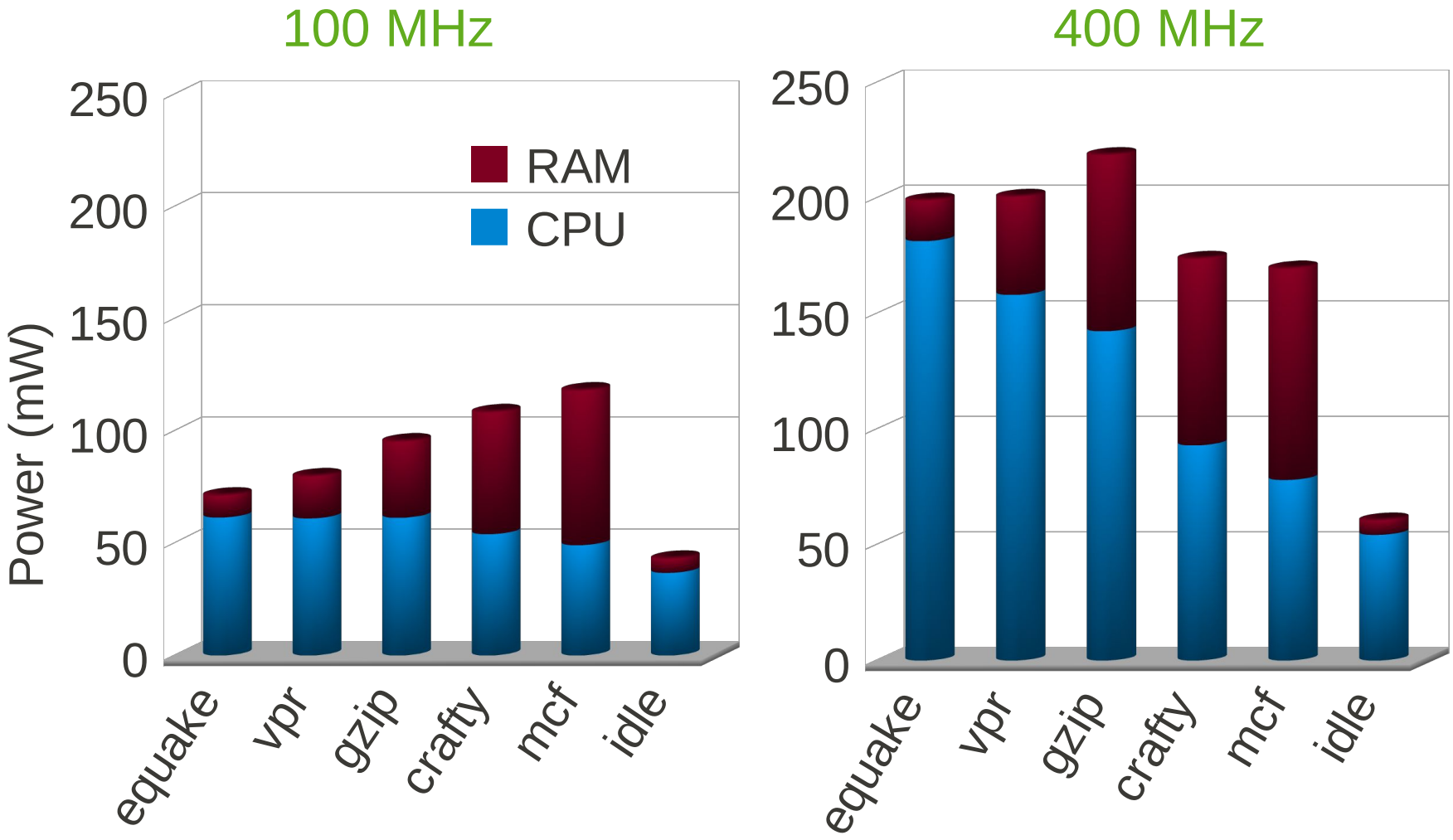
Idle Power



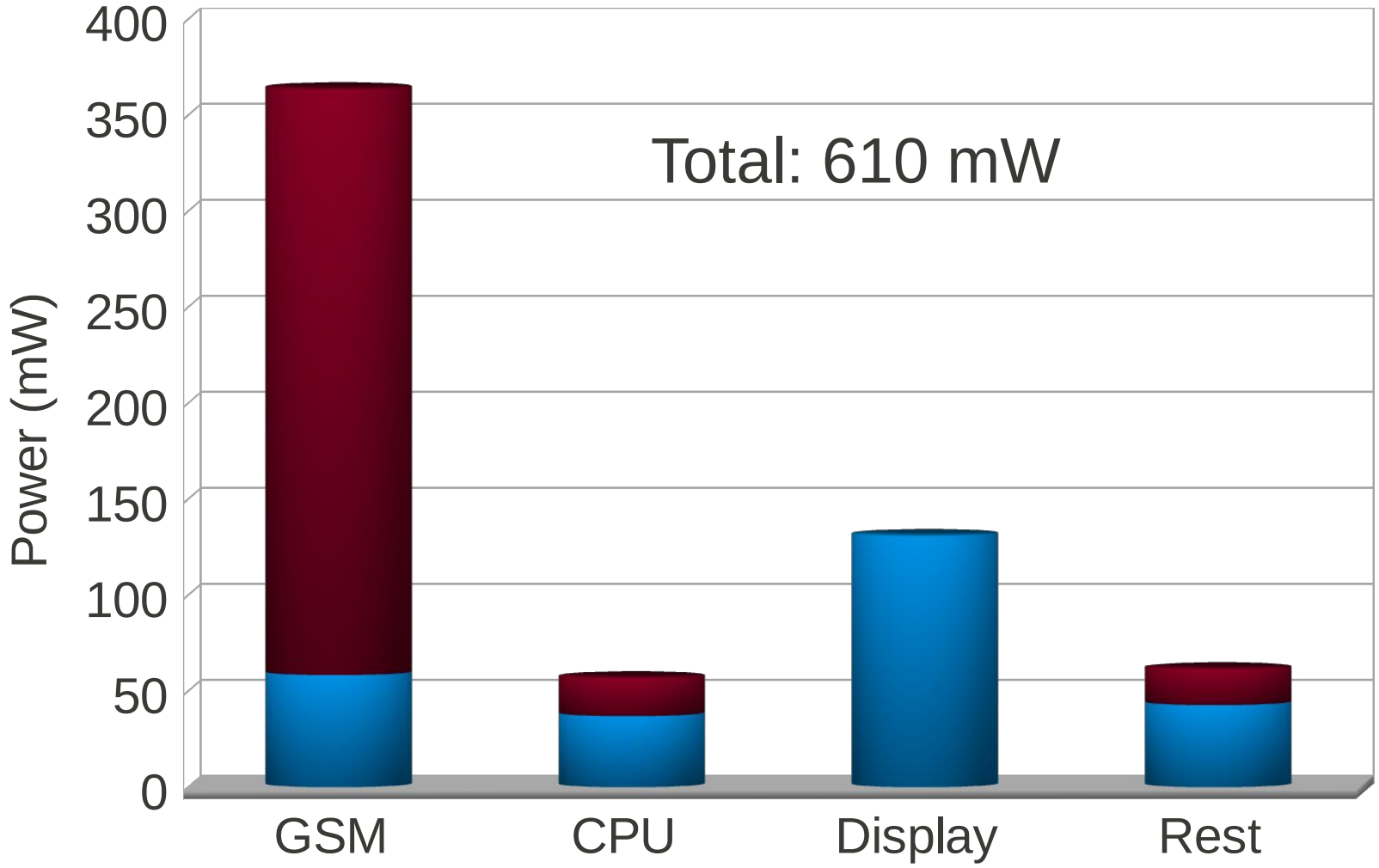
Display Power



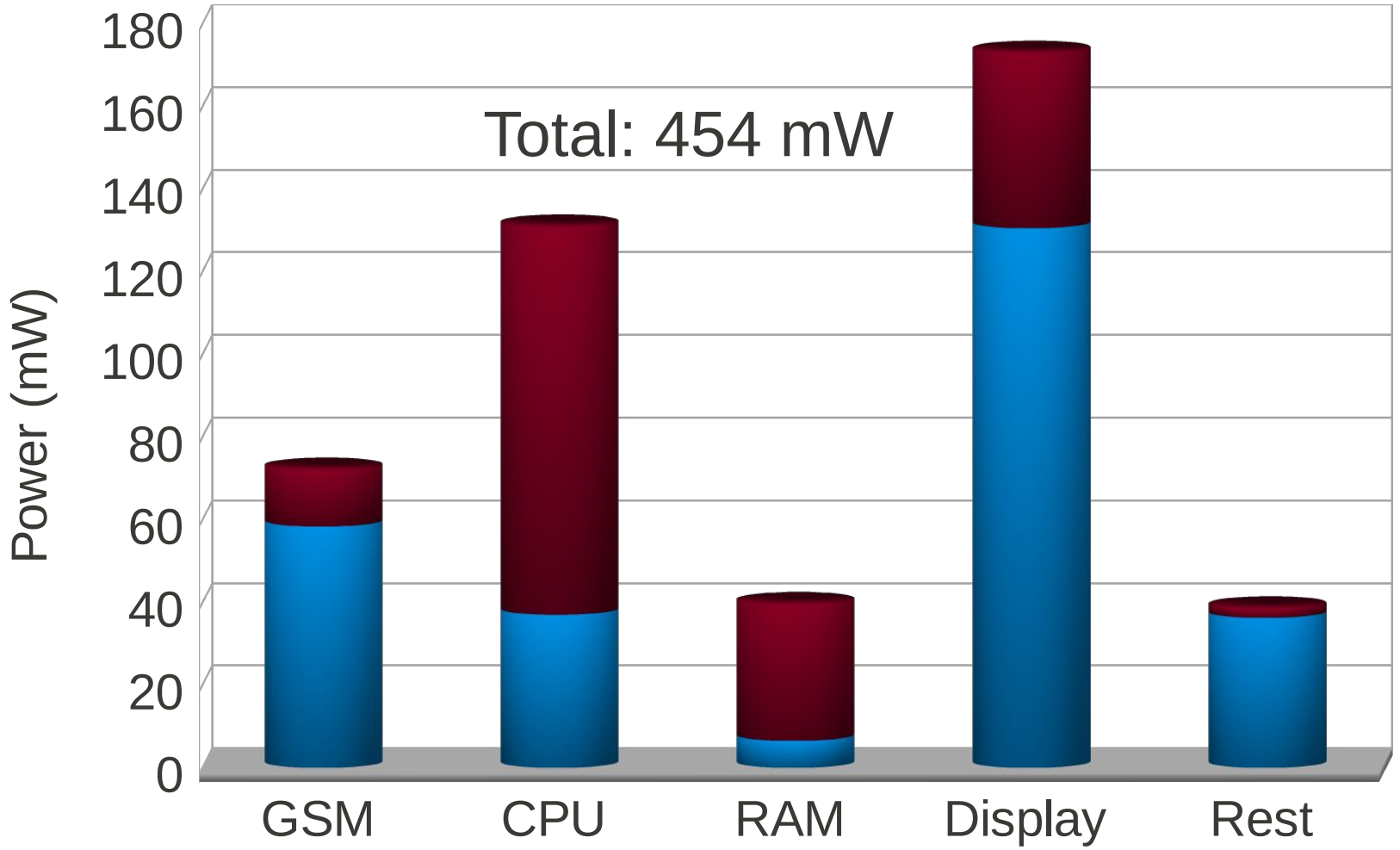
CPU and RAM



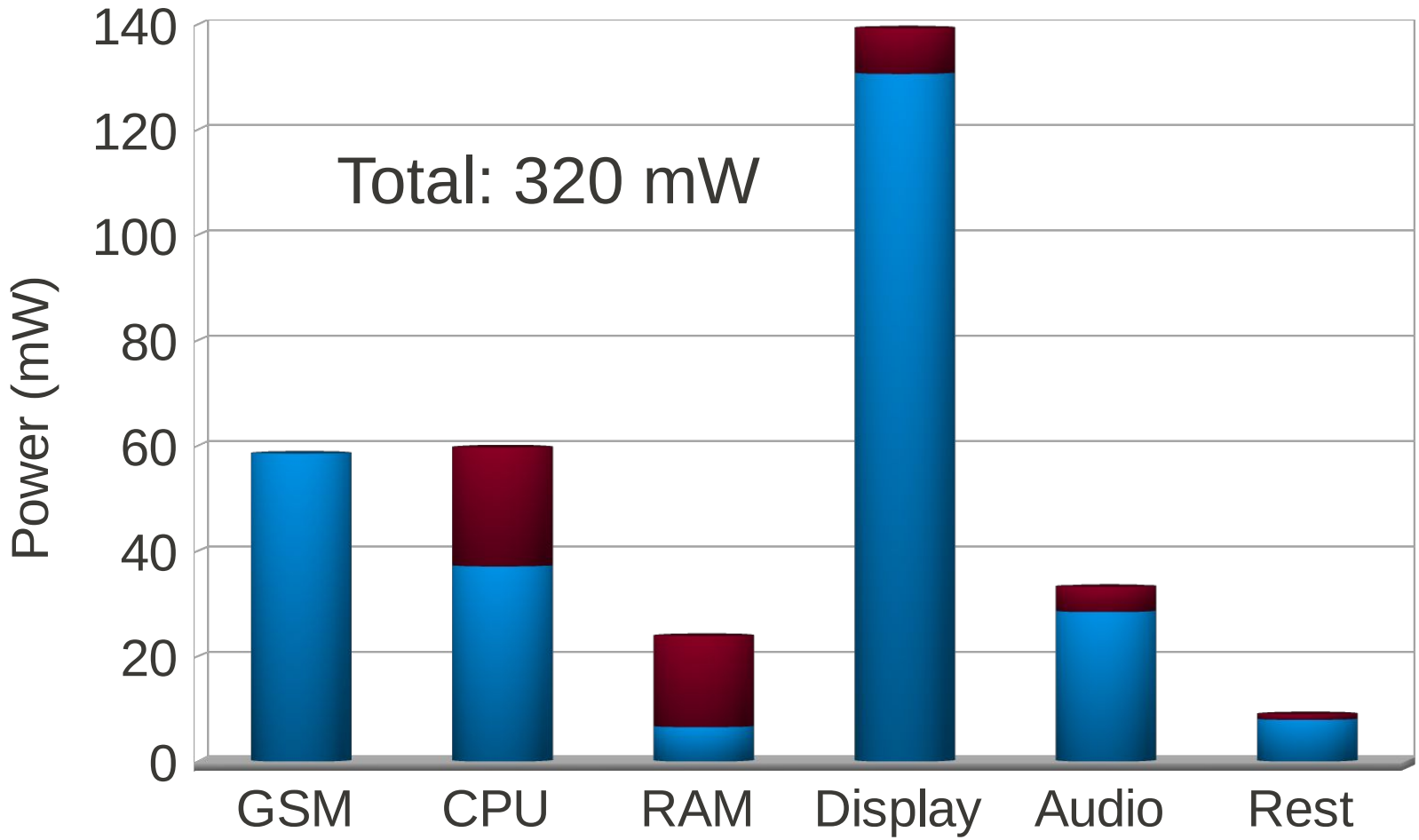
Email



Video



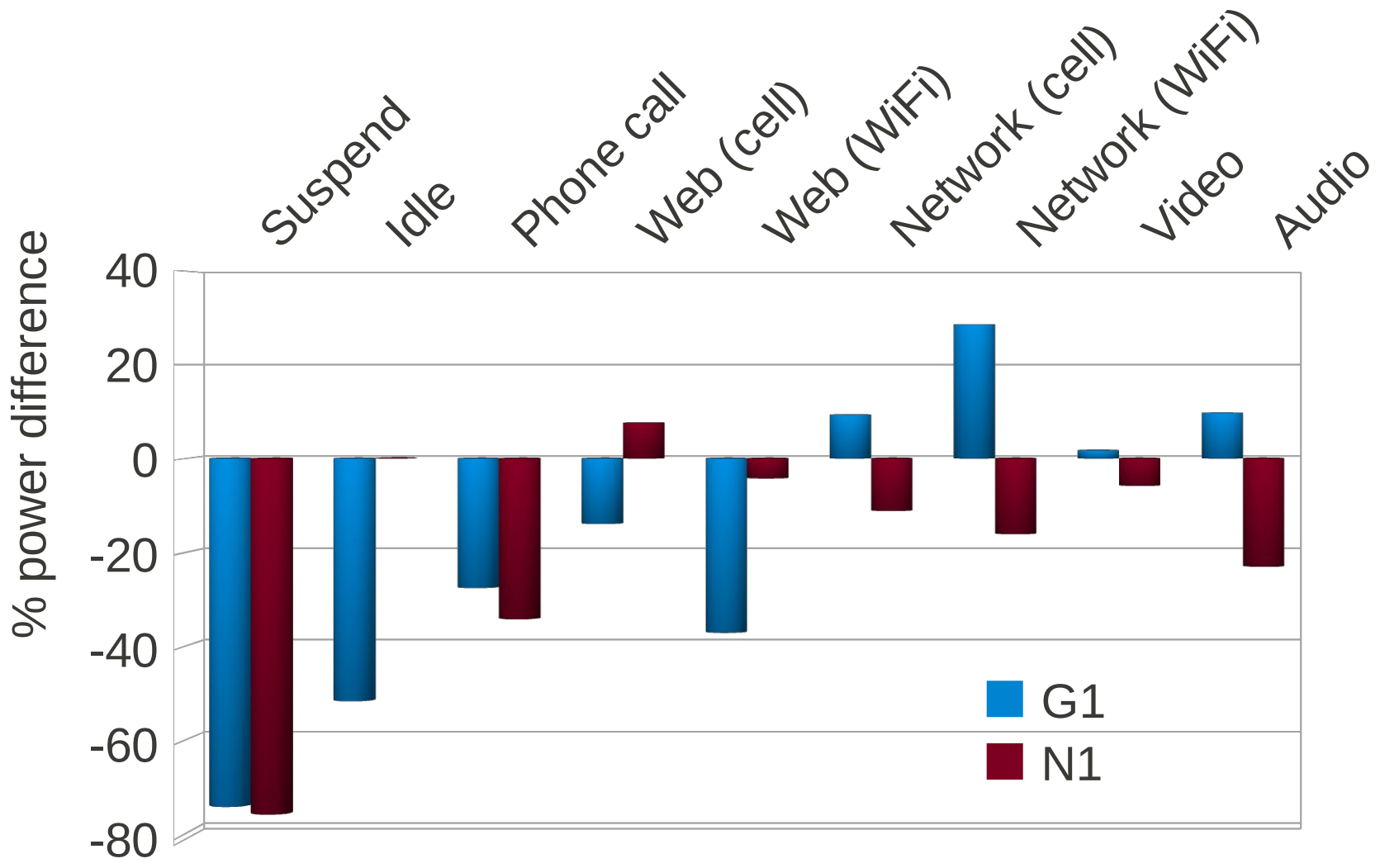
Audio



Validation

- Benchmarks repeated on two devices:
  - HTC Dream (G1)
  - Google Nexus One (N1)
- Total system power only
- 3-4 years of mobile technology

Validation

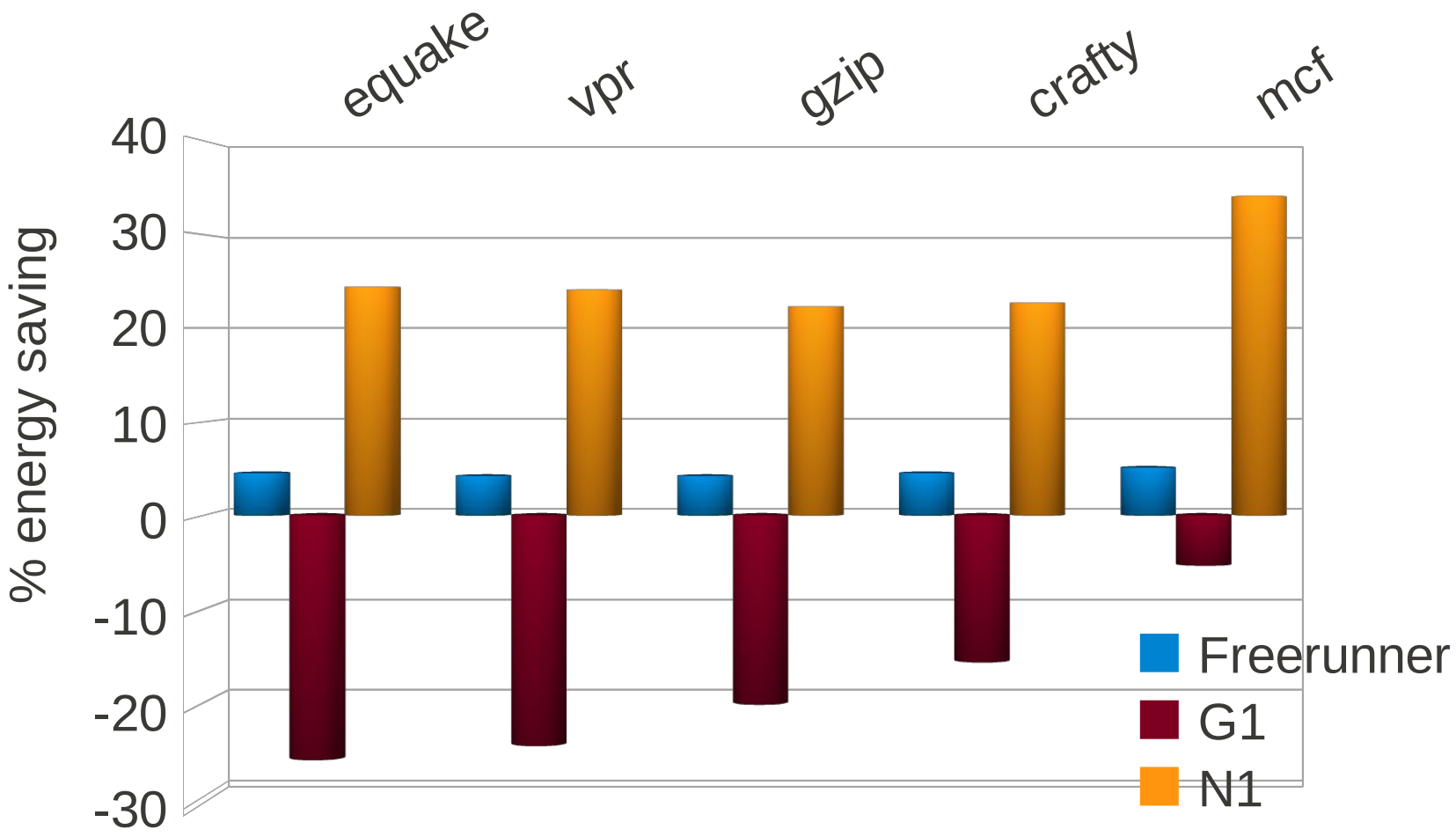


DVFS

- Dynamic Voltage and Frequency Scaling
- DVFS reduces power

  … but does it reduce energy?

DVFS



Conclusions

- Major consumers: display & cell radio
  - WiFi power low in most situations
- CPU can be significant
  - Future power driver
- Where power is **not** going:
  - RAM
  - Audio
  - Bluetooth
  - Storage

Conclusions

- Both dynamic and static power important
- DVFS hanging on (for now)
- Networking power not increasing