

Power Management for Mobile CPU

DVFS for Embedded Linux

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What is Power?

- General Terms
 - Ability to do something
 - Collins Cobuild
 - In physics, power is the rate at which work is performed or energy is converted.
 - wikipedia.org

What is Power?

- The energy consumed by electric components



Why is Power Important?

- More need for power
 - More components into a mobile equipment
 - More powerful functions need more power
- The longer, the better



CPU Power Consumption

- Why CPU?
 - It's the most important for computer systems



CPU Power Consumption

- Why CPU?
 - It's known as one of the most power-consuming devices in computers



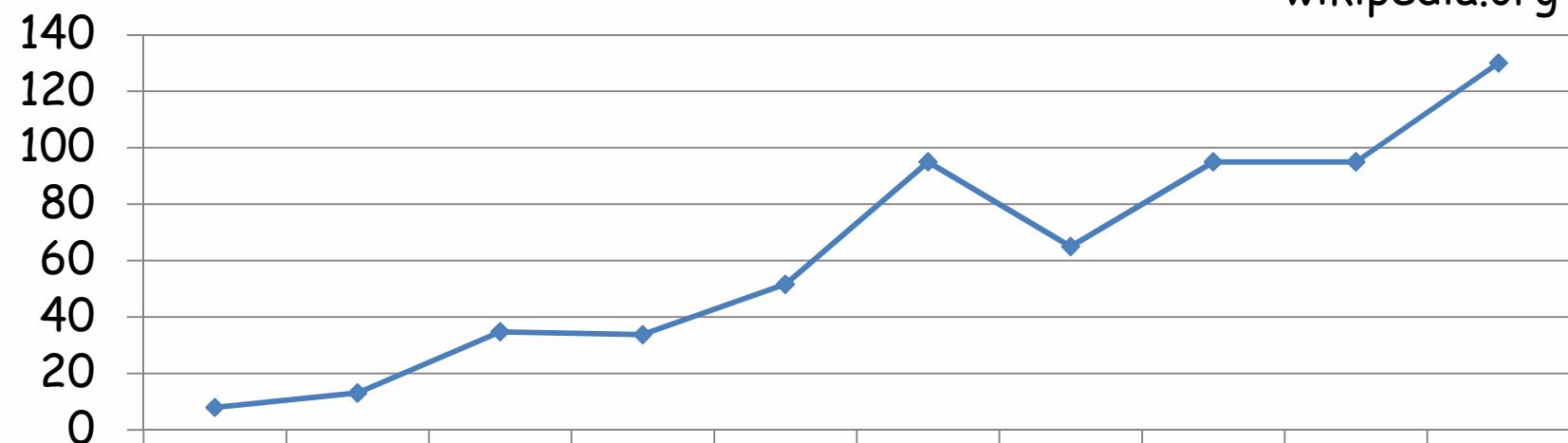
Full: 224W
Idle: 143W



Full: 133W
Idle: 107W

Processors are Evolving

Unit: W



We need something COOL

DVFS

- Dynamic Voltage & Frequency Scaling
 - Allowing devices to dynamically change their voltage and frequency level
 - To utilize varying performance needs

$$P = C \cdot V^2 \cdot f$$

$$f \propto V$$

Examples of DVFS

- Enhanced Intel Speedstep Technology
 - Intel
- Cool'n'Quiet
 - AMD desktop, server chips
- PowerNow!
 - AMD mobile chips

Is It Important?

Lower Power Capabilities

Enhanced Intel® SpeedStep® Technology

Allows for better match of performance to application demand.

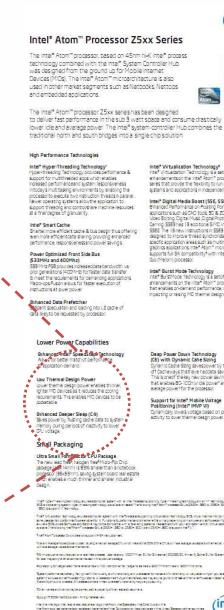
Low Thermal Design Power

Lower thermal design power enables thinner, lighter MID devices as it reduces the cooling requirements. This enables MID devices to be pocketable.

Enhanced Deeper Sleep (C4)

Saves power by flushing cache data to system

Atom Z5xx Brochure



Is It Important?

Samsung S3C6410 Key Features

- ARM1176ZJF 533/667MHz VFP/SIMD
- 65nm low-power process
- DVFS power management
- Dedicated x32 mDDR/DDR, x32 mSDR/SDR
- WVGA or higher display resolution
- Hard-wired 3D GFX accelerator

S3C6410 Brochure



Deep into the Mobile CPU



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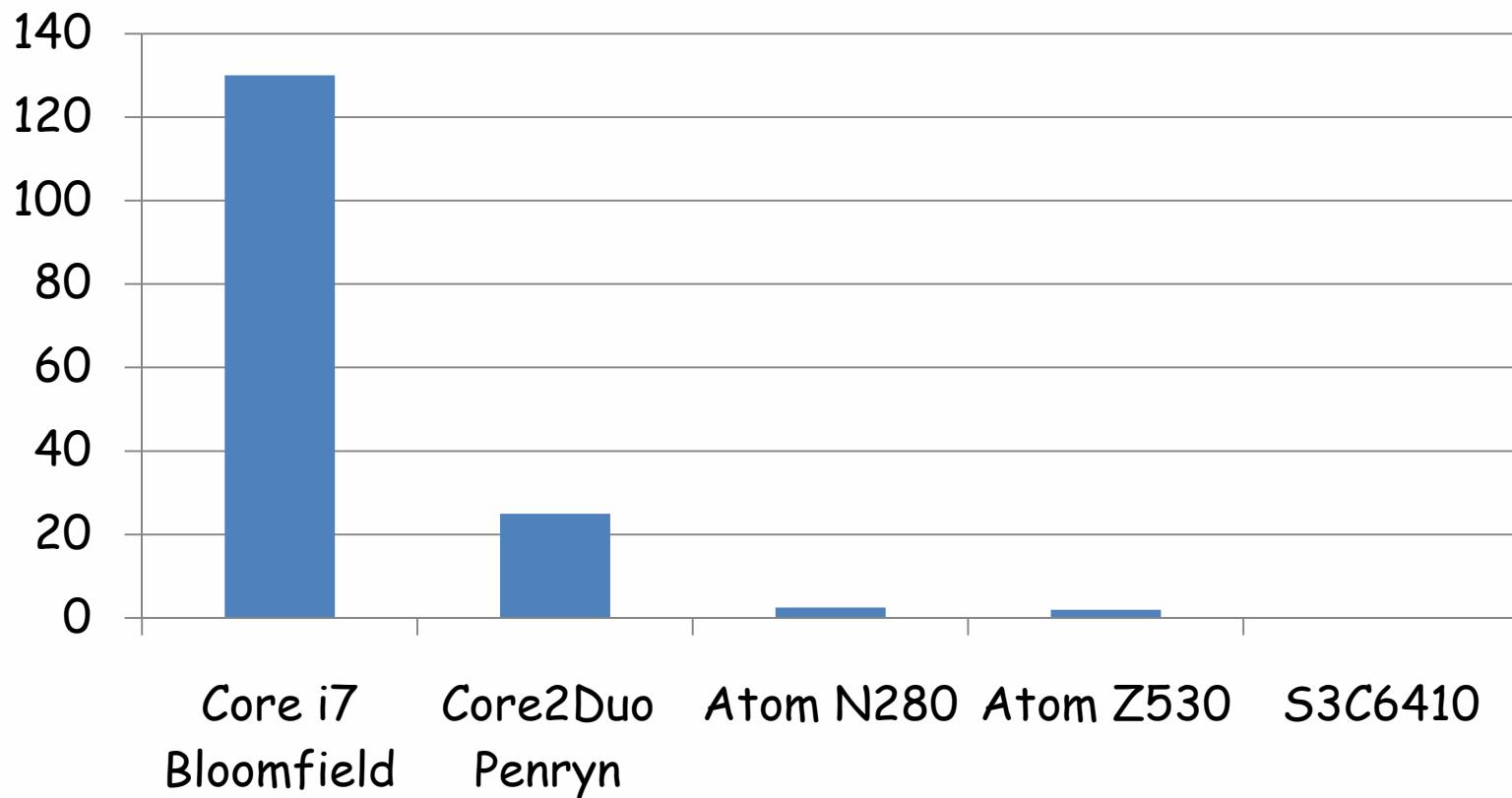
CPU Power Consumption

- CPU is one of ...
 - The most power-consuming devices in the desktop computers
 - The least power-consuming devices in the mobile devices



Anorexia of Mobile CPU

Unit: W

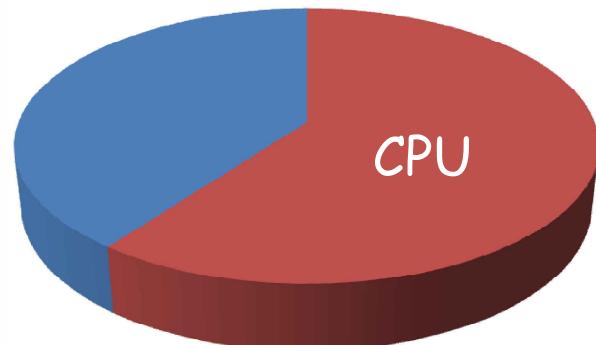


Some data from http://en.wikipedia.org/wiki/List_of_CPU_power_dissipation

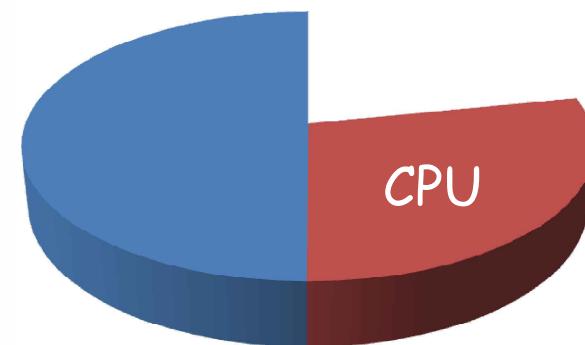
How about Server?

- Xeon Server
 - Intel Xeon E5520 Quadcore 2.26GHz x 2
 - Total 8 cores with SMT
 - Can save 59W of total 225W

2.26 GHz



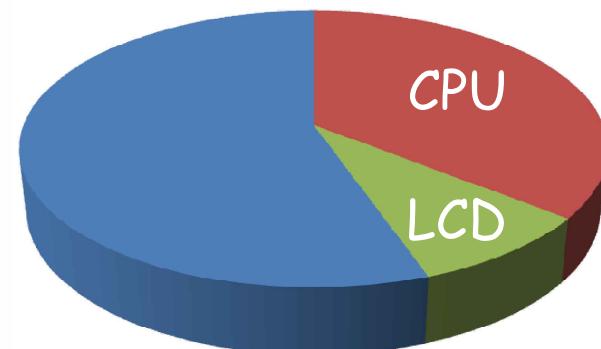
1.6 GHz



How about Laptop?

- Lenovo X60
 - Intel Core Duo T2400 1.83 GHz
 - 2 cores
 - Can save 16W of total 56W

1.83 GHz

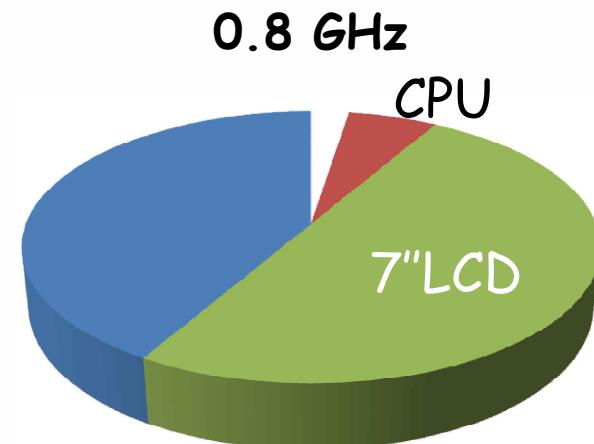
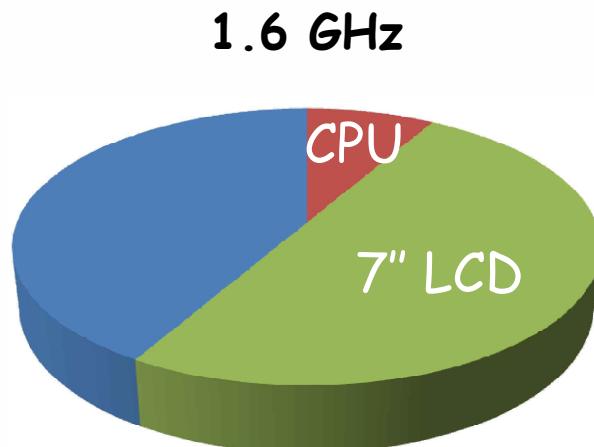


1 GHz



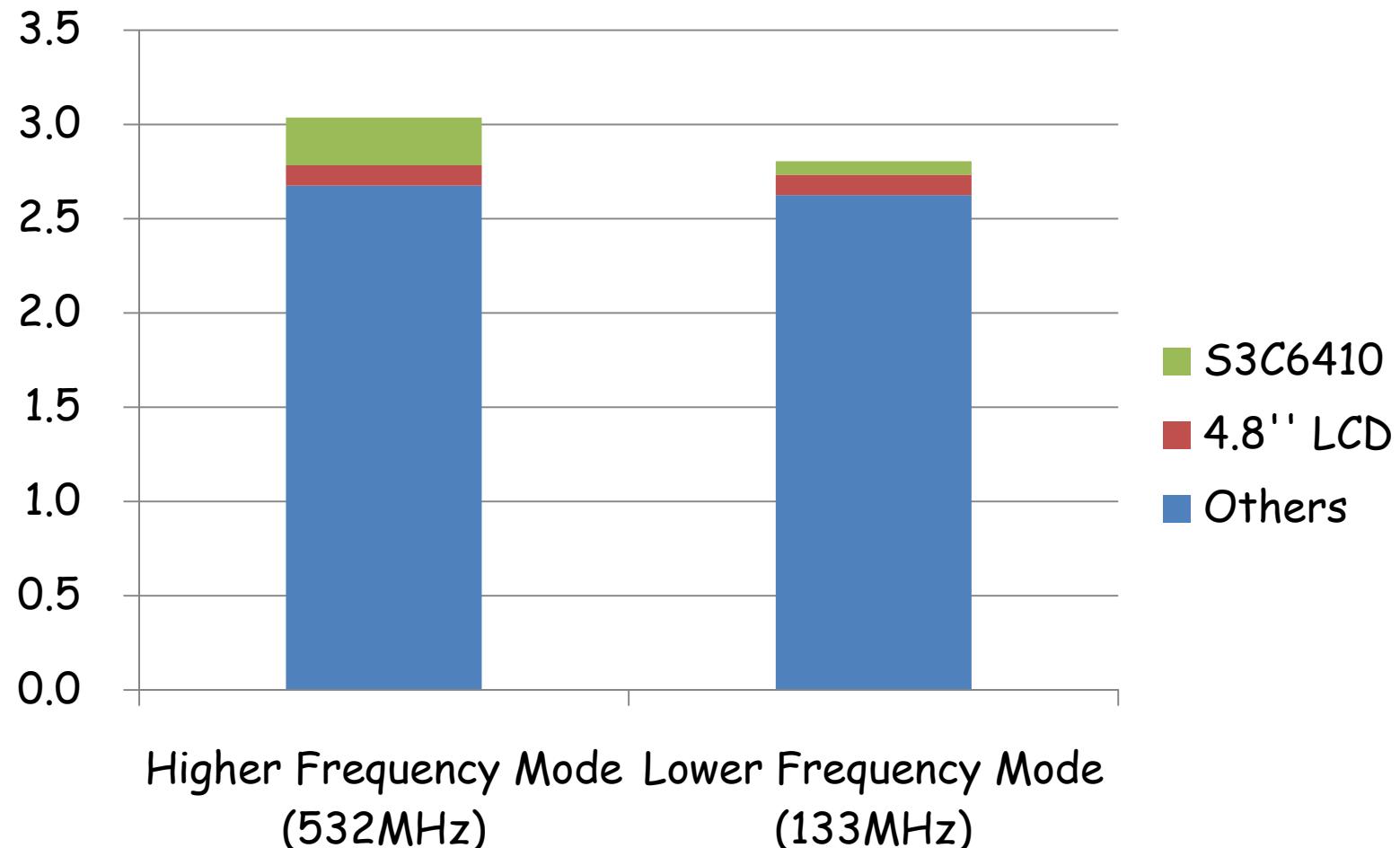
How about Mobile?

- Kontron nanoETXexpress-SP
 - Intel Atom Z530 1.6GHz
 - Unicore with 2 SMT
 - Can save 0.3W of total 12W

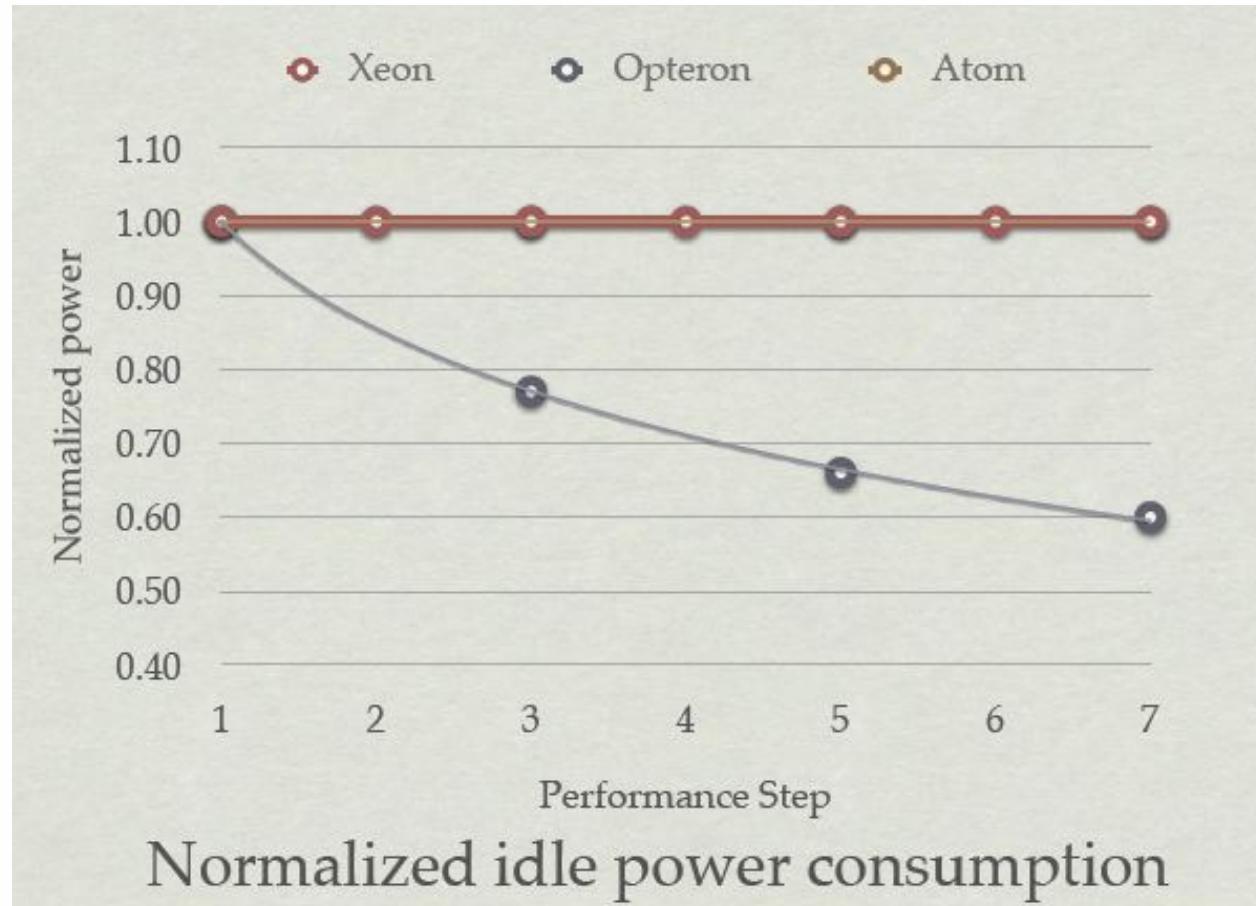


How about Mobile?

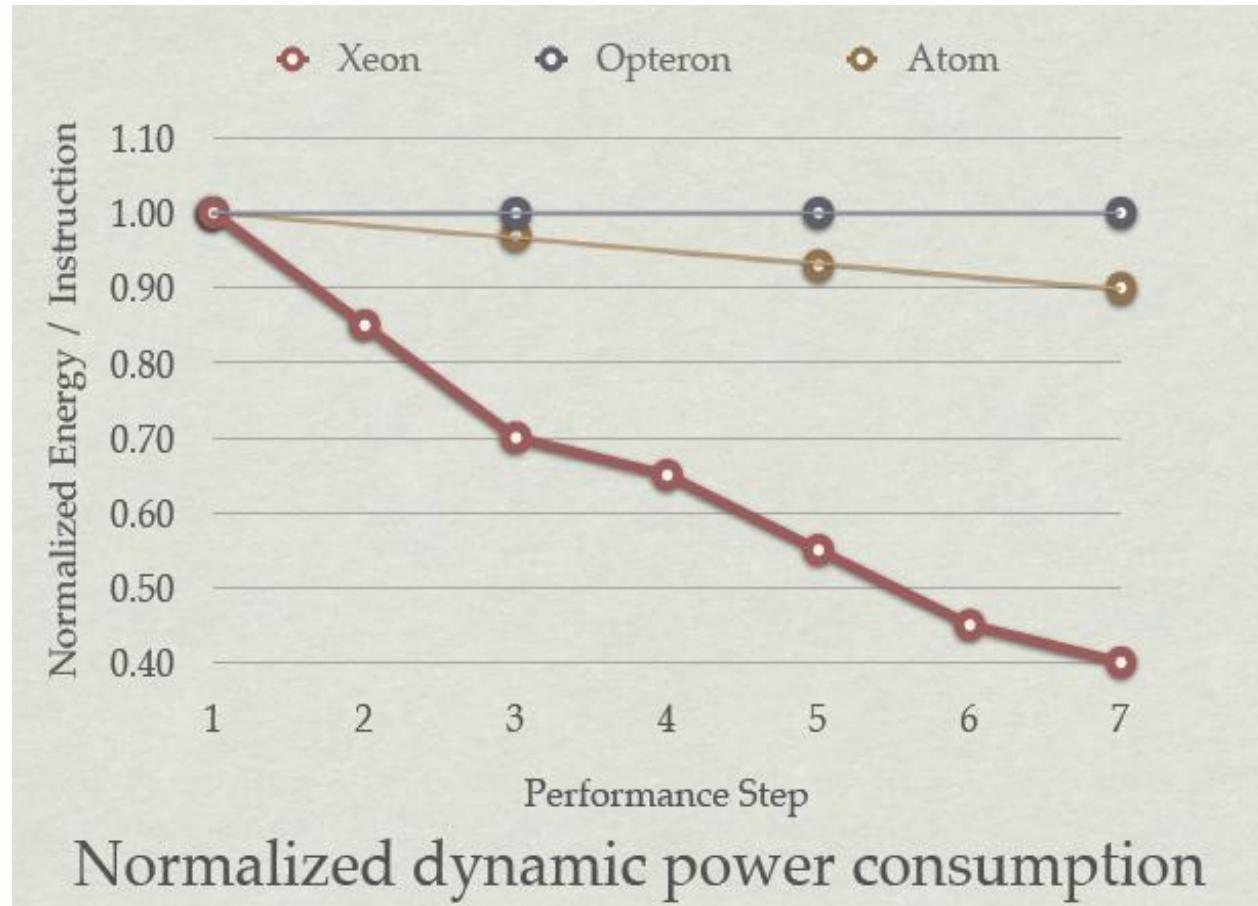
Unit: W



Power Characteristics



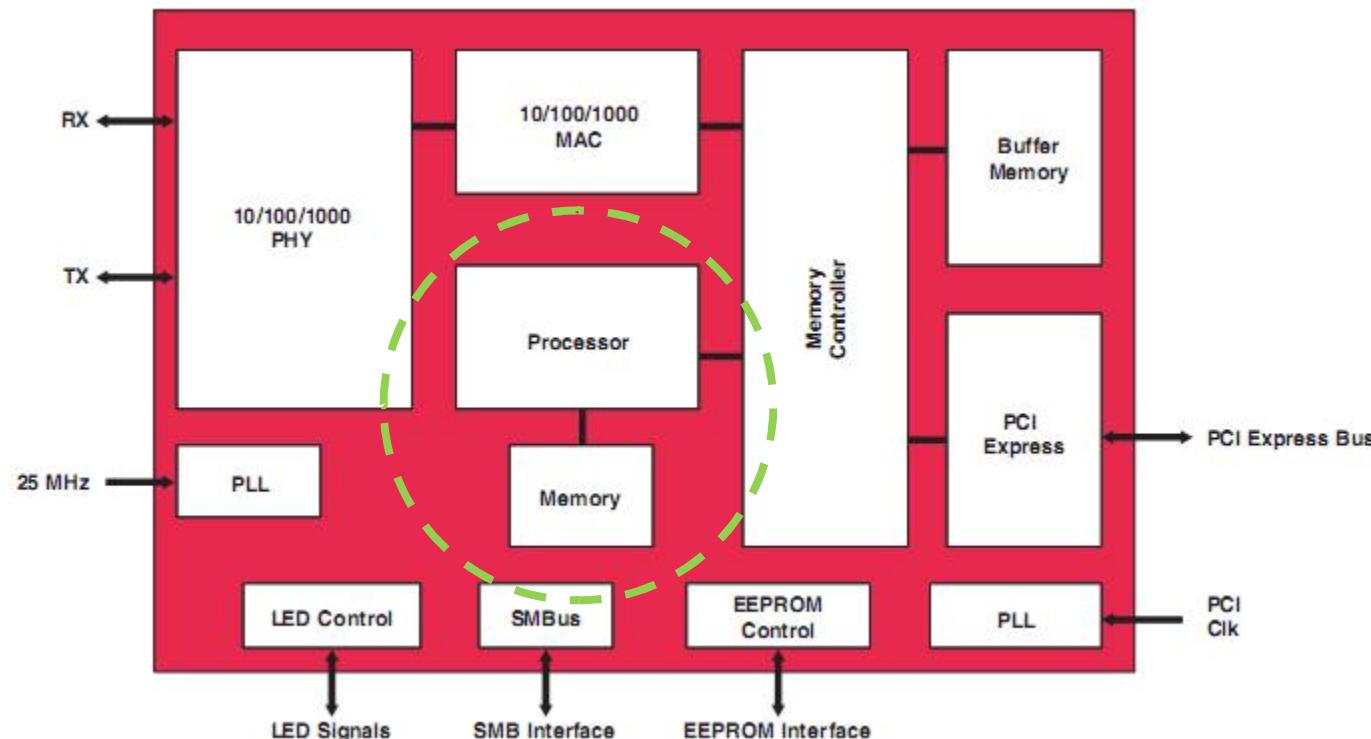
Power Characteristics



Other Devices

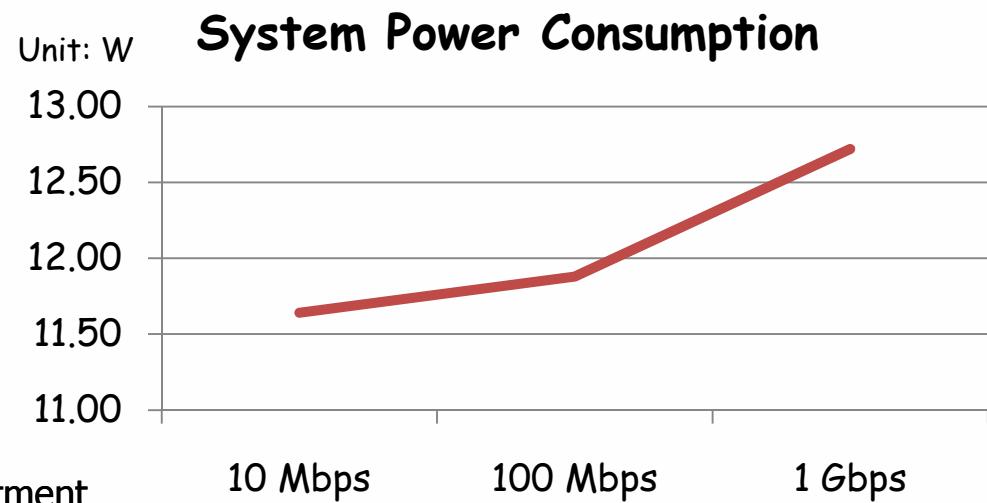
- Network interface card control
 - 1 Gbps NIC is commonly found
 - Modern NIC looks like a small computer
- nanoETXexpress-SP
 - Broadcom BCM 5787
 - 10/100/1000 Mbps
 - High-speed RISC with 32KB cache

Broadcom BCM 5787



NIC Control

- Network Bandwidth Scaling
 - Power increases with higher bandwidth transmissions
 - Not all moments actually need gigabit speeds



NIC Control

- Speed recognition

```
ethtool eth0
```

- Adjustment

```
ethtool -s eth0 autoneg off speed 10
```

Implications

- DVFS is designed to reduce CPU power consumption
- Mobile CPU requires very little power
 - With powerful capability
- Mobile DVFS could be ineffective or even harmful for energy efficiency

Implications

- Different CPU has different power characteristics
- Peripherals are really important
- Need for different strategies specialized for each mobile device

Thank You



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Extra Slides



What can I do ?

- What?
 - Battery Consumers
 - Display
 - CPU
 - Board
 - Peripheral Devices, etc.

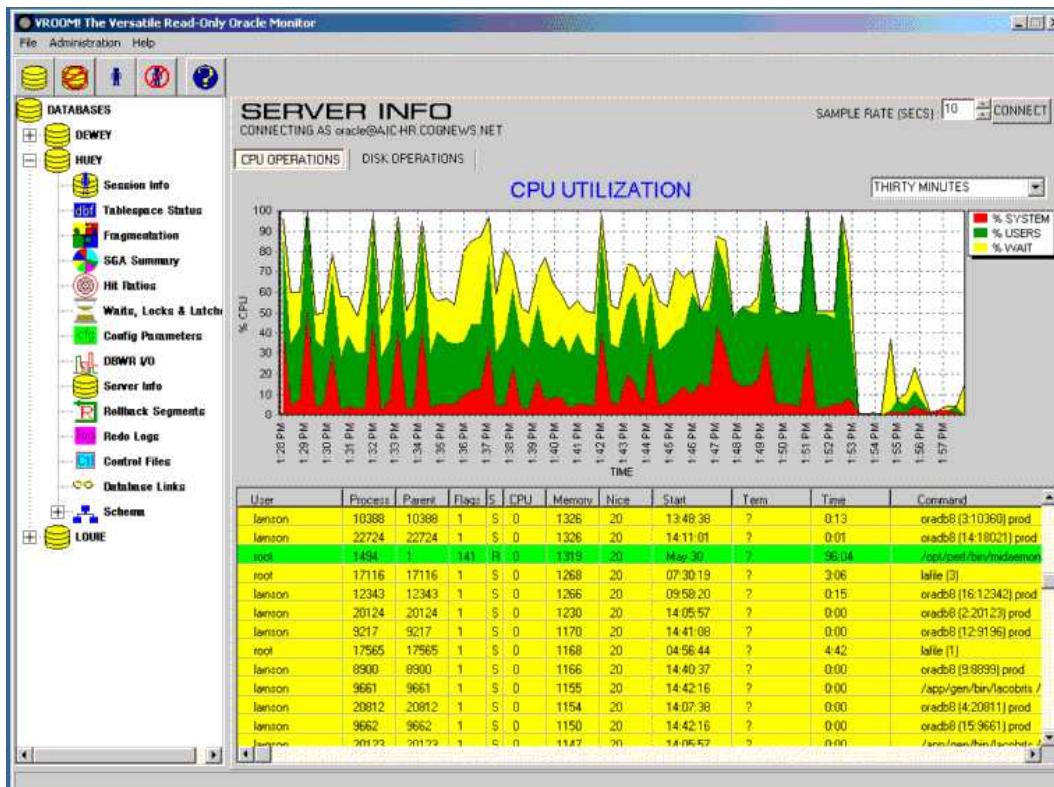
What can I do ?

- Who?
 - Hardware
 - Low-powered hardware
 - Thermal design
 - Software
 - OS
 - Middleware
 - Application
 - User



What can I do ?

- When?



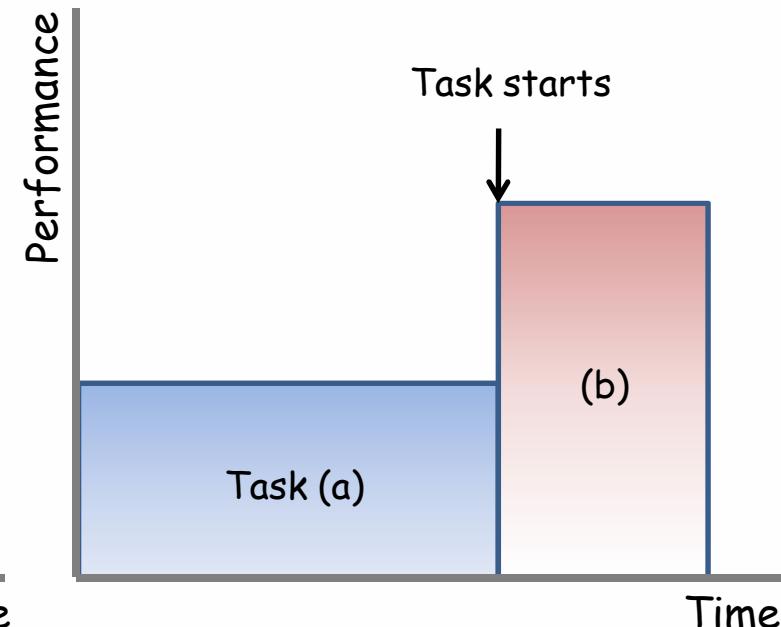
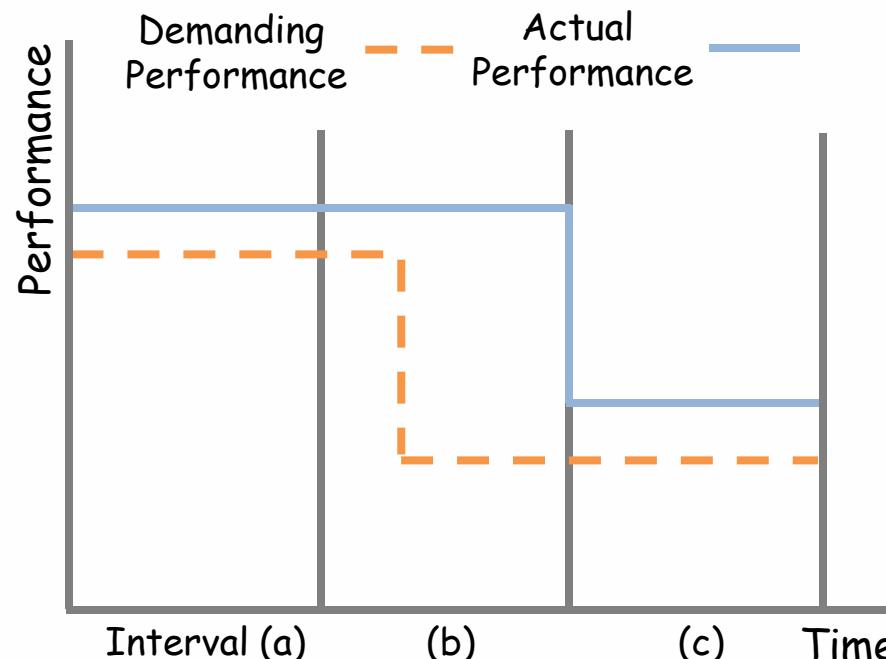
What can I do ?

- How?
 - Hardware takes orders from software
 - Turning off
 - Slowing down

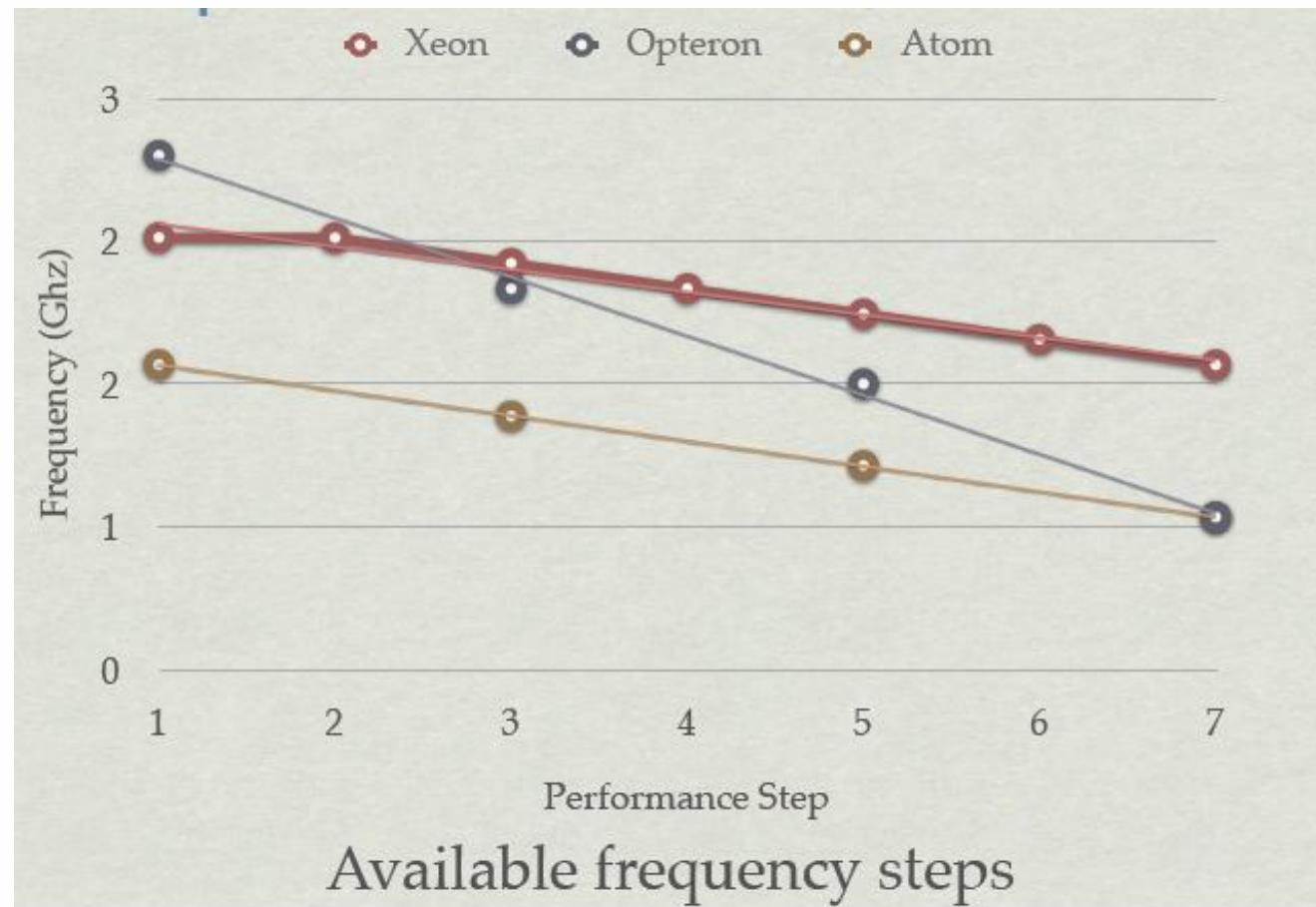


DVFS Algorithms

- Interval-based Algorithm
- Task-based Algorithm



Power Characteristics

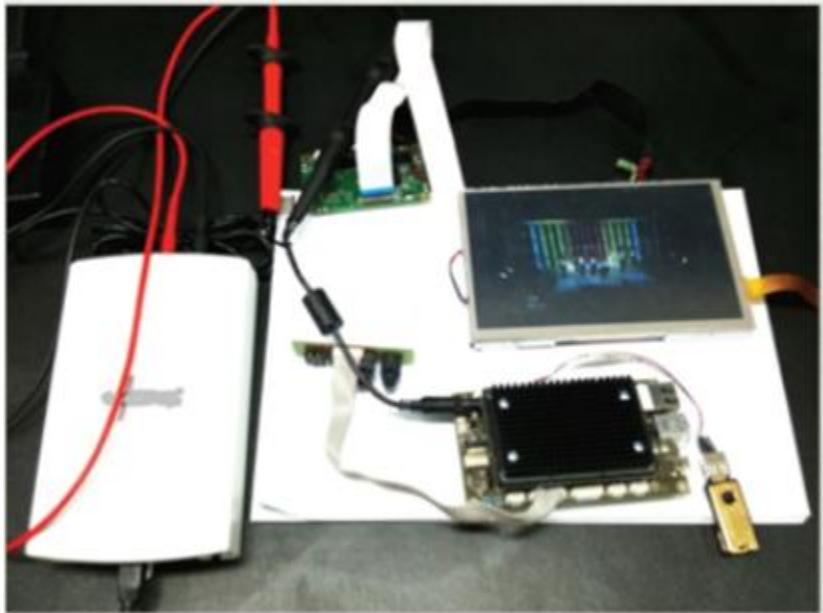


Environment

- Xeon Dual-Processor Server
 - Intel Xeon E5520 QuadCore 2.26GHz
- Lenovo X60
 - Intel Core Duo T2400 1.83 GHz
- Kontron nanoETXexpress-SP
 - Intel Atom Z530 1.6GHz
- Samsung SMDK6410
 - S3C6410 532MHz

How to Measure

- National Instrument DMM



Xeon Server	AC Power 220V
Lenovo Laptop	
Atom Board	DC Power 12V
6410 Board	DC Power 5V

References

- LessWatts
 - <http://www.lesswatts.org/>
- Wikipedia
 - <http://www.wikipedia.org/>