Research Topics for Senior Projects

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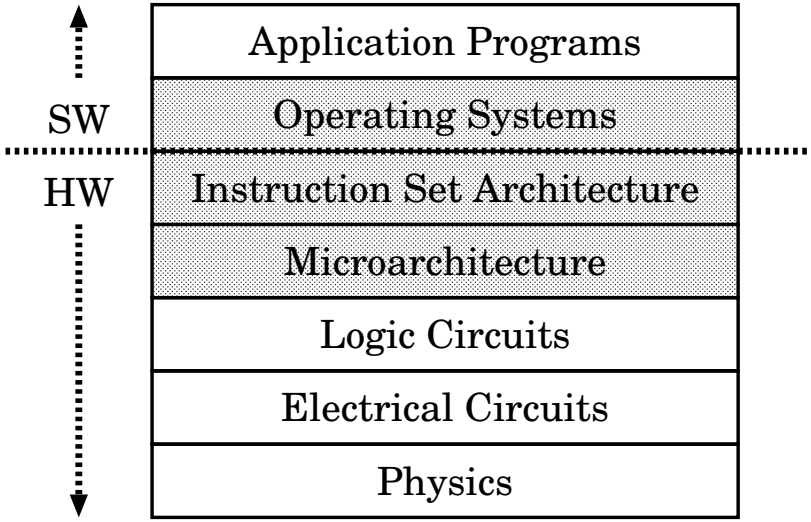
Computer Systems Abstraction Layers



We are mostly working in the shaded layers

Research Interests in General

Hardware/Software Interaction and Co-Design

- How modern (& realistic) software accesses hardware components ?
- How modern computer systems are designed and how they can be better utilized ?

Primary Metrics

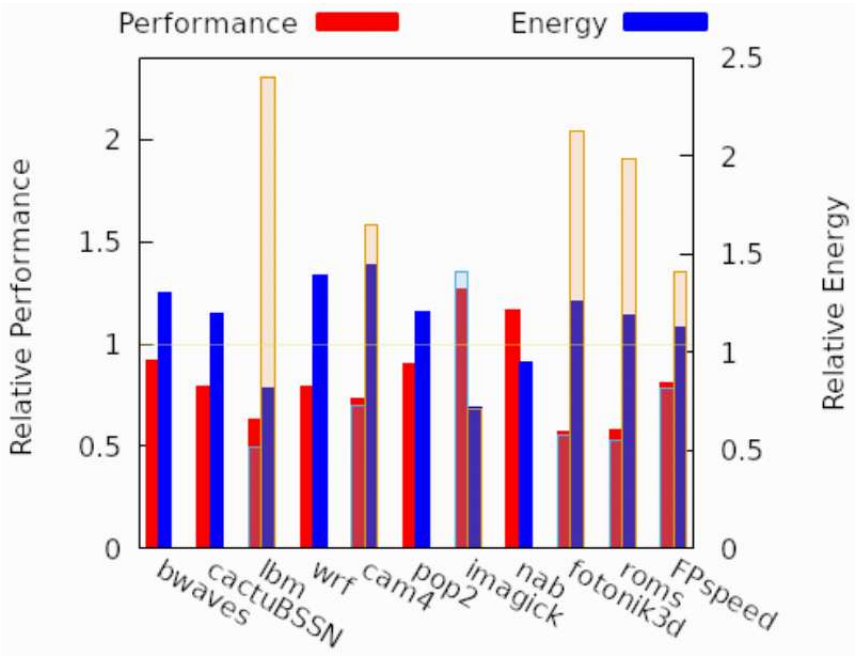
- Performance: How many tasks (or much work) can be finished in a fixed amount of time ?
- Energy-efficiency: How can we reduce the energy consumption for the same amount of work ?

Example of Recent Research

Intel Core i7 vs AMD Ryzen 5 using SPEC CPU2017

- Both are (relatively) new higher-end CPUs from competing companies
- Before Ryzen, high-end CPU market was dominated by Intel
- The particular models used in this study are Core i7-8700 and Ryzen 5 1600; both are six-core and 12-thread processors.
- Ryzen has: larger L1I, L2 and L3 caches and dedicated schedulers for INT and FP (Core has a shared scheduler).
- CPU2017 is the latest benchmark suite from SPEC. Next slide shows the comparison using FP Speed.

Comparison with SPECspeed Floating Point



- Relative Speed of Core i7 is 57 to 127% of Ryzen 5 (Red).
- Relative energy 69 to 139% (Blue).
- In 4/10 benchmarks, best performance/energy efficiency achived wit less than 12-threads.

Topics of Recent Students (1)

Security in Internet of Things

- Things that used to work stand-alone are now connected each-other and accessible over the Internet
- For example, electrics appliances are connected to the Internet and collect information; you can check the stock of your fridge and make (semi)-automatic order of missing items.
- On the other hand, they can be security holes:
  - These 'things' look like ordinary electric appliances and don't seem to to require security protection
  - Due to the price (& other) restrictions, resources are limited (e.g. CPU, power supply); methodologies for resource-rich devices may not be applicable (e.g. encryption).

Topics of Recent Students (2)

μ-architecture Effect on Performance and Power

- x86 (desktop and servers) and ARM are two most dominant CPU architectures.
- *Basically*, programs written for an architecture should run on any platforms on the same architecture (binary compatibility).
- However, there are many different hardware-implementations of the same architecture (microarchitectures), which result in variations in the performance and power consumption.
- A student studied the effect of microarchitectures using a standard benchmark programs.

Suggested Research Topics (1)

Linux File Systems

- File systems store various and huge amount of information, such as programs, user data, system configuration.
- In addition to the increasing capacity (amount of stored information), various requirements are emerging: speed (latency and throughput), reliability, flexibility, ...
- Study the designs of current file systems and identify the issues for further improving the file systems.
- Study the types and characteristics of the workload against file systems.

Suggested Research Topics (2)

Inter-Domain Communication in Virtualized Systems

- Multiple independent "machines" can be accommodated on a single platform (virtual machines, VMs, or domains).
- When multiple VMs form a large system (multi-tier system), communication between VMs takes place.
- Inter-domain communication goes through different paths than that of physical machines (NIC, network switch, LAN cable..)
- Investigate the inter-domain communication overhead, and relate it to the behavior of the applications and configurations of the VMs.

Suggested Research Topics (3)

Hardware Acceleration of Java Virtual Machine

- Java programs (source files) are compiled into an abstract machine instructions, Java Bytecodes.
- The, Java Bytecodes are either interpreted or compiled by the CPU of the system executing the Java application (Java Virtual Machine, or JVM).
- JVM has advantages, such as platform independence, but some operations are inefficient.
- With a programmable hardware platform (e. g. FPGA), we can design a module to which inefficient operations can be offloaded.

Suggested Research Topics (4)

Heterogeneous Multi-Core Systems

- Multi-core CPUs are ubiquitous: even your smart phones should have dual or quad-core CPUs.
- Also, in addition to the main (general-purpose) CPUs, GPUs are included for faster-graphic processing
- Another type of multi-core CPUs are emerging: heterogeneous-microarchitecture. Example of commercial product: ARM big.LITTLE
- Cores have the same ISA ($\approx$ can run the same machine code programs), but implementations are different. The difficult (but worth investigating) part is how to assign a right job to a right core.

Suggested Research Topics (5)

Training ML Model with Edge AI Devices (Still Immature)

- AI Inference Chips/Devices for Edge Computer are available (e.g Intel NCS2 or Google Edge TPU)
- They are inexpensive and power-efficient, but can only be used for inference using pre-trained models.
- ML models are usually trained with high-performance (& power and money hungry) GPUs, but the Edge AI chips can still be used for Imprinted Weights training.
- There are several restrictions and limitations in this method: "the last layer needs to be calculated on CPU, not NPU/TPU," or "INT $\Longleftrightarrow$ FP conversions."

References

- Group Website: `http://www.oslab.biz` , follow links to `Public Area` for the theses of past students
- Open Campus website: `http://opencampus.oslab.biz` ; a bit old but written in plain Japanese for general public.
- Research page:
  `http://www.u-aizu.ac.jp/~hitoshi/RESEARCH/`
  publication and other research activities.
- Posters outside the lab (Research Quadangles 241-E).

QR Codes for above pages