Performance:More Than Just Speed

We are not programming in 1969 (or even 1984) anymore

by
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Who Am I?

- *Half* Electrical Engineer, *Half* Business, *Half* Computer Software
- In the computer industry since *1969*
  - Mainframes 5 years
  - Unix since 1980
  - Linux since 1994
- Companies (mostly large): Aetna Life and Casualty, Bell Labs, Digital Equipment Corporation (DEC, DECUS), SGI, IBM, Linaro, WIT
- Organizations: USENIX, Linux International, Linux Professional Institute
- ***Programmer***, Systems Administrator, Systems Engineer, Product Manager, Technical Marketing Manager, ***University Educator***, Author, Businessperson, Consultant
- Taught OS design and compiler design
- *Extremely* large systems to *extremely* small ones
- Pragmatic
- Vendor *and* an "open source" customer

Who Needs Performance?

- “CPUs are fast enough”
  - I have been hearing that for over 50 years...
- “JAVA is the only language people need”
- “Nobody codes in assembler language any more”
- “Virtual machines make architecture knowledge obsolete”

Performance

- "Real" problems
  - Petabytes of data, thousands of processors
- Real-time
  - REAL real-time
    - Lower those rods!
  - Linus and "soft real time"
- Cell Phone Apps
  - Saving battery life
- Saving the environment!
  - Only 9000 servers!
- "New" (or at least newly affordable) advancements
  - Field Programmable Gate Arrays (FPGAs)
  - Digital Signal Processors (DSPs)

To Write Really *Great* Code...

...you need to understand machine architecture and that includes machine/assembly language

Examples From My Past

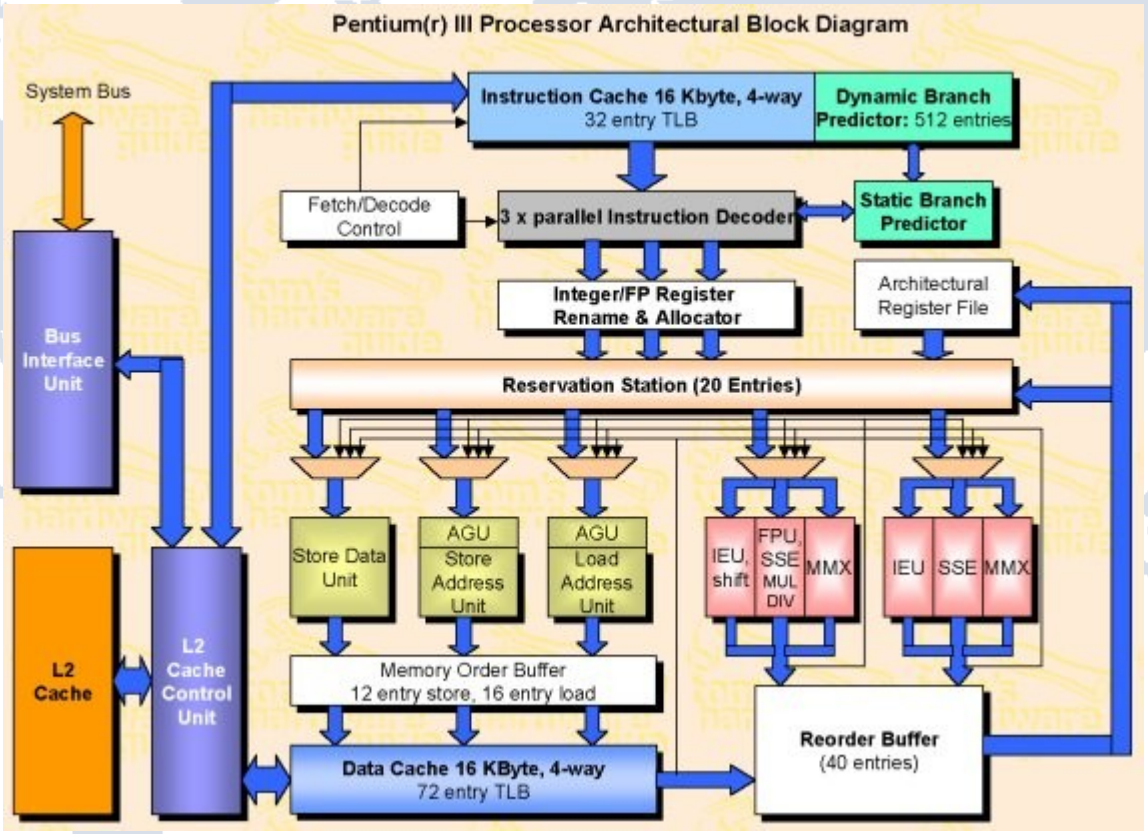
- Compiler errors (?!?)
- Cache
  - Digital Unix – ½ the size, 7% faster
  - 40 times (David Mossberger-Tang)
  - 220 times (not 200%) – PDP-11/70 + RSTS-E
- Tapes (OMG!) - start/stop and streaming tapes

Today

- (Some) College Students learning
  - "Microsoft Office and Oracle" instead of "Office Systems and Databases"
  - JAVA and "IT/TI" instead of Assembly and Operating Systems
  - Virtual machines instead of "real iron"
- High school students
  - Games and HTML

How Most High School Students See Computers

How Computers Really Look



Ways of Holding Numbers

- EBCDIC/ASCII Codes
  - One “Digit” per byte
- Packed Decimal
  - Two “Digits” per byte
  - Just a “squidge less”
- Binary
- Floating point (mantissa and exponent)

Which One Is Used for Indexing?

Please do not say “EBCDIC/ASCII”

Real Life Effects of “Dumb Down”

“Incoming freshmen know less than they knew 20 years ago” - Raspberry Pi Foundation

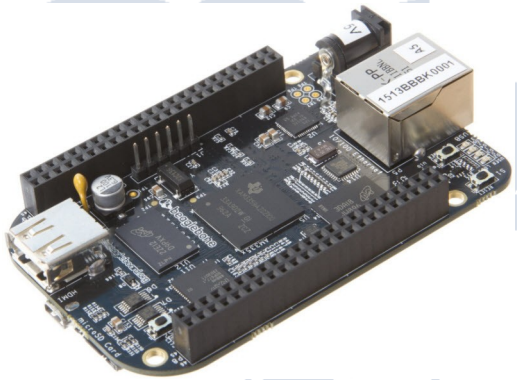
The Raspberry Pi was created to help fix this problem.

Raspberry Pi – 35 USD

- Single Core ARM – 700Mhz
- ½ Gbyte RAM
- 3D GPU
- One HDMI port
- USB 2.0
- 10/100 Ethernet
- 802.11 b/g Wireless
- Bluetooth 4.0
- GPIO Pins
- 3W

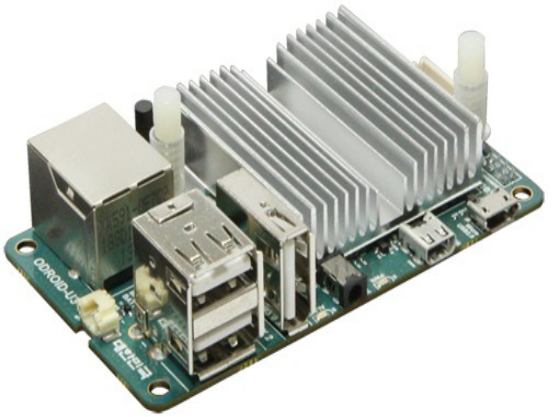
- Four Core 64-bit ARM8 – 1.5GHz
- Two GB RAM (4 and 8 GB available)
- 3D GPU
- Two micro-HDMI ports (4Kp60)
- USB – two 2.0, two 3.0
- Gbit Ethernet
- 802.11 b/ac Wireless (2.4 and 5.0 Ghz)
- Bluetooth 5.0 BLE
- GPIO Pins
- 13.5 W

Many Little Computers: 45 USD – 199 USD

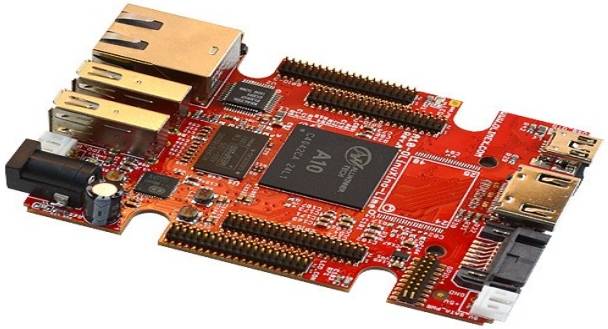


BeagleBoneBlack

Hackberry 10



ODROID-U3



OlimoX - LIME

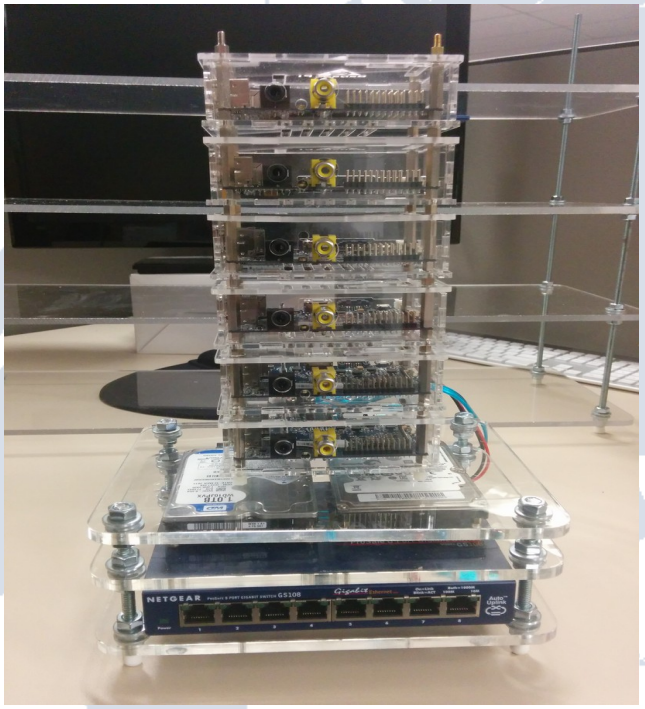
Pandaboard

Galileo

Why Do I Show You All This?

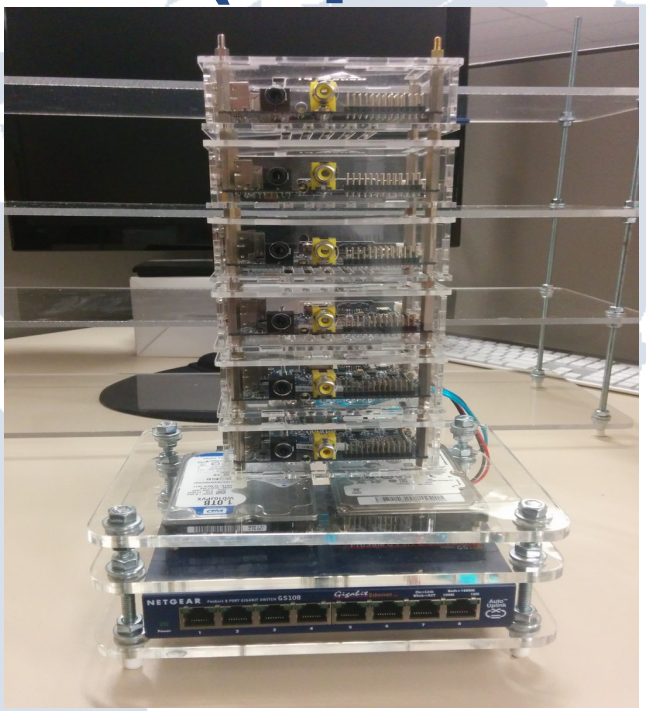
Because Of THIS!

- 12 ARMv7 Cores at 1 GHz each
- 6 GBytes of RAM
- 6 HDMI ports
- 6 SATA ports (currently driving two disks)
- IR on board
- 2 TB SATA disk
- 8 Port Gbit ETHERNET
- 70 Watts
- Fits in standard briefcase



Because Of THIS (Updated)!

- 24 ARMv8 Cores at 1.6 GHz each in RPi 4
- 48 GBytes of RAM (8GB each)
- 12 HDMI ports
- 12 USB-3 ports (currently two driving two SATA disks)
- 2 TB SATA disk (RAID)
- 8 Port Gbit ETHERNET
- 100 Watts
- Fits in standard briefcase



Why Is This Interesting?

- Can be used to teach
  - HPC computing
  - HA computing
  - heterogeneous computing (programming and systems administration)
- Very portable, can be assembled in minutes
- Very modular
- Prototype cost: 800 USD
  - Currently using “Raspberry Pi 4”
- Production cost: < 600-1000 USD
  - Could also use (6) new “Labrador/Model D”

GNU/Linux: Programming For The *Future*

- "Beowulf" supercomputers (1994)
  - Non Uniform Memory Architecture (NUMA)
  - Please *do not* build one out of RPi Zeros
    - Not a big one, anyway…..
- GPUs – not just for graphics anymore
- Field Programmable Gate Arrays (FPGA)
  - More efficient than GPU
  - More flexible than an ASIC
- Quantum computing – nooooooooooo!

Can we make our code *better*?

Summary

- Learn ***SOME*** assembly/machine language (any assembly language)
- Choose your algorithms and data carefully
- Use the right language for the right job
- Examine the assembly/machine language that is generated
- Speedups of “only” 2-3x are “ok”….you don't need 1000x (but that is really cool)

Resources

- "The Definitive Guide to GCC: 2nd Edition" by William von Hagen (Apress, 2006)
- "The Art of Debugging with GDB, DDD, and Eclipse" by Matloff and Salzmann (No Starch Press, 2008)
- "Valgrind 3.3: Advanced Debugging and Profiling for GNU/Linux applications" by Seward, Nethercote et. al. (Network Theory Ltd., 2008)

More Resources

- "ARM Assembly Language – an Introduction" by J.R. Gibson (Lulu, 2007)

Questions, Comments, Ideas?