Ten (or so) Small Computers

by
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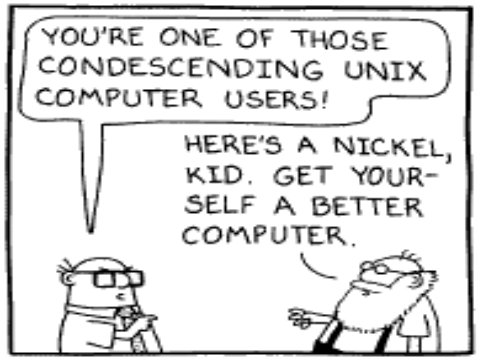
Linux International
and
President, Project Cauã

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



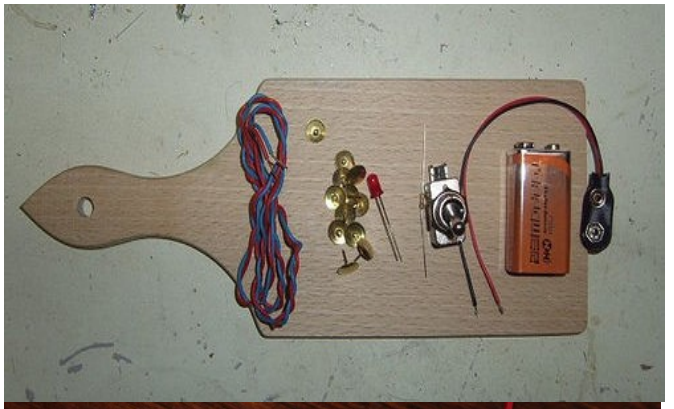
- Companies (mostly large): Aetna Life and Casualty, Bell Labs, Digital Equipment Corporation, SGI, IBM, Linaro
- Programmer, Systems Administrator, ***Systems Engineer***, Product Manager, Technical Marketing Manager, University Educator, Author, Businessperson, Consultant
- Taught OS design and compiler design
- *Extremely* large systems to *extremely* small ones
- Pragmatic
- Vendor *and* a customer

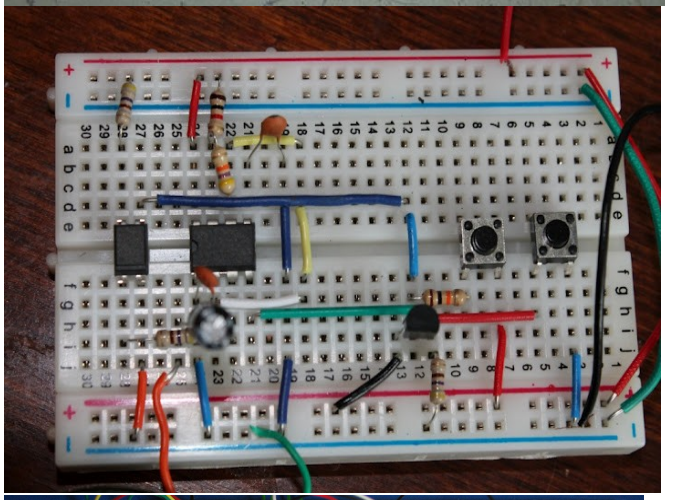
Warnings:

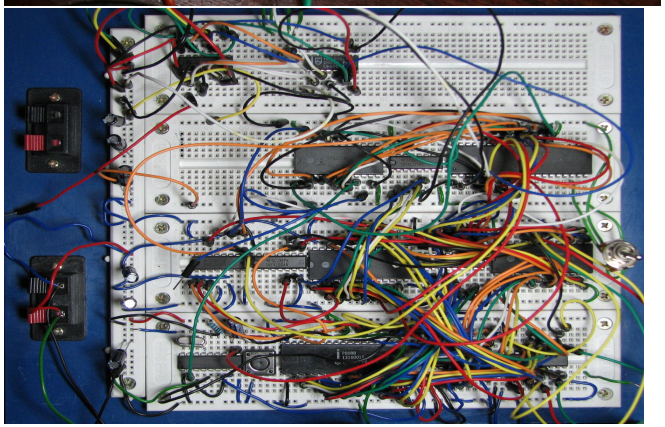
- This is an overview guide!
- Study specifications of each processor at manufacturer's site to make sure it meets your needs
- Prices not normally listed because they are all over the map…shop wisely

Definitions

- Microcontroller vs Microprocessor
- CPU vs “Core”
- System On a Chip (SoC)
- Hard vs Soft Realtime
- GPIO Pins
  - Digital
  - Analog
- Printed Circuit Board (PCB)
- Shield, Cape, etc.
- Breadboard
  - Patch cables







Definitions (Cont.)

- Disks
  - IDE
  - SATA
  - e-SATA
- Graphical Processing Unit (GPU)
- Field Programmable Gate Array (FPGA)
- Digital Signal Processing Chips (DSP)
- Unless otherwise specified, all microprocessors are ARM-32 bit

Still More Definitions!

- Circuit Diagrams
- Surface Mount Technology – large robots
  - Through board holes in PCBs
  - Surface mount
- CAD Files
  - PCB layout
  - “Gerbers” for SMT lines

Criteria For Selection

- Real or Soft Realtime?
- History of Project or Company
- Distributions surrounding it?
  - GNU/Linux
  - Android
  - *BSD
  - RTOS
  - Windows 10 CE?
- Community around it?
- Cases

Criteria For Selection (Cont.)

- Power of System
  - Number of cores
  - Clock speed
  - GPU
  - Amount of RAM
- Disk Controller
  - If not, USB 3.x
- BUS
  - CAN or other specialized bus?
  - Shared among how many devices?
- ETHERNET 10/100/1000

Criteria For Selection (Cont.)

- Wireless 802.11 b/g/n
  - Remember contention!
- Bluetooth?
- Power Requirements (Wattage=Voltage * Amps)
- Temperature, heat sinks and fans

Speaking of Power…
…things to watch out for!

- Not all power supplies are equal!
  - Typically 5V, but current? Buyer beware!
  - Buy quality power supply from vendors
- Do not starve CPU with USB devices
  - Use powered devices or hub
- SD cards
  - Size
    - 4GB typically minimum
    - 8 GB Good
  - Class 10, not class 4

Processors Are Often Combined or "Combinable"

- Arduino processor or board does real-time
- "Other board" does more complicated processing

Embedded Systems: Prototype, Introduce, Cost Reduce

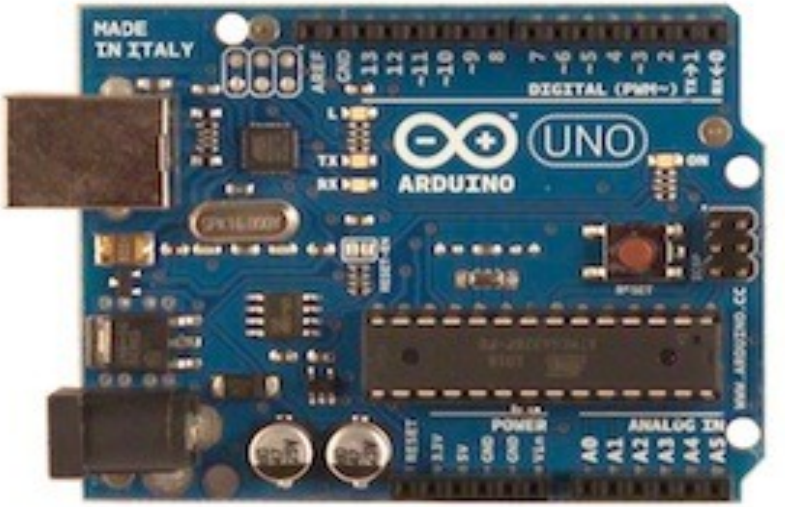
- Build control circuits on simple PCB
  - Motor controls
  - Heater controls
  - Input isolation (latches, etc)
  - Multiplexers
- Use small computer for processing, communications
- Re-engineer for cost reduction later

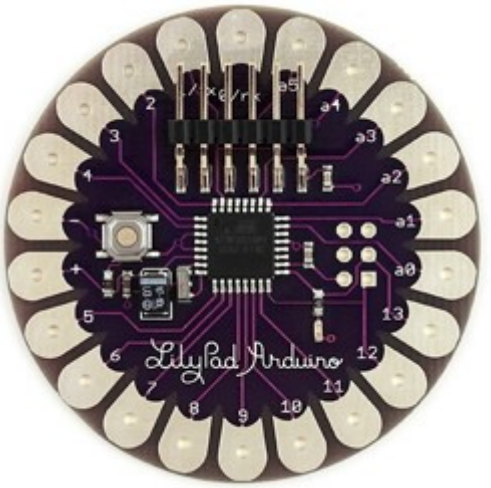
Having A Prototype Helps Financing

- Angel and First Round Investors
  - Less Risk
  - Shorter Time to Market
- Less of company owned by investor
- Kickstarter and Indiegogo

Arduino

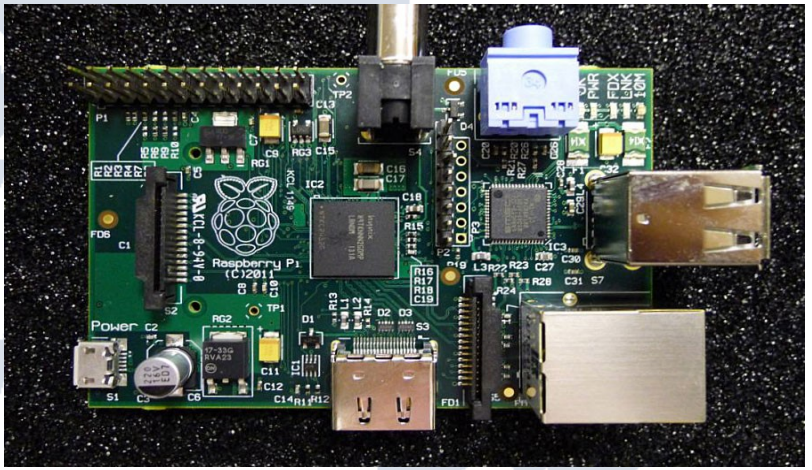
- Microcontroller
  - “Slow” clock
- “Small memory”
- No Operating system
  - Single program
  - Hard Real Time
- IDE Programming
- “Open” Hardware
- Large variety of “shields”





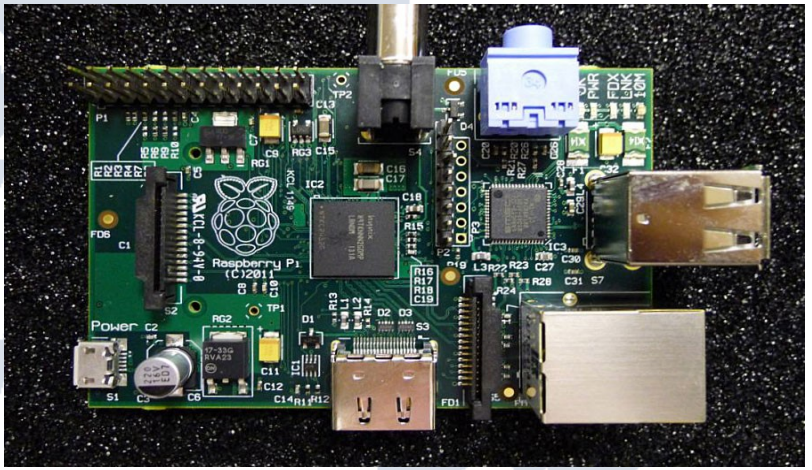
Raspberry Pi Model B – 35 USD

- Single Core ARM – 700Mhz
- ½ Gbyte Memory
- 3D GPU
  - Hardware video decode
- USB 2.0 (two ports)
  - 10/100 Ethernet
- HDMI
  - Analog AV also
- GPIO Pins - 23
- 6W



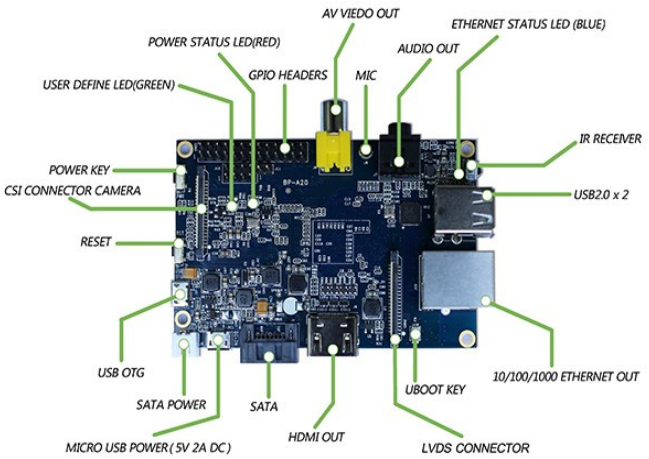
Raspberry Pi Model B+ – 35 USD

- Single Core ARM – 700Mhz
- ½ Gbyte Memory
- 3D GPU
  - Hardware video decode
- USB 2.0 – 4 ports
  - 10/100 Ethernet
- HDMI
- Composite V out through audio
- GPIO Pins - 40
- 9W

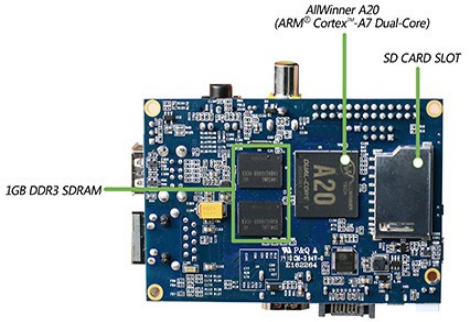


Banana Pi – 50 USD

- Dual Core ARM – 1000 Mhz
- Gbyte RAM
- 3D GPU - Hardware video decode
- USB 2.0
  - 10/100/1000 Ethernet
- HDMI
  - Analog AV also
- GPIO Pins
- SATA
- IR receiver/transmitter
- 3W – better power management



Front side



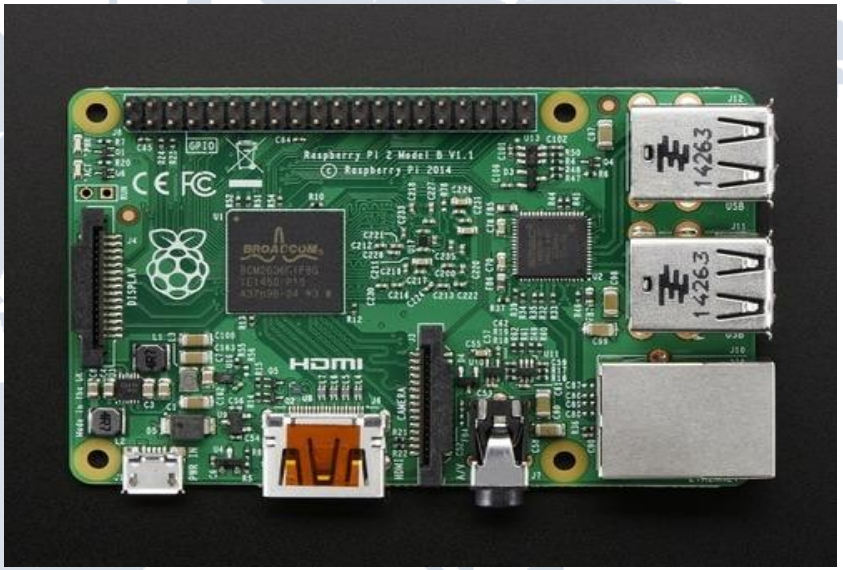
Back side

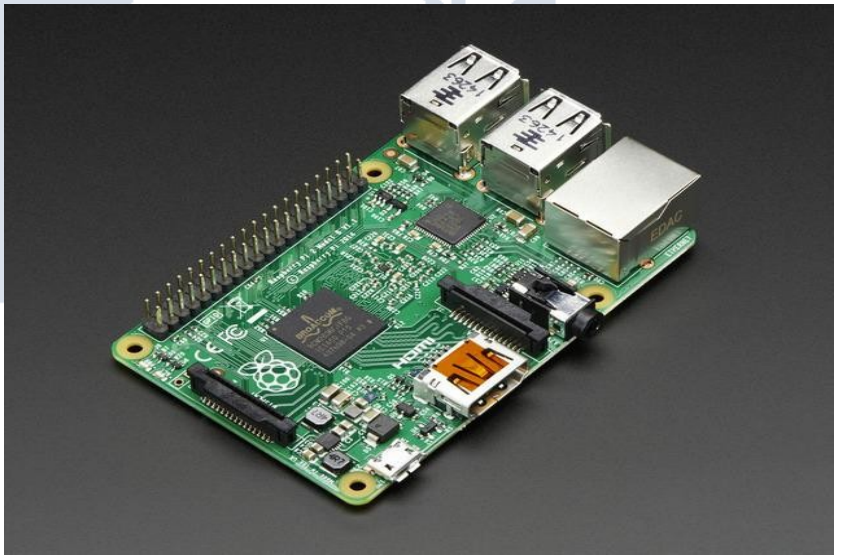
New Raspberry Pi 2 Model B 35 USD!

- ARMv7 Quad Core

(85% improvement single-core performance, up to 7.5x parallel performance improvement)

- 1GByte RAM
- HDMI
- Audio out
- Gbit ETHERNET
- Micro SD card
- Physical as RPI B+
- 9W

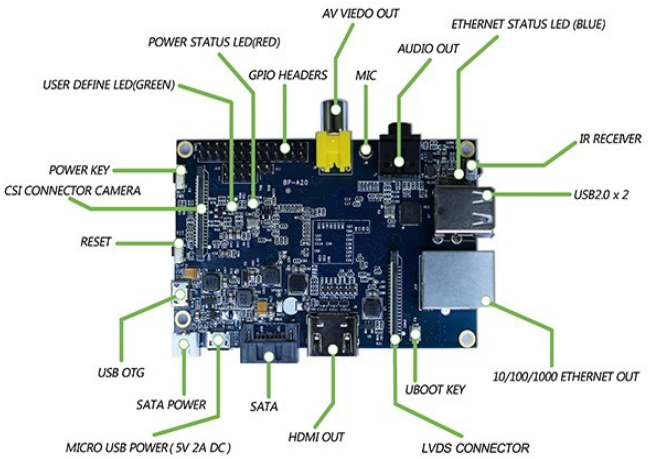




Remember GNU/Linux does a lot in parallel....

Banana Pro – 50 USD

- Dual Core ARM – 1000 Mhz
- Gbyte RAM
- 3D GPU - Hardware video decode
- USB 2.0
  - 10/100/1000 Ethernet
- HDMI
  - Analog AV also
- GPIO Pins – 40 pins – Compatible with RPi
- SATA V2.0
- IR receiver/transmitter
- WiFi – 802.11 b/g/n
- Bluetooth optional
- 3W – better power management



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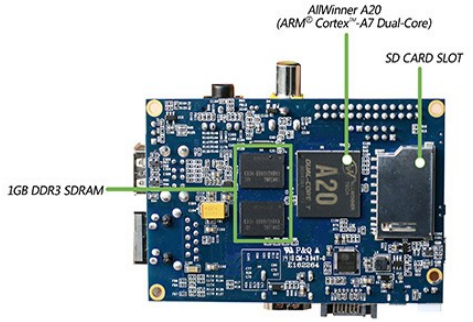


Back side

UDOO

- Three different Models ARM at 1 GHz
  - Dual Core Basic
  - Dual Core
  - Quad Core
- Contains Arduino DUE (3.3V) and compatible shields
- 1 GB RAM
- 3 Separate GPU (2D, OpenGL, OpenVG
- ETHERNET 10/100/1000
- HDMI
- USB 2.0
- Camera
- Microphone
- Audio out
- WiFi
- SATA on Quad Core
- 12 V

UDOO
Dual Basic, Dual, Quad Core

Adapteva's Parallella – 249 USD Supercomputer On A Card

- Zynq Z7020 System On a Chip:
  - Two core ARM 9 processor
  - Field Programmable Gate Array
  - Digital Signal Processing chips

- Epiphany: 16 or 64 core processor, each core having its own memory directly addressable, as well as direct access to other core's memory
- 5 W

Parallella In Detail

- Xilinx Zynq®-7000 All Programmable SoC (XC7Z010/XC7Z020)
  - Dual Core ARM A9 CPU
  - FPGA
  - DSPs
- Epiphany III (16 or 64-core CPU Accelerator)
- 1GB DDR3 SDRAM
- 128Mb Quad-SPI flash
- Ethernet 10/100/1000
- Micro HDMI connection
- Micro SD Card Slot
- Micro USB 2.0 (two)
- Dimensions are 3.4" x 2.1"

ODROID (“Hardkernel”)

- Three models
  - ODROID-U3 – QUAD-core 2GB RAM
  - ODROID-XU3 – Big/Little with USB 3.0
  - ODROID-C1 - “'Raspberry PI 2' with more speed (higher clock) and RAM” but same price

OlinuXino:
Open Software and Open Hardware

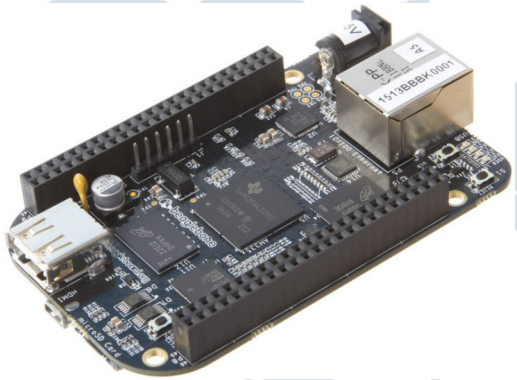
- Circuit and CAD files available
- Parts available in small quantities
- Parts chosen for industrial temperatures -25 to +85 degrees C
- No restrictions on manufacture

https://www.olimex.com/Products/OLinuXino/open-source-hardware

Series of OlinuXino Boards

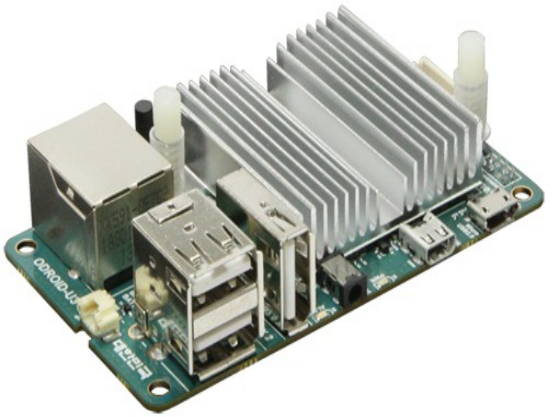
- Simple single core Allwinner A10 CPU and GPU
  - Includes SATA!
- Dual core Allwinner A20 CPU and GPU
  - 1GByte RAM
  - SATA connector and power on board
  - HDMI
    - Full HD (1080p) playback
  - 100Mbit/sec ETHERNET
  - 6-16V noise resistant power input (battery backup)
  - 160 GPIO pins on three connectors(!)

Many Little Computers: 45 USD – 199 USD

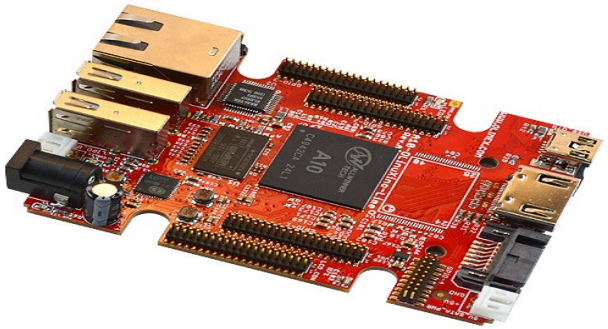


BeagleBoneBlack

Hackberry 10



ODROID-U3



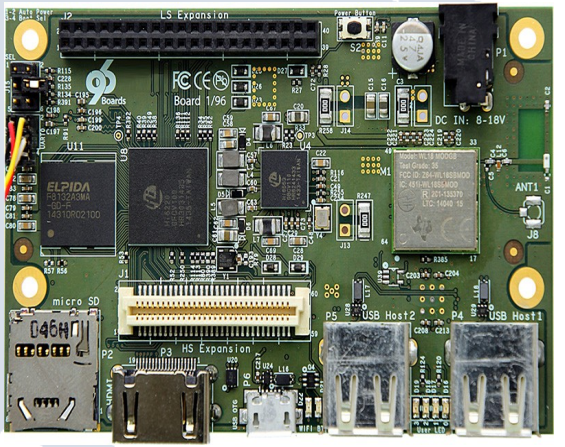
OlimoX - LIME

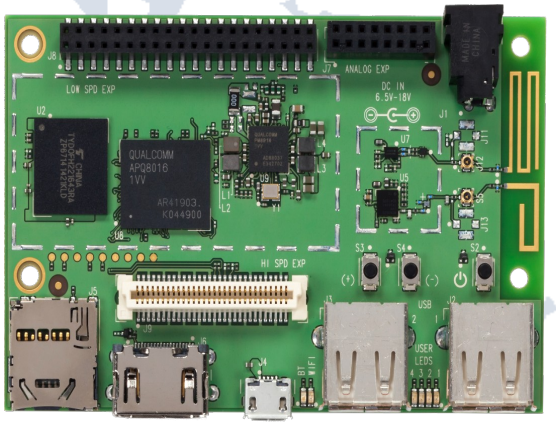
Pandaboard

Galileo

96boards.org

- Two specifications for board design
  - “Consumer” < 100 USD
  - “Enterprise” < 300 USD
- 32-bit and 64-bit ARM processors
- Specifies
  - board layout
  - connector layout
  - Power suggestions
- Open to all vendors

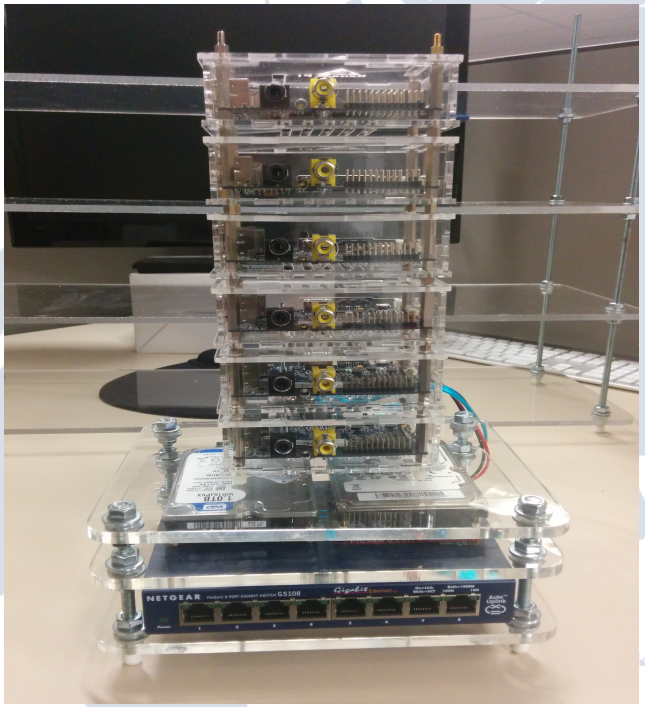




Why Do I Show You All This?

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



Why Is This Interesting?

- Can be used to teach HPC computing
- Can be used to teach HA computing
- Can be used to teach heterogeneous computing
- Can be used to teach heterogeneous systems administration
- Very portable, can be assembled in minutes
- Very modular
- Prototype cost: 500 USD
  - Currently using “Banana Pi”
- Production cost: < 400 USD
  - May use (4) new “Raspberry Pi 2 Model B”
  - Will increase from 12 to 20 ARMv7 cores
- May incorporate Parallela Board – DSP, FPGA and 16-core CPU

inveneo LEMAKER ARM

MICRO-DATA CENTER DESIGN CHALLENGE

The *$10,000* Micro-Data Center Design Challenge

Students, engineers, researchers, and innovators

The Challenge

Design a solar powered micro-data center for communities in the developing world using ARM based technologies.

The Impact

The winning innovative design will serve as a model that can be replicated around the world, impacting millions.

The Specifics

- First prize: $10,000 and winning design built and deployed outside U.S.
- Second prize: Google Nexus 7 tablet for each teammate.
- Entries must be submitted by June 10th.
- Winners announced on July 15th.

www.lemaker.org

Register/ learn more:

http://www.inveneo.org/designchallenge/

Announcing: “maddog and Linaro's GNU/Linux Optimization Program”

Optimize 1400 GNU/Linux modules with ARM 32-bit code

- Measure performance on platform
- Optimize code (and port to ARM-64)
- Measure performance after optimization
- Document performance improvements
  - Compiler switches used
  - Algorithm changes
  - Assembly code eliminated

Goals Of Contest

- Make sure all 1400 modules of GNU/Linux work well on ARM-64 processors through “porting”
  - Compile and test
    - Best performance options on gcc in make file?
  - Insert proper ARM-64 assembly if needed
  - Eliminate need for assembly language
- Increase performance of GNU/Linux for all architectures
- Create material for Li[bv]re course in software performance techniques.

Questions, Comments, Ideas?

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performance.linaro.org