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The Embedded Systems Conference

Open Source Hardware and the Future of Embedded Systems

bunnie

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BLACK HAT EMBEDDED
INTERNET OF THINGS
HARDWARE STARTUP
ANDROID ENGINEERING
FPGA ENGINEERING
SUPER C++ TUTORIAL
UBM Tech

In the Beginning....

Model 5X5 Series
(Chassis No. RC-406)
Five-Tube, Single-Band, AC-DC Multiplex Superheterodyne Receiver
Model PLF-10
Power Line Filter Coupling Unit

Electrical and Mechanical Specifications

FREQUENCY RANGE
Receiver ..... 540-1,720 kc
Remote Control Oscillator ..... 540-800 kc

TUBE COMPLEMENT
(1) RCA-12SA7 ..... 1st-Detector-Oscillator
(2) RCA-12C8 ..... I-F Amp., 2nd-Det., and A.V.C.
(3) RCA-12SC7 ..... 1st A-F and Remote Control Osc.
(4) RCA-35L6GT ..... Power Output
(5) RCA-35Z5GT ..... Half-Wave Rectifier

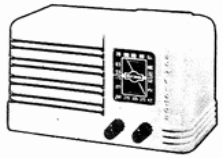
Intermediate Frequency ..... 455 kc

POWER SUPPLY RATINGS
A-C Rating ..... 100-125 volts, 50-60 cycles, 30 watts
D-C Rating ..... 100-125 volts, direct current, 30 watts

POWER OUTPUT (125 volt, 60 cycle supply)
Undistorted ..... 1.5 watts
Maximum ..... 2.0 watts

LOUDSPEAKER
Type ..... 4 inch Electrodynamic
Cabinet Dimensions (inches) Height 5¼, Width 8½, Depth 4½
Weight (net) ..... 5¼ pounds

General Description



Model 5X5I
RC-406A
Ivory Finish

Model 5X5W
RC-406
Walnut Finish

The following features are incorporated in the design of the Little Nipper Multiplex 5X5 Series Receiver:

First, it is a "standard broadcast" receiver. Second, it will operate any other radio in the home by "remote control" without the use of connecting wires. Third, records may be reproduced through the Little Nipper when used with Victrola Attachment. Fourth, the Model 5X5 (when used with Victrola Attachment) will reproduce records through any other radio in the home without the use of connecting wires.

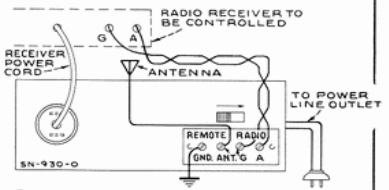
When using the 5X5 as a remote control, the Model PLF-10 Power Line Filter Coupling Unit should be used in conjunction with the receiver to be controlled. The filter is connected between the power line receptacle and the receiver being controlled, as shown in accompanying drawing.

Set-up Procedure for Remote Control

1. Install the 5X5 and tune in any desired station.
2. Turn the control switch on the back of the 5X5 to its clockwise position marked "Remote." The 5X5 becomes silent.
   The 5X5 now becomes a small relay station for signalling to the controlled receiver via the power line wiring.
3. Next tune the main receiver to the exact frequency of transmission of the 5X5, usually 540 kc. Tune carefully to this frequency, setting the volume control as high as permissible with regard to hum and noise conditions. The station to which the 5X5 was tuned will be heard. If the receiver is equipped with tuning indicator (Magic Eye) the correct point will most easily be obtained by observing the indicator.
4. Now any station tuned in on the 5X5 dial will be heard on the controlled receiver. The volume will also be controlled with the 5X5 volume control.
5. If it is desired to operate the controlled receiver on its own controls it is only necessary to set the switch on the Power Line Filter Coupling Unit to its position marked "Radio."
6. In the event that, with the 5X5 being used as a remote control, other receivers in the home are in use, trouble may be experienced due to noise and hum. To avoid this, connect a Power Line Filter Coupling Unit, RCA Victor PLF-10, to each of these other receivers, as shown in accompanying drawing.

Precautionary Lead Dress

1. Dress 1st I-F plate and grid leads against chassis and away from each other. Dress plate lead from 12C8 close to chassis.
2. Dress A.V.C. condenser (0.1) close to chassis and tight to 0.25 mfd. condenser.



PLF-10 COUPLING UNIT

Alignment Procedure

Output Meter Alignment.—Connect the meter across the voice coil, and turn the receiver volume control to maximum.

Test-Oscillator.—Connect the low side of the test-oscillator to the receiver chassis, through a .01 mfd. capacitor, and keep the output as low as possible.

The Remote Control Oscillator in the 5X5 is set at the factory to approximately 540 kc. The frequency may be varied between 540 and 800 kc to suit local conditions by adjusting the trimmer condenser C7.

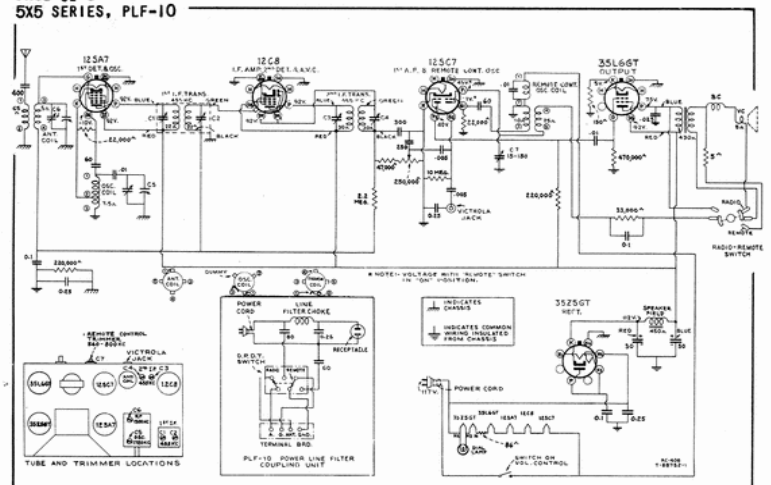
Power-Supply Polarity.—For operation on d-c, the power plug must be inserted in the outlet for correct polarity. If the set does not function, reverse the plug. On a-c, reversal of the plug may reduce hum.

If the electric supply circuit is a three-wire system, it may be necessary to connect a ½ mfd 700-volt capacitor between the two outside lines of the three-wire system.

Antenna.—The set is equipped with length of antenna wire. Do not connect the antenna to ground. If an outdoor antenna is used, it should not be longer than 100 feet, including lead-in. If it is longer, connect a 100 to 200 mmf. capacitor in series with the lead-in.

Victrola Attachment.—A jack is provided on the rear of chassis for connecting a Victrola Attachment into the audio-amplifying circuit. The cable from the Victrola Attachment should be terminated in # Stock No. 31048 plug to fit the jack.

Steps	Connect the high side of test-oscillator to—	Tune test-osc. to—	Turn radio dial to—	Adjust the following for max. peak output—
1	Tuning condenser stator (osc.) in series with .01 mfd.	455 kc	Quiet point at 1,600 kc end of dial	C1, C2, C3, C4 (1st and 2nd I-F transformers)
2	Antenna term. of ant. trans. in series with 100 mmfd.	1,720 kc	Full clockwise (out of mesh)	C5 (oscillator)
3		1,500 kc	Resonance on 1,500 kc signal	C6 (antenna)



Replacement Parts

Insist on genuine factory-tested parts, which are readily identified and may be purchased from authorized dealers.

STOCK No.	DESCRIPTION	STOCK No.	DESCRIPTION
	CHASSIS ASSEMBLIES	32969	Socket—Dial lamp socket
13057	Capacitor—60 mmfd.	14278	Socket—Phonograph socket
12488	Capacitor—250 mmfd.	32537	Socket—Tube socket
12952	Capacitor—300 mmfd.	30585	Spring—Drive cord spring
30433	Capacitor—400 mmfd.	33319	Transformer—First i-f transformer
4838	Capacitor—.005 mfd.	32578	Volume control and power switch
4937	Capacitor—.01 mfd.		**POWER LINE FILTER PLF-10**
4870	Capacitor—.025 mfd.	13057	Capacitor—60 mmfd.
4839	Capacitor—0.1 mfd.	12484	Capacitor—0.25 mfd.
12484	Capacitor—0.25 mfd.	33492	Coil—Choke coil
33321	Capacitor—Electrolytic, 2 sections 30 mfd. each	33493	Receptacle—Power receptacle
32572	Coil—Antenna coil	33491	Switch
33320	Coil—Duplex oscillator coil		**SPEAKER ASSEMBLIES (39105—2)**
32962	Coil—Oscillator coil	32964	Transformer—Output transformer
33323	Condenser—Trimmer 20-150 mmfd.		**MISCELLANEOUS ASSEMBLIES**
32968	Condenser—2-gang variable tuning	X-639	Cabinet—Ivory finish—Model 5X5I (net)
32634	Cord—Drive cord	X-638	Cabinet—Walnut finish—Model 5X5W (net)
32946	Drum—Condenser drive drum	32942	Dial—Glass dial scale
12409	Lead—Antenna lead	33317	Fastener—Push fastener to hold cabinet back
33322	Resistor—6 ohms, 5 watts	33306	Knob—Black tuning knob—Model 5X5I
14671	Resistor—33 ohms, ½ watt	32447	Knob—Ivory knob—Model 5X5W
13428	Resistor—150 ohms, ½ watt	32943	Nut—Speed nut to hold dial
13998	Resistor—22,000 ohms, ½ watt	31646	Spring—Knob retaining spring
12454	Resistor—33,000 ohms, ½ watt		
12412	Resistor—47,000 ohms, ½ watt		
12264	Resistor—220,000 ohms, ½ watt		
12285	Resistor—470,000 ohms, ½ watt		
12679	Resistor—2.2 meg., ½ watt		
13601	Resistor—10 meg., ½ watt		
32945	Shaft—Tuning knob shaft and bushing		

Additional Replacement Parts:

Stock No.	
32946	Drum—Condenser drive drum and indicator
11765	Lamp—Dial lamp, Mazda No. 51
33324	Switch—"Remote" switch
32967	Transformer—Second I-F trans.
34569	Speaker—Complete—less transformer

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UBM Tech

Addendum to the

Apple II Reference Manual

The main logic board
electromagnetic inte
the Apple boards whi
Manual. It will not
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You will know you ha
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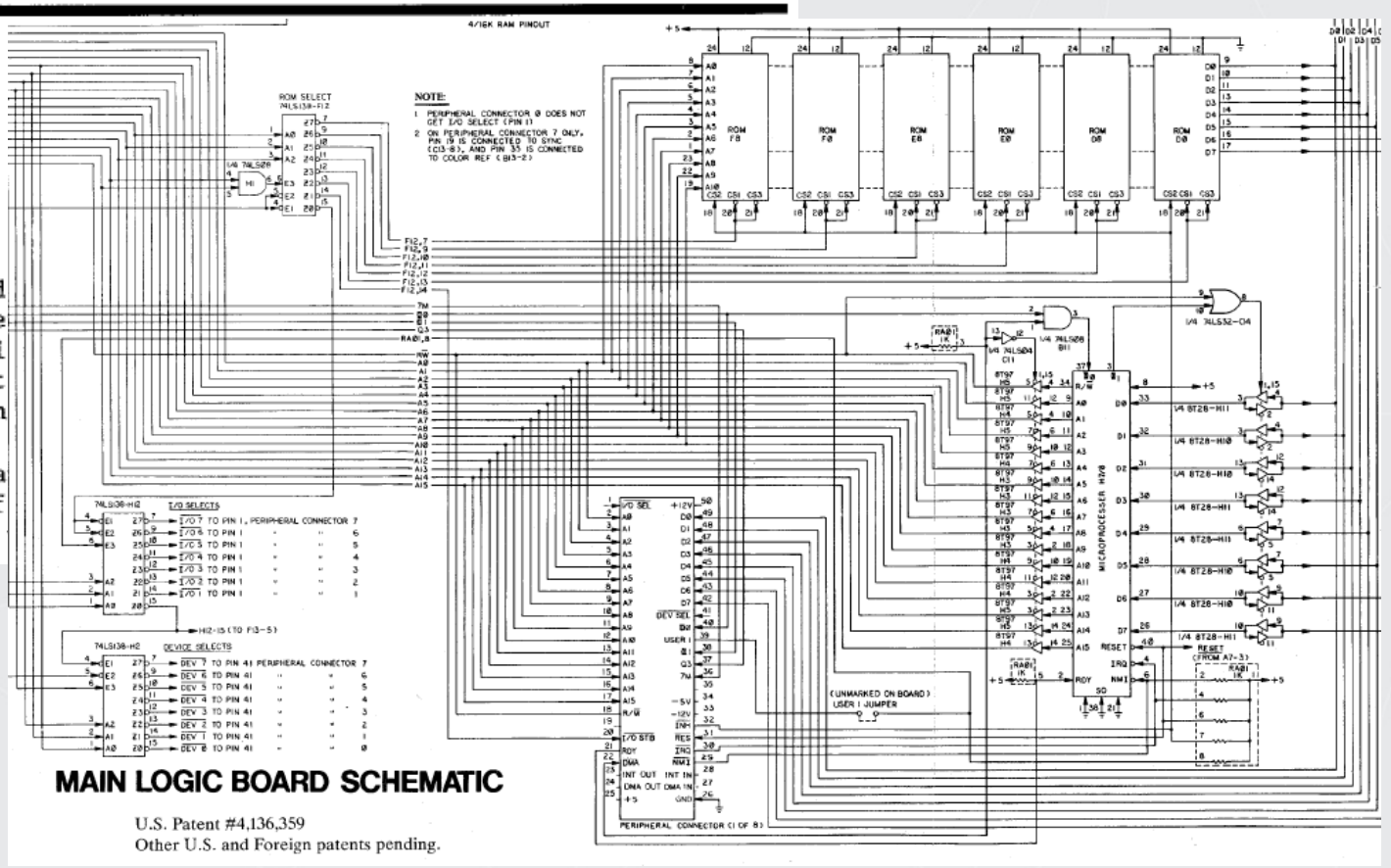
number 820-0044-xx,



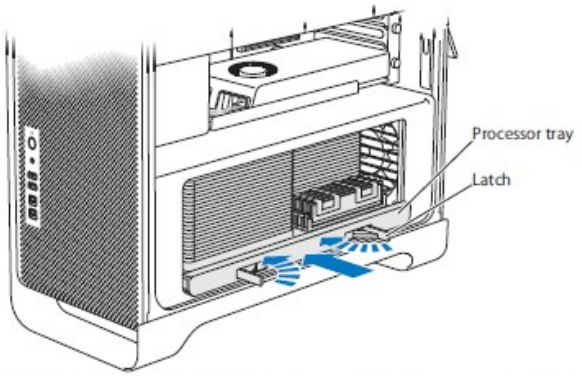
MAIN LOGIC BOARD SCHEMATIC

U.S. Patent #4,136,359
Other U.S. and Foreign patents pending.

But Today...

6 Reinstall the processor tray, pushing it in until the latches are at a 90-degree angle.

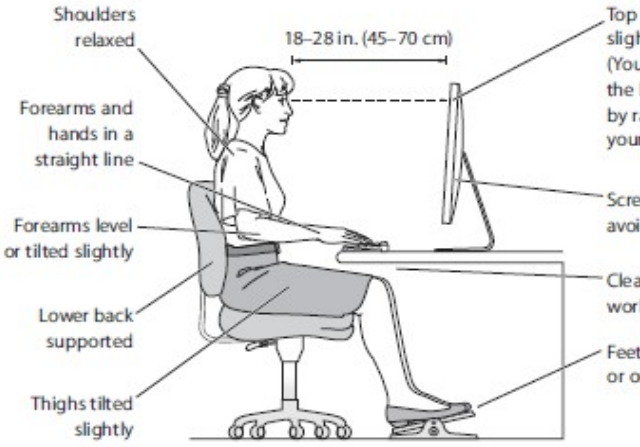
7 Push the latches all the way in to close them and seat the processor tray.



8 Replace the side panel, following the instructions starting on page 52.

NOTICE: Always replace the side panel after installing components. Your Mac Pro doesn't operate properly without the side panel in place.

Congratulations, you and your Mac Pro were made for each other.



More information about ergonomics is available on the web:

www.apple.com/about/ergonomics

What Happened?

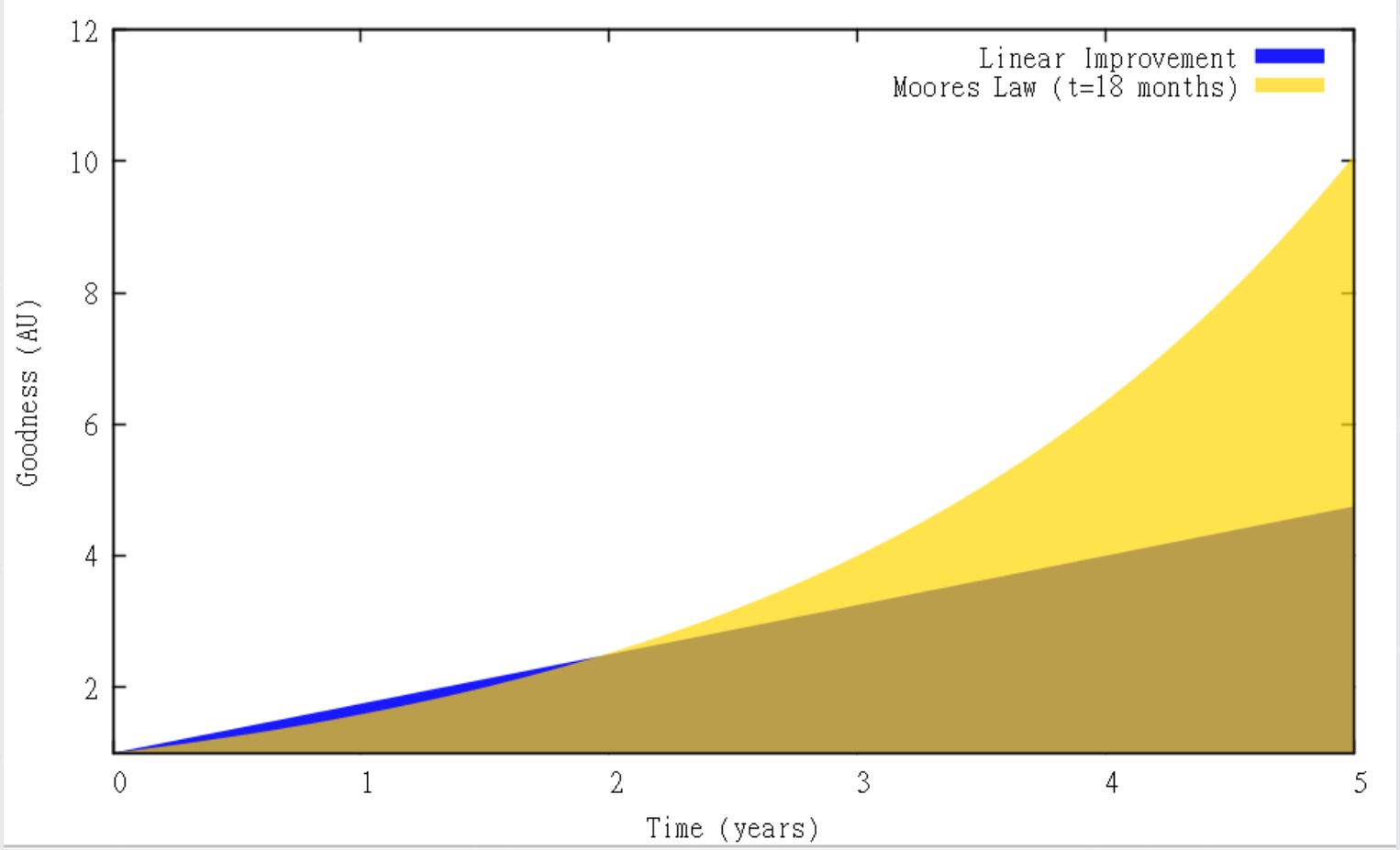
What Happened?

Did hardware become too hard and complex?

No!

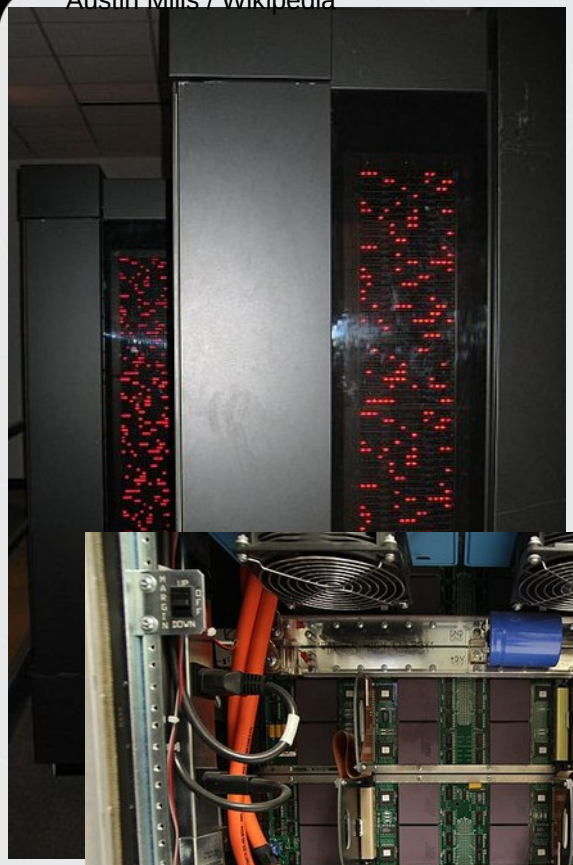
- Actually, hardware has been far too "*easy*" to improve

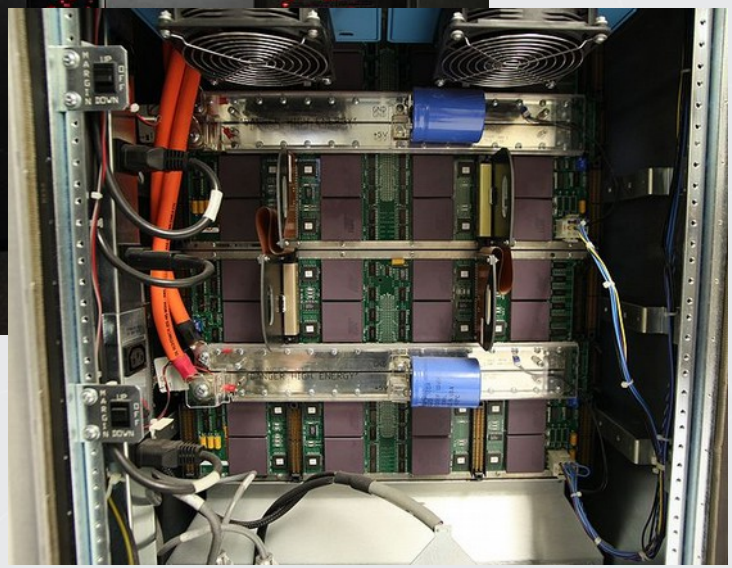
The Unrelenting Treadmill of Moore's Law



Hardware's Classic Problem: “Sit and Wait” >> Innovate

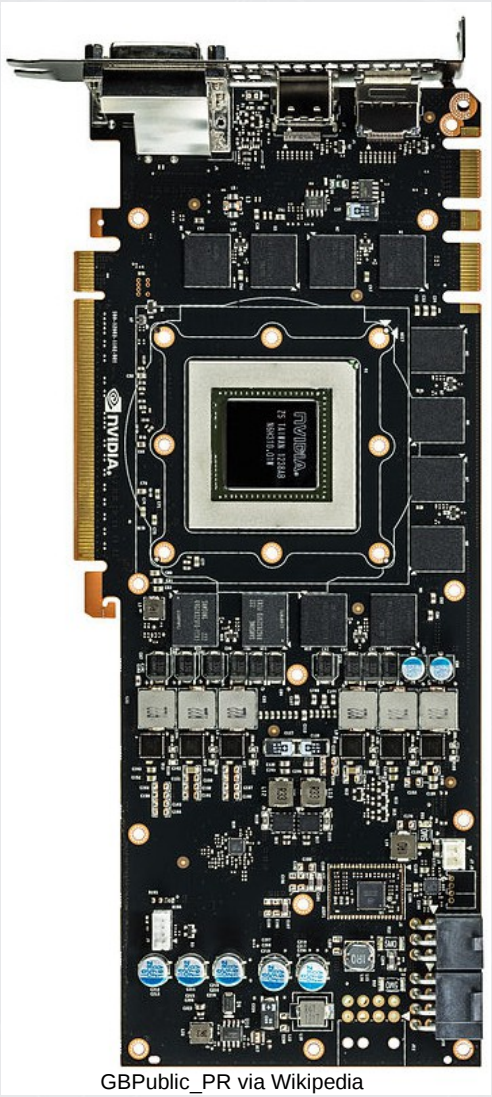
Austin Mills / Wikipedia





Autopilot via Wikipedia

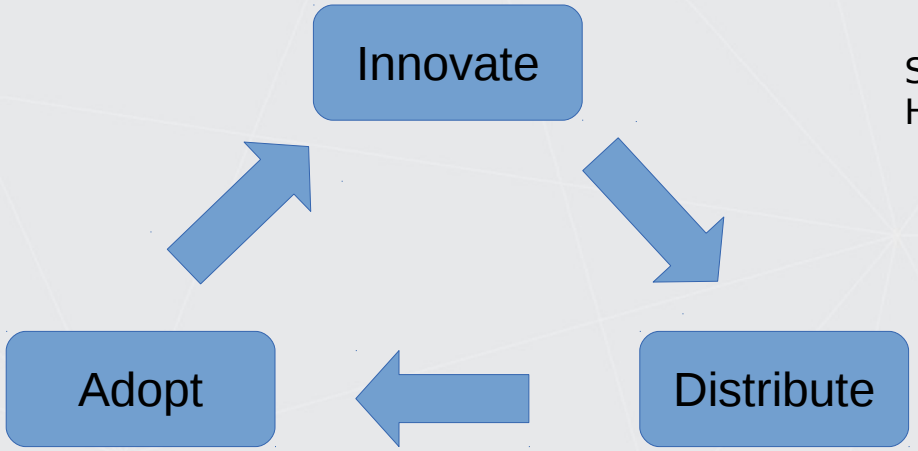
<



GBPublic_PR via Wikipedia

Product Cycle Times: HW vs SW

S: days to weeks
H: weeks to months



Total cycle time:

Software: weeks-months
Hardware: months-years

S: weeks to months
H: months to years

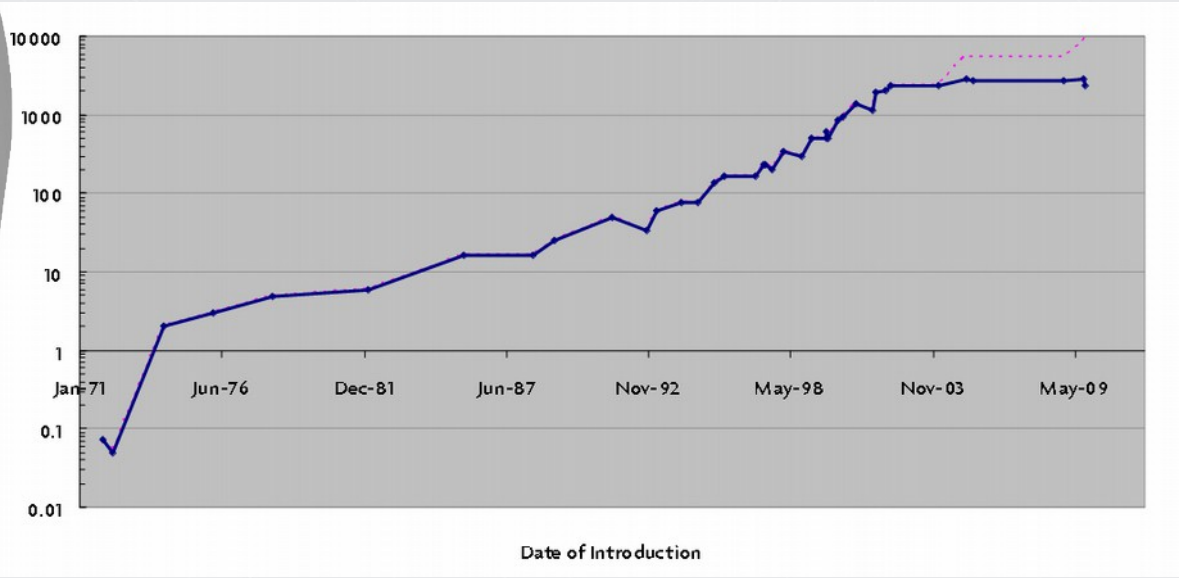
S: seconds to minutes
H: months

In HW, Moore's Law Favors Big Business

- Product Pipelines
  - 2-3 generations in simultaneous development
- Massive distribution
  - Infrastructure to build, deploy millions per month
- Secrecy
  - Secrecy buys a few months delay from competition

This Too Shall Pass.

Clock Scaling 1970-2003 RIP



Famous Last Words...

Flickr/AndYaDontStop

Flickr/Jo Naylor

Is Moore's Law Dead?

- Density doubling rate is slower than 18 months
- Certain fundamental parameters have already hit the wall – Vdd, Vth, gate oxide thickness
- Where does it end?
  - Sometime between 2020-2030, gate length = 5nm (H. Iwai, Microelectron. Eng. (2009), doi:10.1016/j.mee.2009.03.129)

designlines MEMORY

Blog

28nm – The Last Node of Moore's Law

Zvi Or-Bach, MonolithIC 3D Inc.
3/19/2014 06:46 PM EDT
33 comments post a comment

NO RATINGS
5 saves
RATE IT SAVE IT

Like 95 Tweet 24 Share 224 +1 34

We have been hearing about the imminent demise of Moore's Law quite a lot recently. Most of these predictions have been targeting the 7nm node and 2020 as the end-point. But we need to recognize that, in fact, 28nm is actually the last node of Moore's Law.

What does this mean?

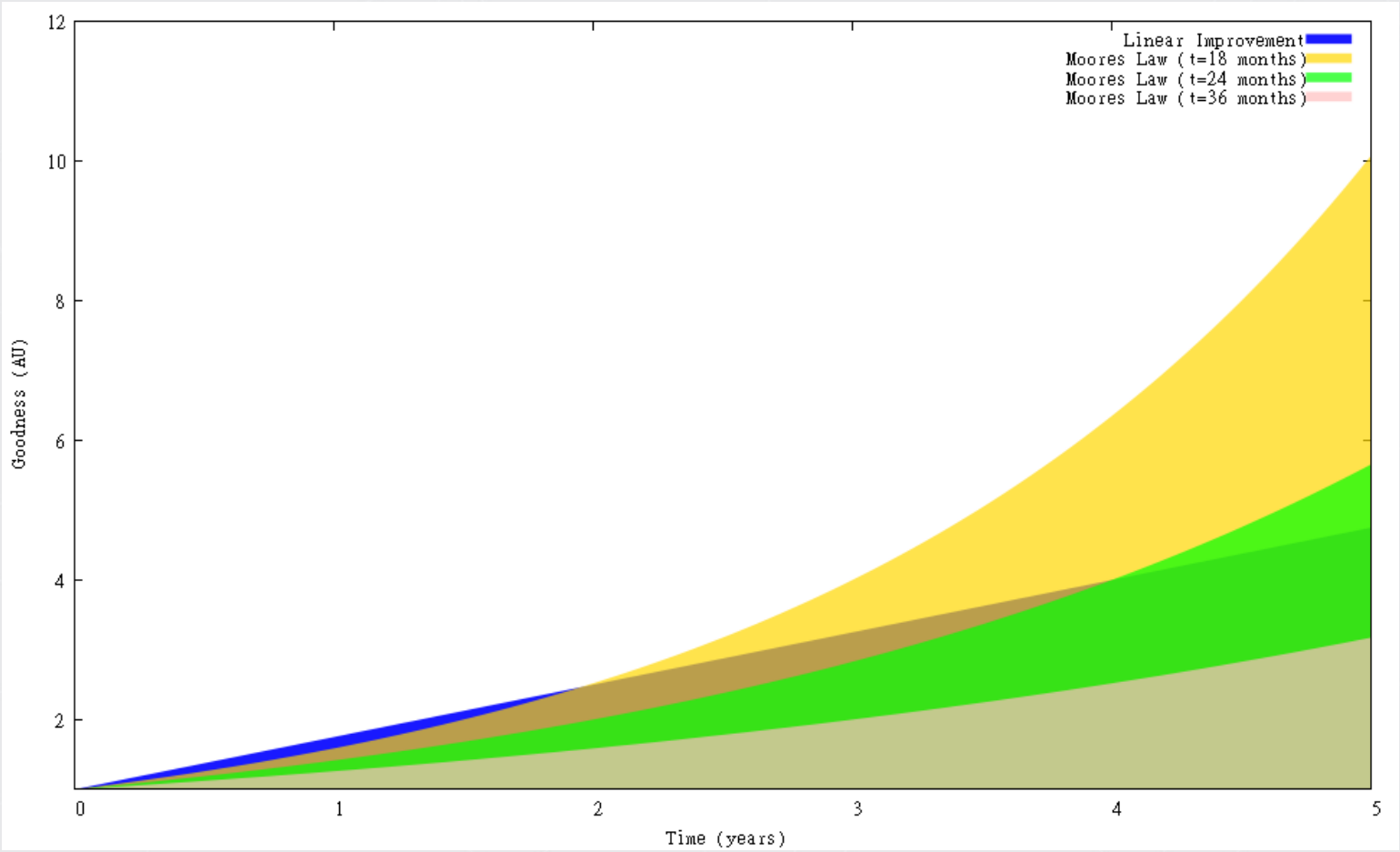
- Soon, these statements will be more true than false:
  - "Next year, you can't buy a faster computer"
  - "Next year, you can't buy a flash drive that stores more data"
  - "Next year, your phone won't be smaller or more powerful"

(* of course, all normalized to cost)

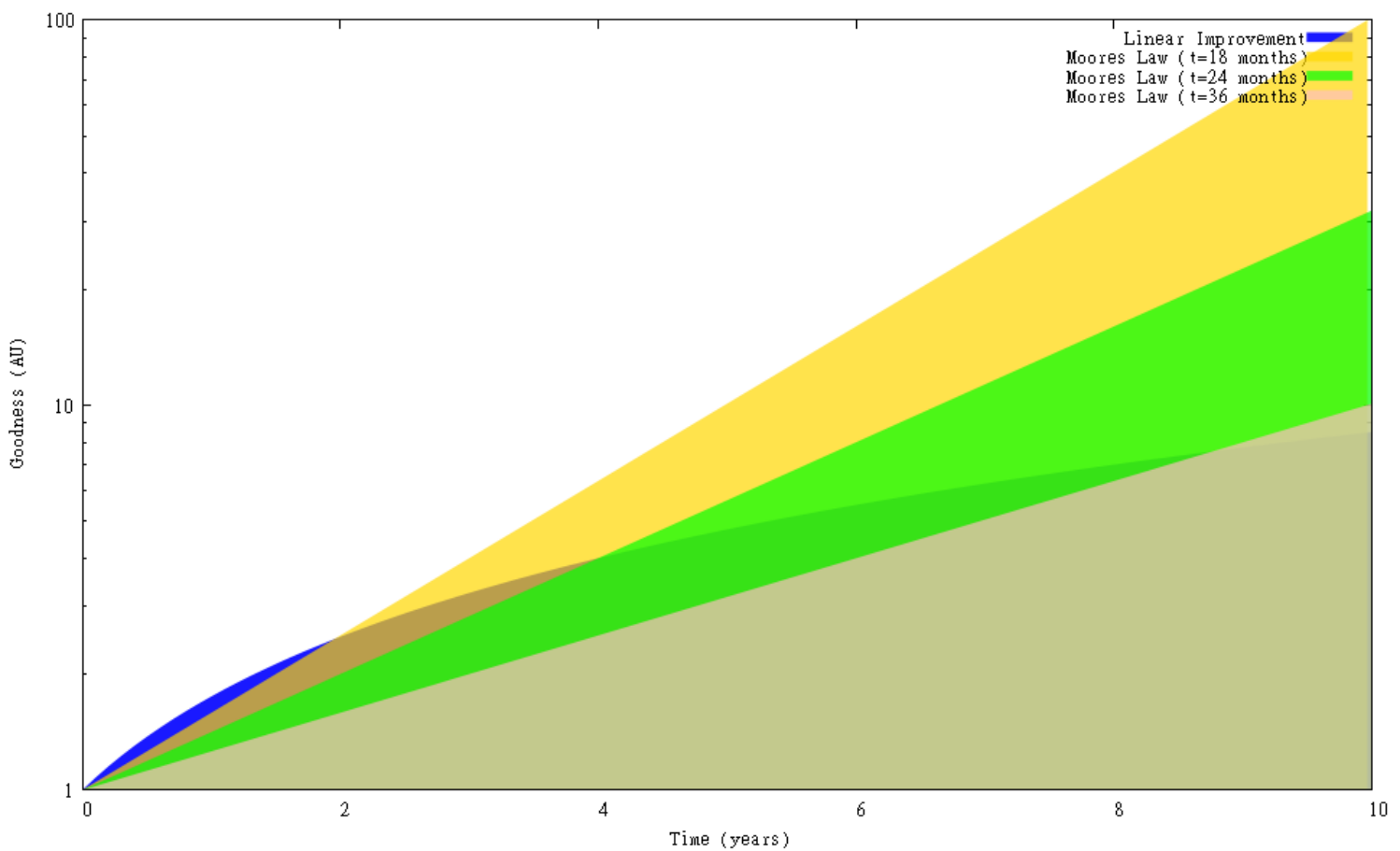
This is Good News.

(at least for “unemployed” engineers like me)

Moore's Law Revisited



Moore's Law Revisited (Log Scale)



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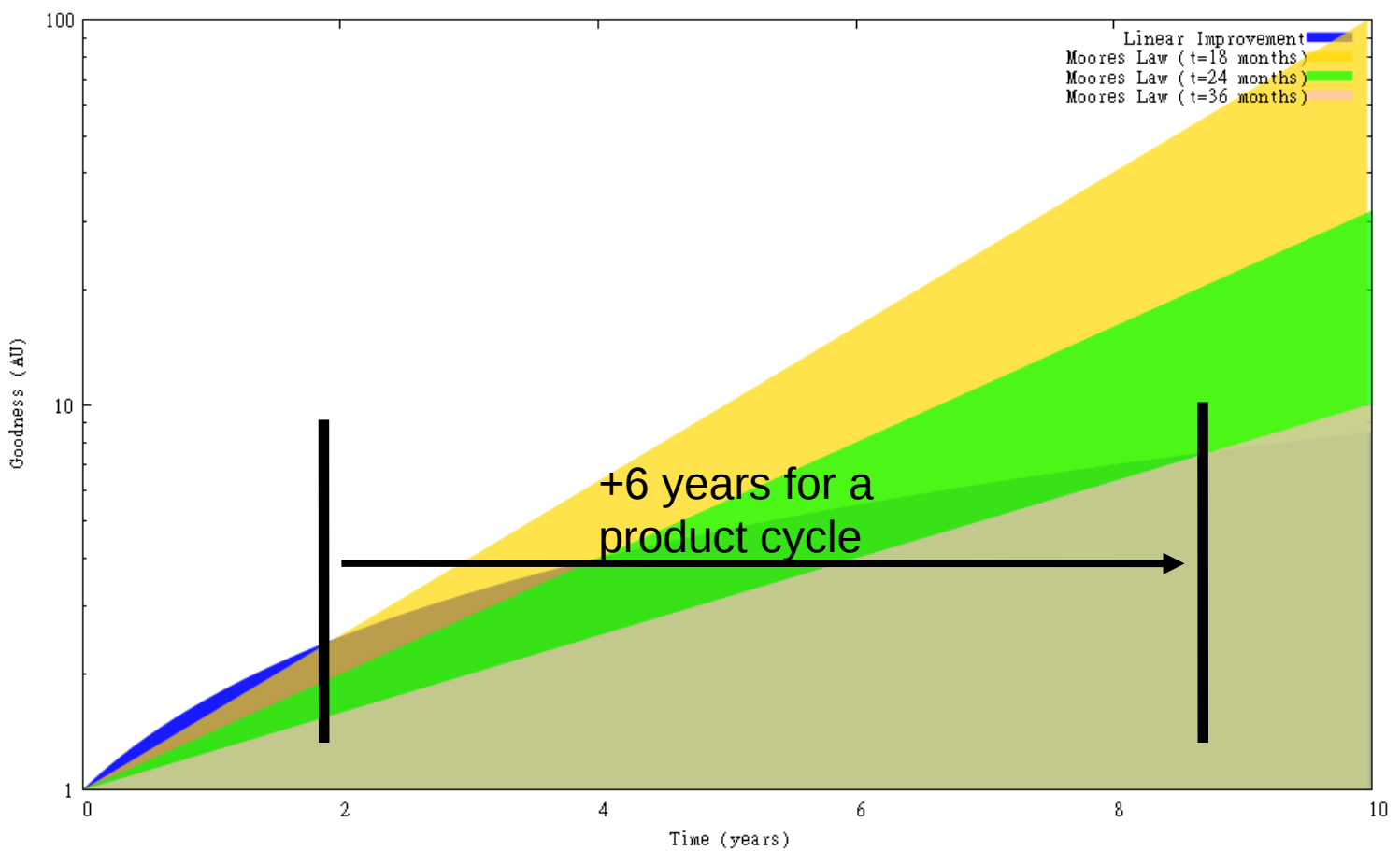


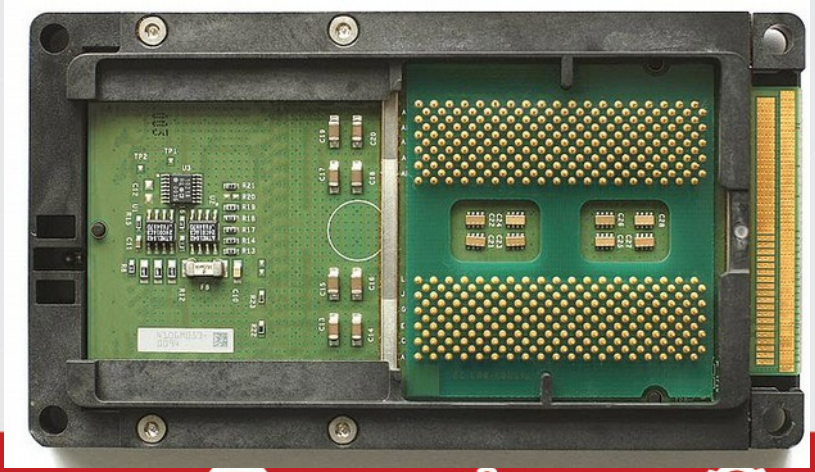
Implications

Architecture Becomes Relevant

- Status Quo: Nobody challenges x86
  - Alpha, SPARC, MIPS, PowerPC...all supplanted by x86
  - 4-6 years for development, compilers, code base porting
  - In same period of time, die-shrinking x86 gets 4x-8x performance boost
- Post-Moore
  - Taking a few years to roll out a new ISA...might just be worth it?

Example of the Past: Itanium

- Itanium
  - Merced, 180nm, 2Q01, 733MHz
  - Madison, 130nm, 4Q04, 1.6 GHz
  - Montvale, 90nm, 4Q07, 1.5GHz
  - Tukwila, 65nm, 1Q10, 1.5GHz
  - Poulson, 32nm, 4Q12, 2 GHz



Konstantin Lanzet via Wikipedia

- x86
  - Foster, 180nm, 2Q01, 1.4GHz
  - Prestonia, 130nm, 2Q02, 1.8GHz
  - Nocona, 90nm, 2Q04, 2.8GHz
  - Tulsa, 65nm, 3Q06, 3+ GHz
  - Clarkdale, 32nm, 4Q09, 3GHz x 4 cores
  - Ivy Bridge, 22nm, 4Q12, 3.5GHz x 4 cores

The Rise of ARM

- ARM used to be a controller for toasters and DVD players
- Now, it is a serious contender to x86
  - Cortex A15 implementations pushing 2+GHz, 4 cores
  - 64-bit versions targeting servers

Optimization Becomes Relevant

- Status Quo: don't optimize, cram in more features, wait 2 years and the software will start to run well
  - Remember how slow WinXP and Vista ran when they first came out?
  - Focus on features enabled due to new capability
- Post-Moore:
  - Spending 1.5 years to hand-optimize a library to get 2x performance makes sense
  - Got a big problem? Take a couple years to make a custom ASIC
    - e.g. Bitcoin

Style and Fashion Matters More

- Status Quo: Incentive to buy based solely upon hardware spec improvement
  - Performance
  - Size
  - Battery life
  - Cost
- Post-Moore: As specs flatten out, products must differentiate through other means
  - Style
  - Fashion
  - Usability
  - Apps

Irfan Nasir via Wikipedia

Moore Era

Post-Moore

Wikipedia /
Zach Vega (5S),
Justin14 (4 & 5C)

A Higher Value on Craftsmanship and Design

Flickr / midnightcomm

Public domain

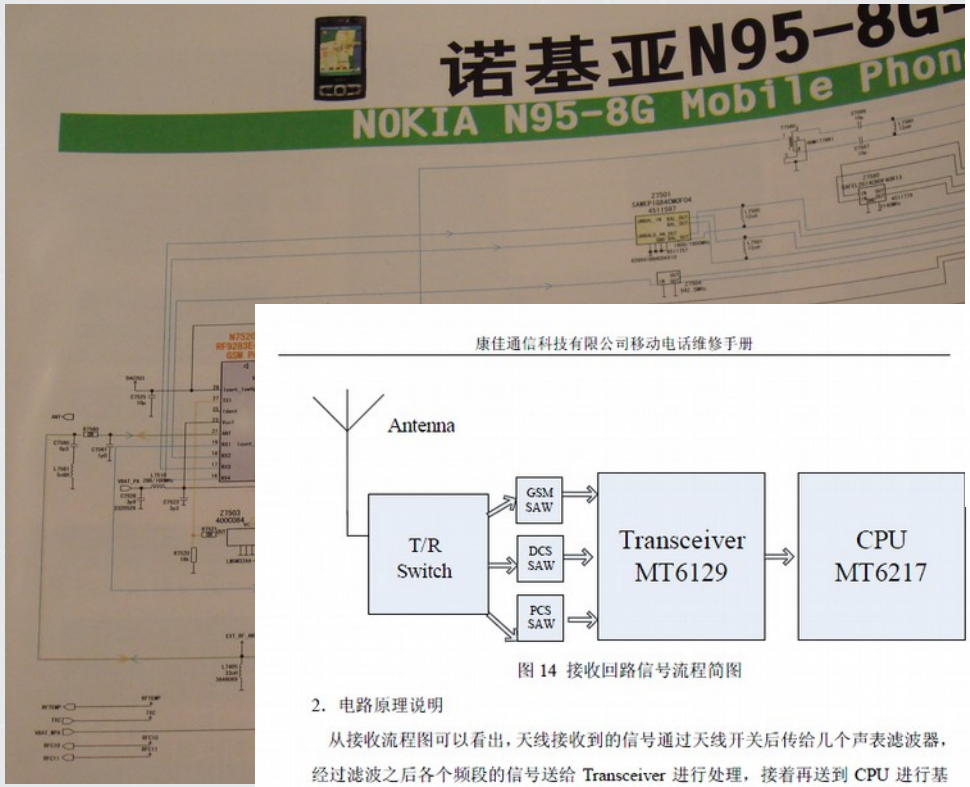
A Rise in Repair Culture

- Status Quo: Replace, don't fix; the new model is better and cheaper than repair
- Post-Moore: Less incentive to replace, more incentive to fix
  - Corollary #1: Broken gadgets have recycling value
  - Corollary #2: Reverse engineering has more value

Repair Culture in China

- Emerging markets are a generation or two behind on tech
- Yesterday's phones are today's parts

Information Ecosystem



康佳通信科技有限公司移动电话维修手册

图 14 接收回路信号流程简图

2. 电路原理说明

从接收流程图可以看出，天线接收到的信号通过天线开关后传给几个声表滤波器，经过滤波之后各个频段的信号送给 Transceiver 进行处理，接着再送到 CPU 进行基带处理。

3.故障分析：

接收电路的测试项包括 Rx Level ,Rx Quality,BER 等。根据信号接收流程框图，与接收电路故障相关的主要元器件有天线开关、两个声表滤波器，射频收发 IC 以及 CPU。

图 1 M930 外形图

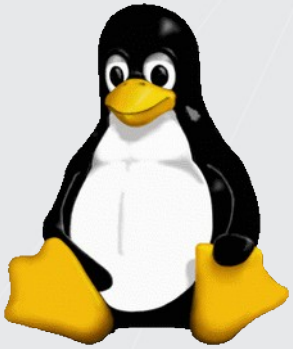
Result: New, Whacky Ideas ("Innovation")

Opportunity for Small Innovators

- "Shanzhai" example demonstrates phones can be made by small teams with low capital investment
  - Stable platforms
  - "Open" documentation
  - Ecosystem of support tools
  - But this didn't happen overnight...

Open Products Take Time

2002



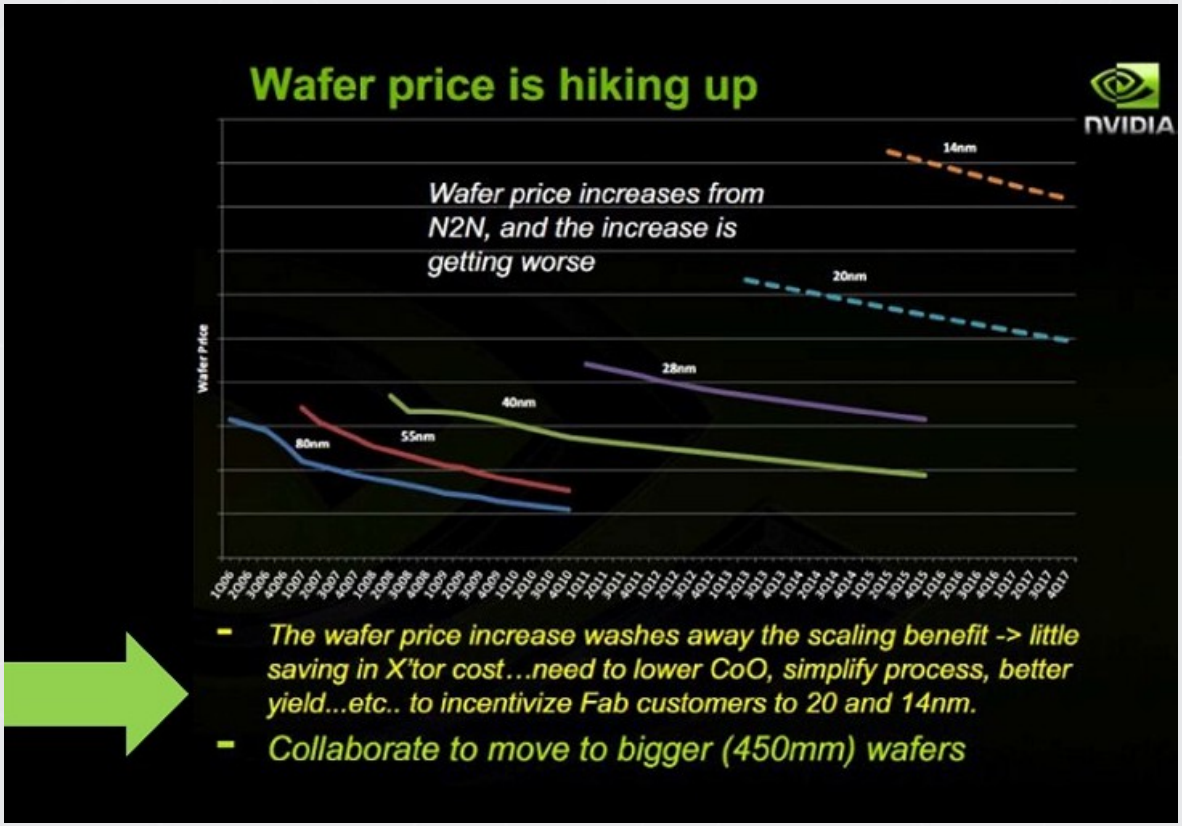
1991

OpenOffice initial release 2002

The Open Hardware Situation

- Why has open hardware yet to take off?
  - Open source communities take years to grow
  - Until now, not a good match for hardware
    - Open source is developed on a shoestring budget
    - Arduino could flourish because its appeal is performance-independent
    - Beaglebone, Rpi have corporate sugar daddies
  - Hardware distribution takes time
    - Individuals have limited capital for investment into supply chain
    - Shelf-life of hardware was too short during Moore's Law

So, Moore's Law Now...?



(source: EETimes, “28nm – The Last Node of Moore's Law” by Zvi Or-Bach)

Adding it All Up

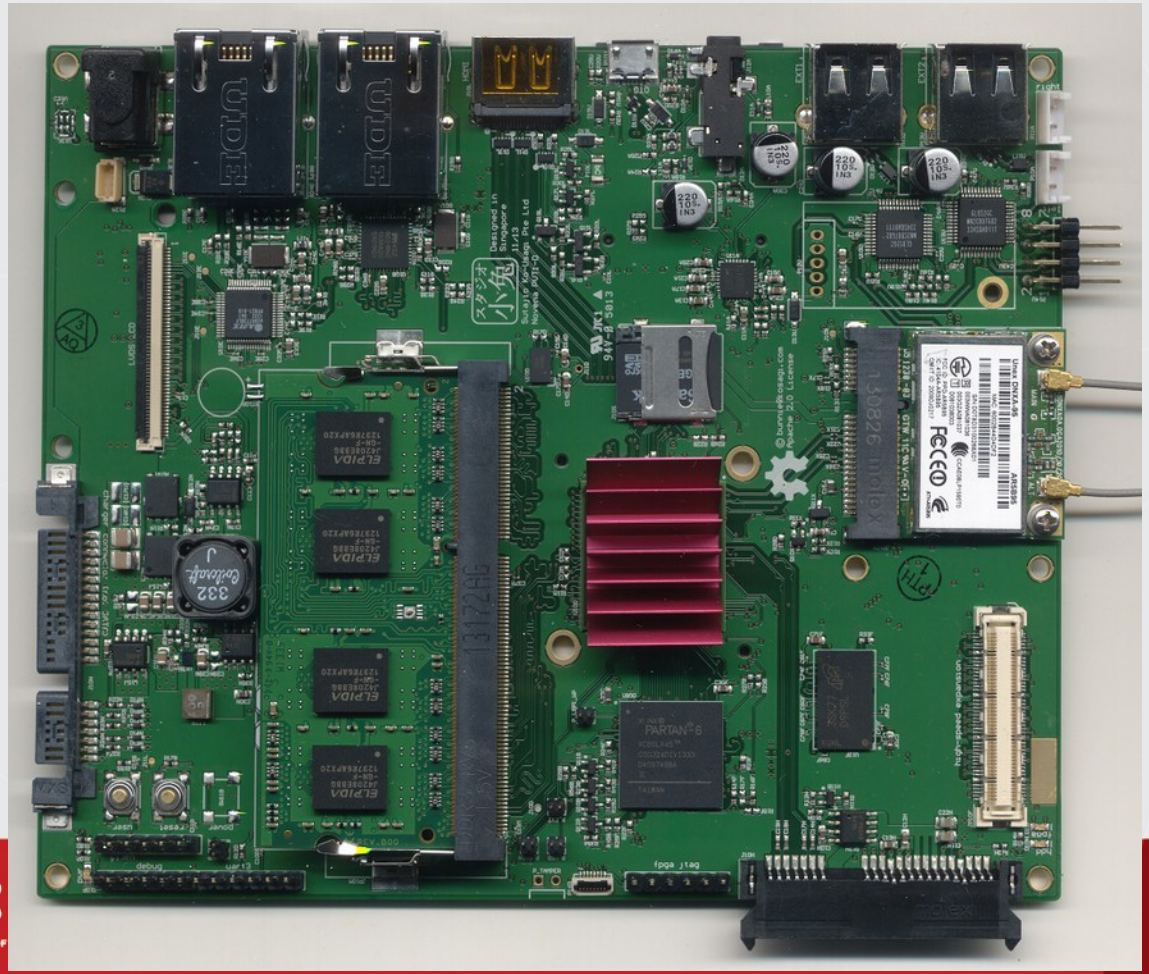
Technology stabilization +
small disruptive teams +
time for organic growth +
repair/DIY culture
=
open hardware impact opportunity

Other Things to Look Forward To

- Arduino-like platforms as powerful as smartphones
- FPGAs that perform comparably to CPUs
- Competitive DIY chassis for notebooks and tablets
- A rise in repair/restoration culture
- The emergence of “heirloom” hardware

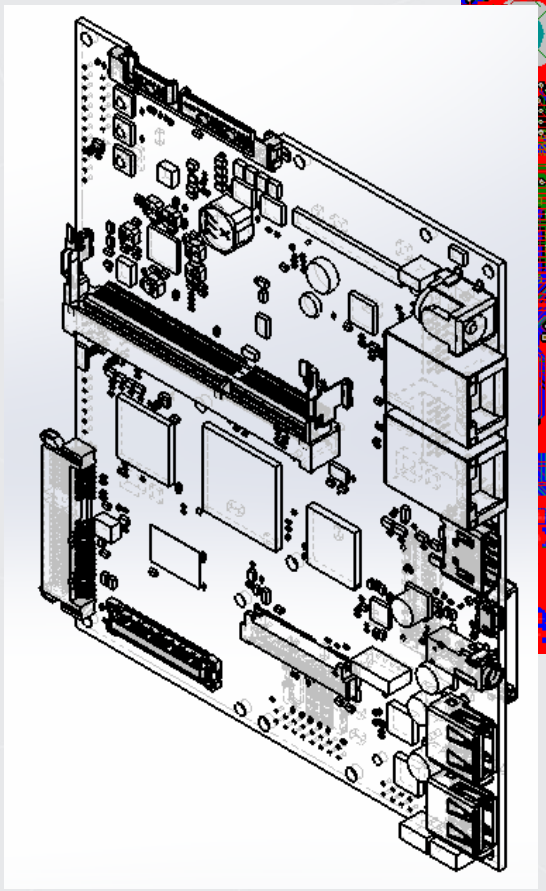
An Open Hardware Experiment

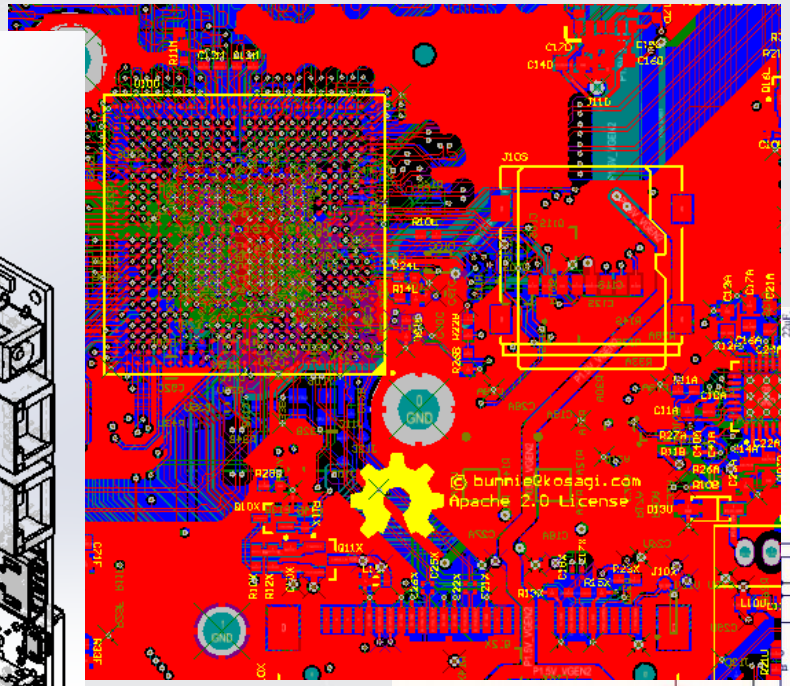
- Our Open Hardware computing platform, “Novena”

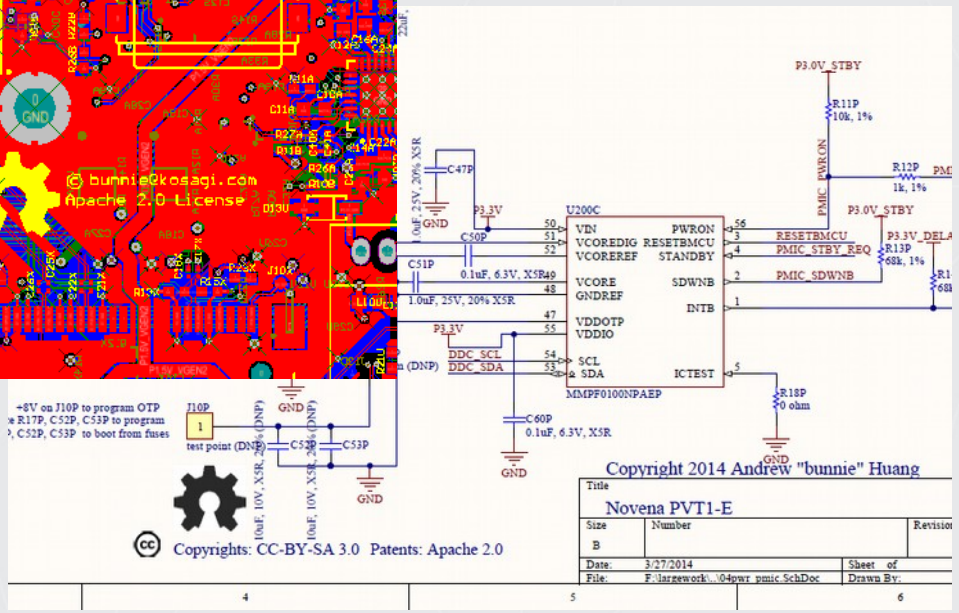


@novenakosagi

Open Hardware

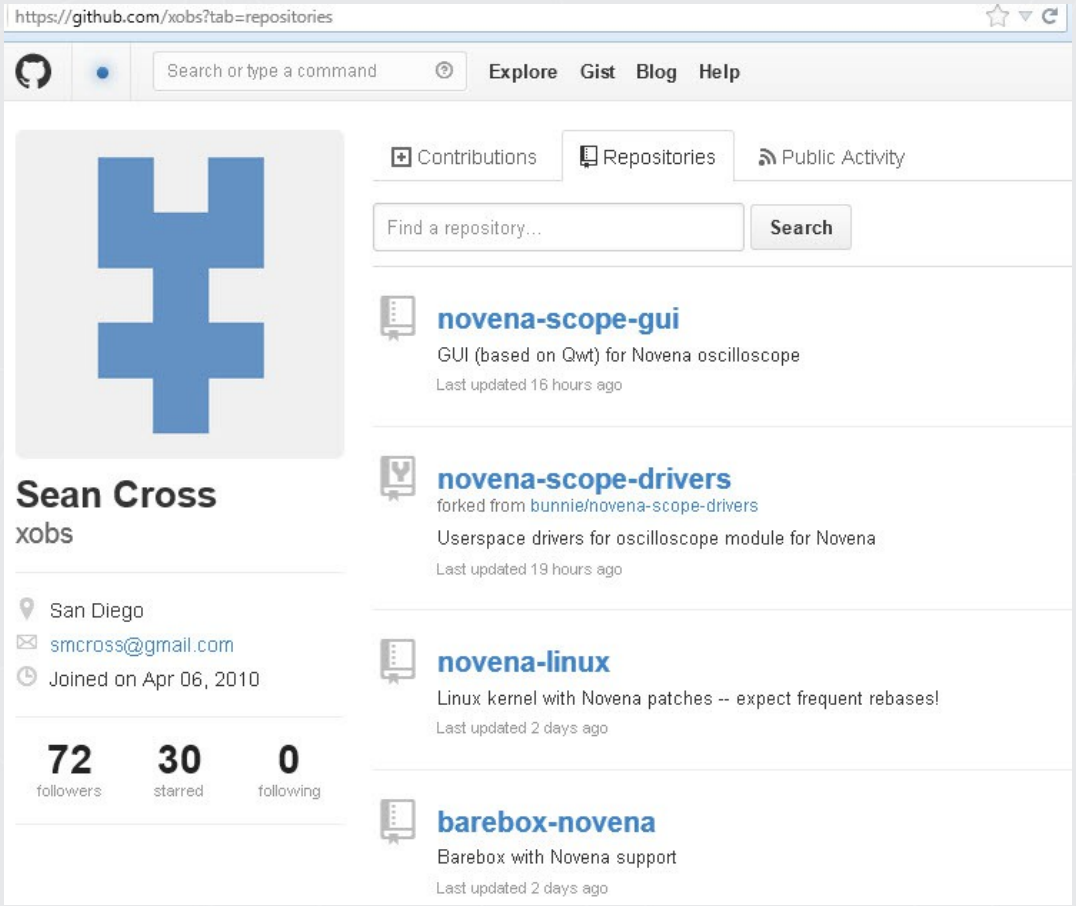






http://www.kosagi.com/w/index.php?title=Novena_Main_Page

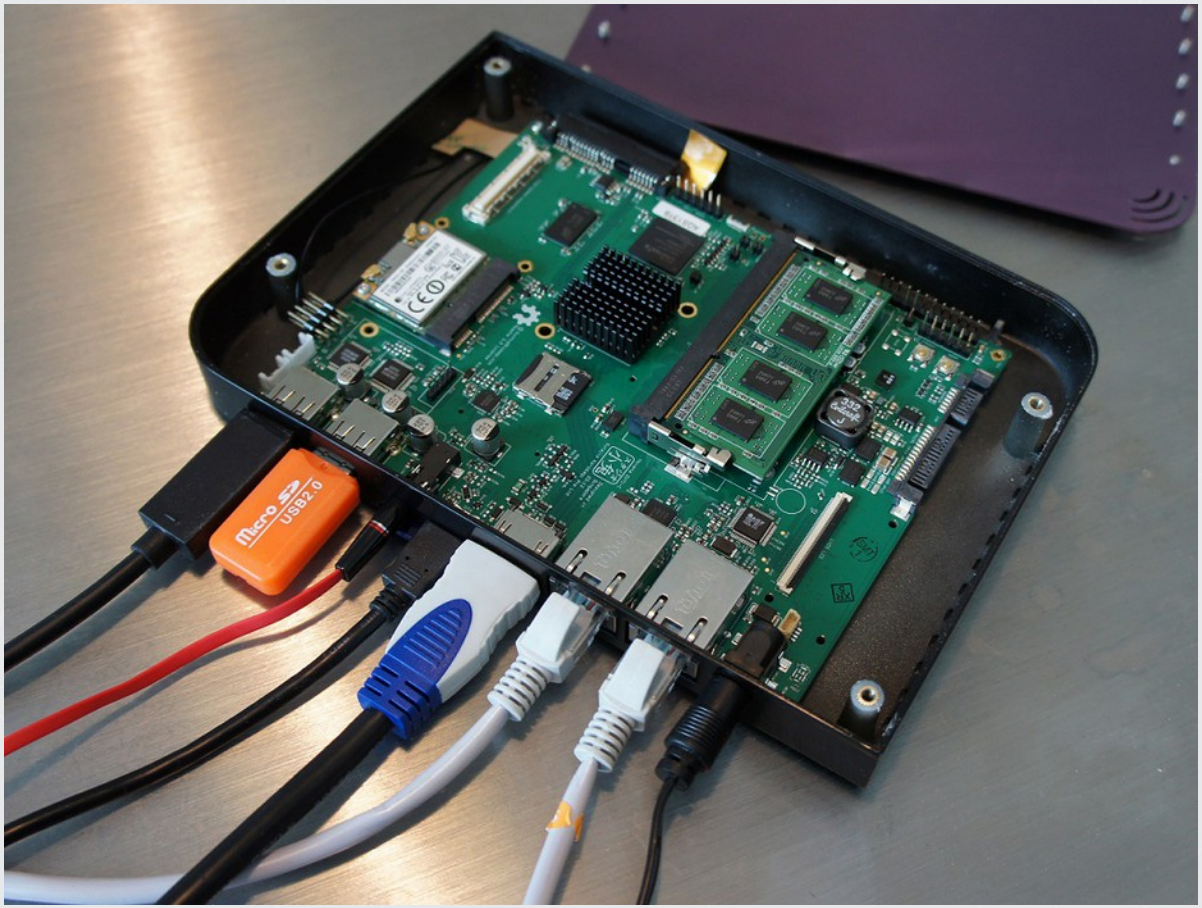
Open Firmware



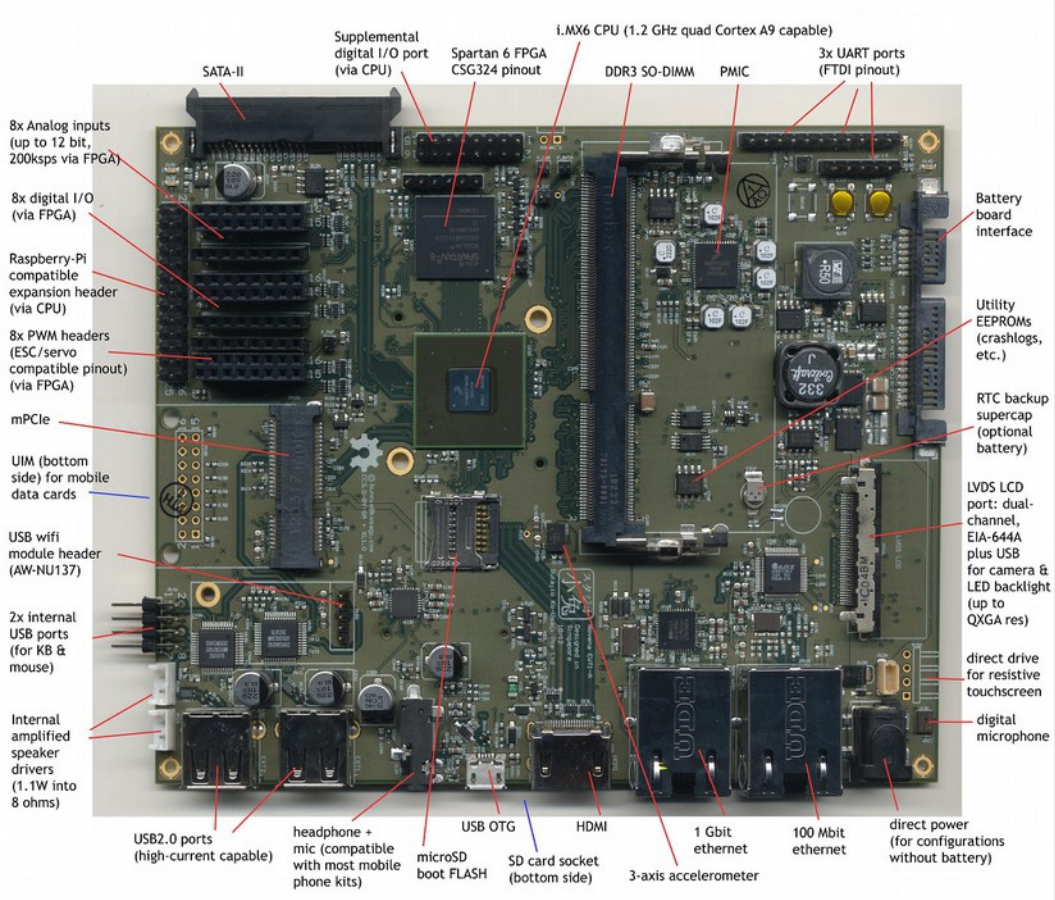
Design Timeline

- Project conceived June 2012
- PCBA EVT – Dec 2012
- “Router-style” prototype case Apr 2013

Inside the “Router” style case



EVT PCBA


SATA-II
Supplemental digital I/O port (via CPU)
Spartan 6 FPGA CSG324 pinout
i.MX6 CPU (1.2 GHz quad Cortex A9 capable)
DDR3 SO-DIMM
PMIC
3x UART ports (FTDI pinout)
8x Analog inputs (up to 12 bit, 200ksps via FPGA)
8x digital I/O (via FPGA)
Raspberry-Pi compatible expansion header (via CPU)
8x PWM headers (ESC/servo compatible pinout) (via FPGA)
mPCIe
UIM (bottom side) for mobile data cards
USB wifi module header (AW-NU137)
2x internal USB ports (for KB & mouse)
Internal amplified speaker drivers (1.1W into 8 ohms)
Battery board interface
Utility EEPROMs (crashlogs, etc.)
RTC backup supercap (optional battery)
LVDS LCD port: dual-channel, EIA-644A plus USB for camera & LED backlight (up to QXGA res)
direct drive for resistive touchscreen
digital microphone
USB2.0 ports (high-current capable)
headphone + mic (compatible with most mobile phone kits)
microSD boot FLASH
USB OTG
SD card socket (bottom side)
HDMI
3-axis accelerometer
1 Gbit ethernet
100 Mbit ethernet
direct power (for configurations without battery)

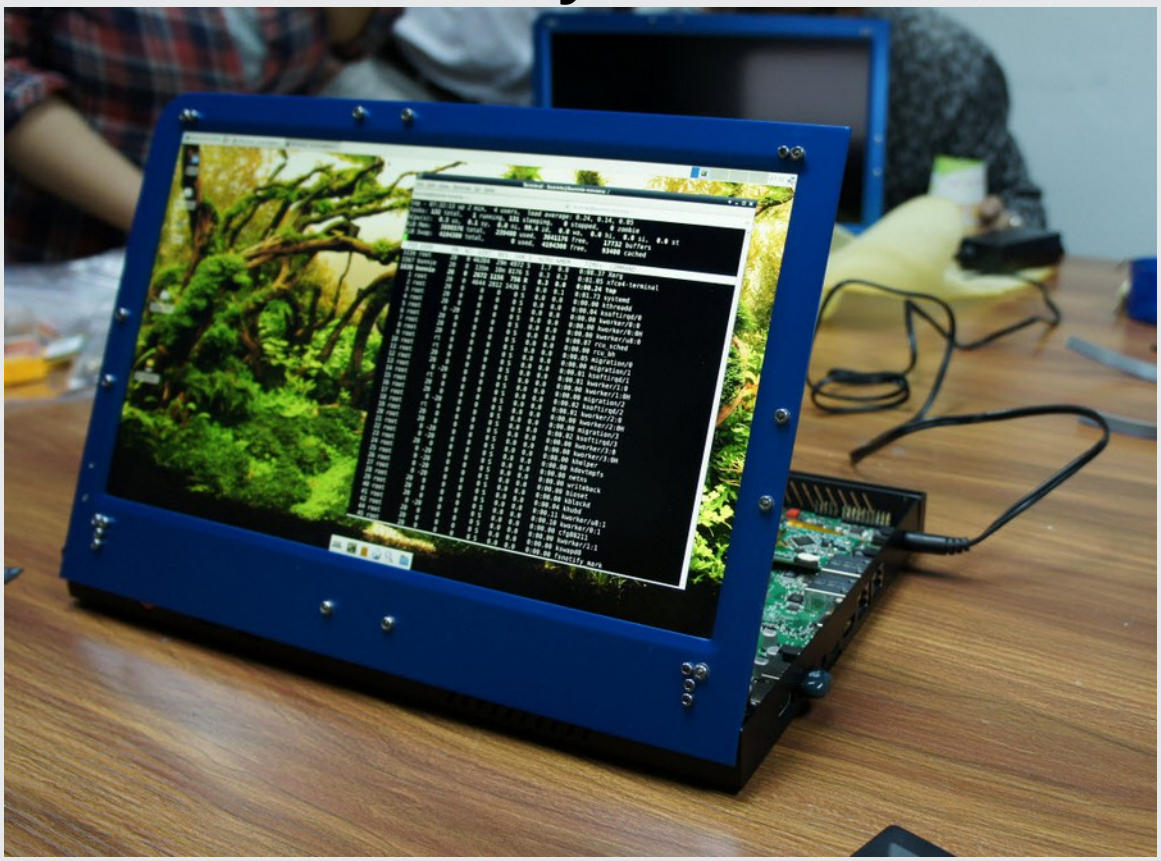
DVT Evolution

- PCBA DVT – May 2013
- Home-made “laptop-style” case Dec 2013

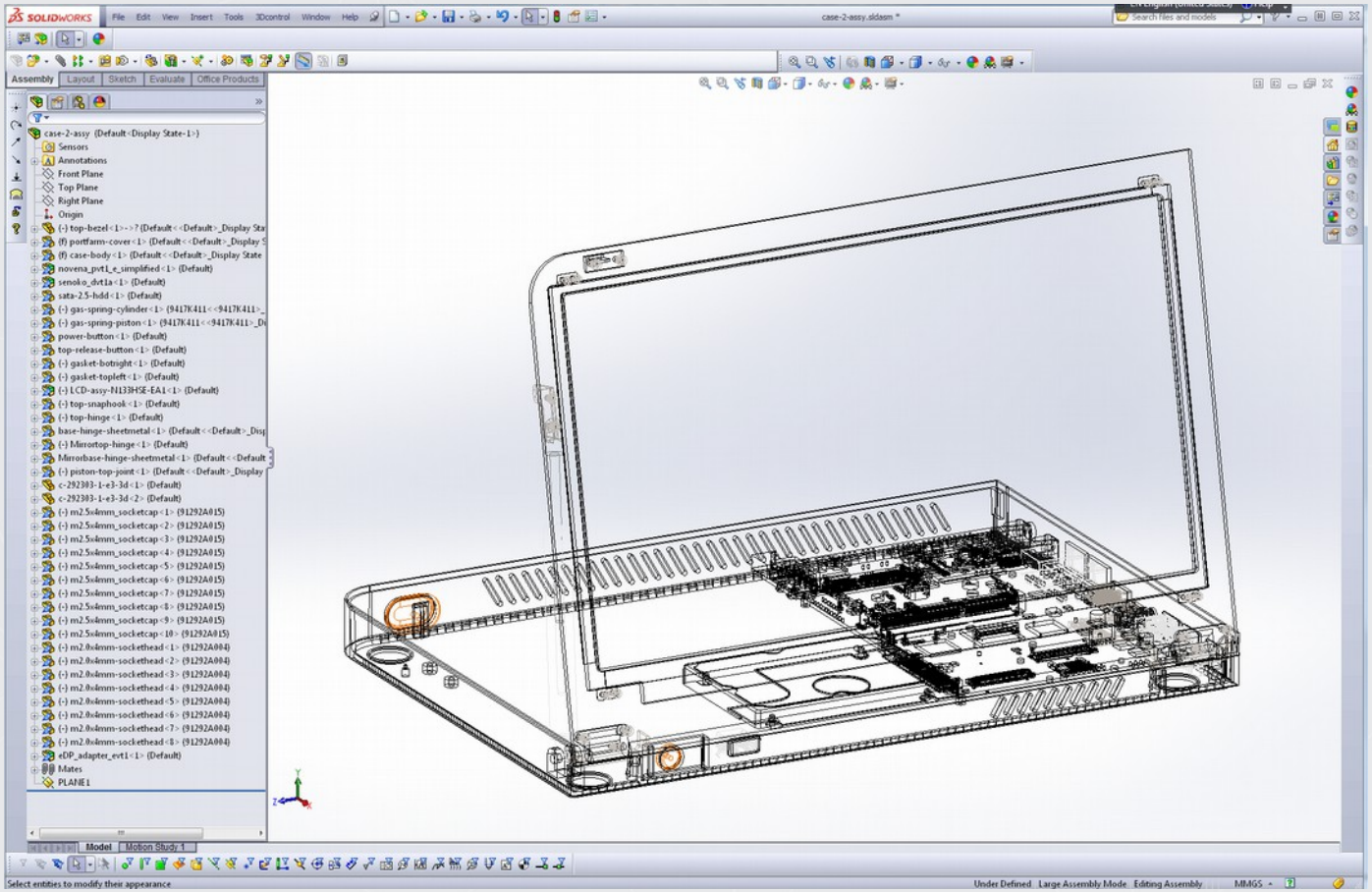
Hand-made proto case

PVT Evolution

- PCBA PVT – January 2014



Gen-2 Design Start – Feb 2014



Proto Build – March 2014

Made for Mods & Hacks

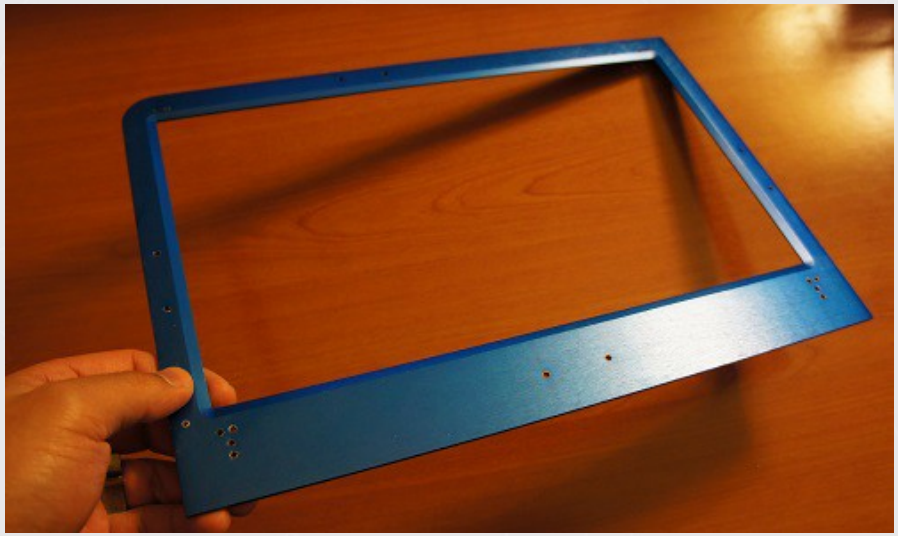
Peek Array

Other Features

- Side panel covering ports is replaceable/upgradeable

Other Features

- "Make it your own"
  - You pick the battery capacity, charger "learns" your battery
  - Easy to replace/fabricate LCD bezel



The “Heirloom” Model

- Invited designer and craftsman Kurt Mottweiler to create an “heirloom”-grade case

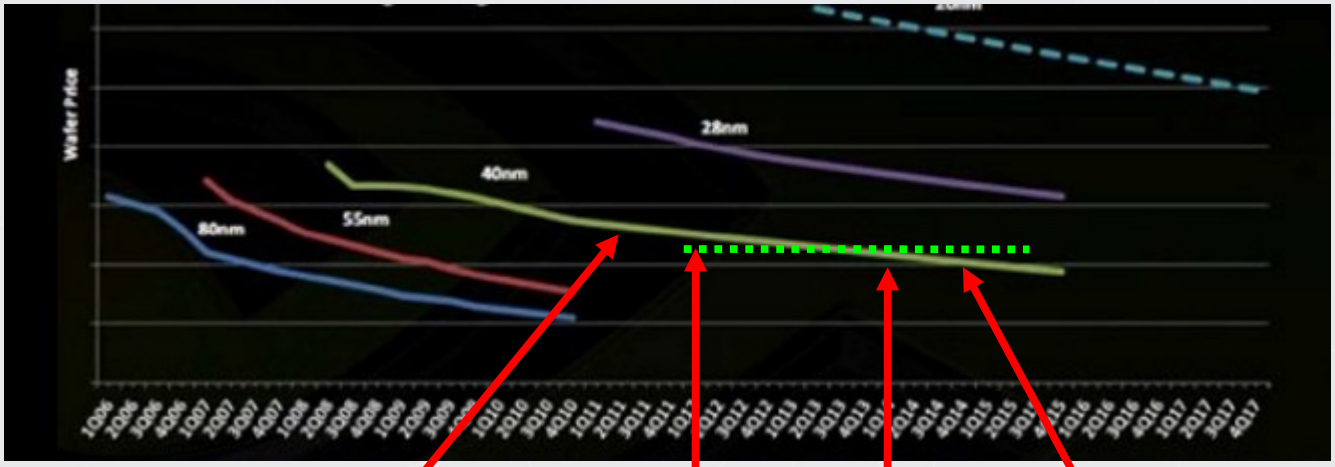
Why Heirloom?

- Make hardware with the intent that it will *not* be thrown away
  - Use of exquisite materials and craftsmanship
- An exercise in open hardware enablement
  - Case intended to be upgraded and used for years to come
  - Concurrent collaboration with 3rd party simplified, enabled; no NDA or onerous contract

Right Now

- PVT and heirloom designs funding at crowdsupply.com
  - https://www.crowdsupply.com/kosagi/novena-open-laptop
  - @novenakosagi

How is Novena Possible?



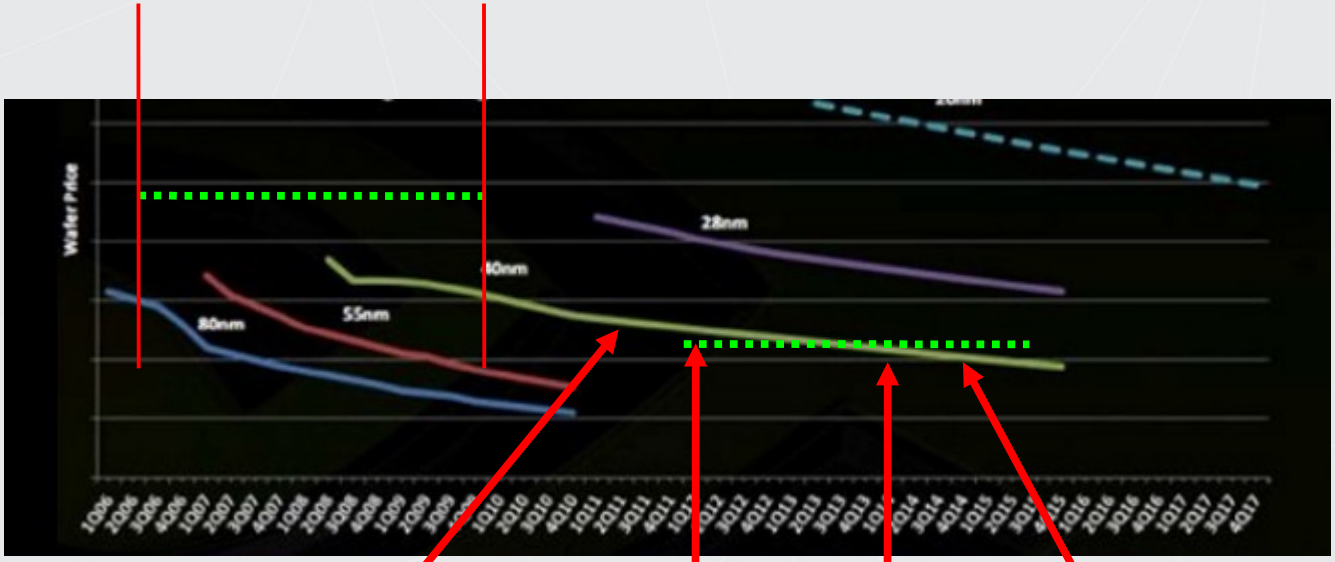
i.MX6 fabbed in 40nm

Conception

Launch

Delivery

Retrospective



i.MX6 fabbed in 40nm

Conception

Launch

Delivery

Where to Go from Here

- Open hardware is about building communities around platforms
  - Please, take our IP! (http://kosagi.com)
  - And if possible, contribute back to the community
  - And, if you don't want to build your own, you can buy it at crowdsupply.com

Recap: The Experiment

Technology stabilization +
small disruptive teams +
time for organic growth +
repair/DIY culture
=
open hardware impact opportunity

Recap: The Experiment

Technology stabilization +
small disruptive teams +
time for organic growth +
repair/DIY culture
=
open hardware impact opportunity

+ crowd funding + backers = realized impact

Thanks!

@bunniestudios / @novenakosagi
www.bunniestudios.com / www.crowdsupply.com