DEF CON

Untrustworthy Hardware

And How to Fix It

PRESENT DAY.

Thanks to Contributors:

- ##FPGA, ##crypto and #openRISC on Freenode

- Shorne and Olofk from #openRISC (hardware and cross-compilation help)

- PropellerGuy (Parallax Propeller open-source IO interface)

- Briel Computers' PockeTerm project

Greetz:

- Maitimo, International Finance, DC408

PRESENT TIME

Layer:01 Software

- core modern open source algorithms for strong cryptography have been heavy scrutinized, tested and are readily available

- weak (DES, WEP, etc) and “black box” privacy tools are becoming a thing of the past

- free and open source software has made it easier to trust the privacy of computer systems

Let’s assume the software (hypothetically) is 100% secure…

Linux

open source

GnuPG

Where do we go from here?

Layer:02 Firmware

- firmware is almost exclusively closed source and controls almost all hardware devices and functions

- due to their low-level nature, malicious firmware persists across OS reinstallations

- (DEF CON 22: Summary of Attacks Against BIOS and Secure Boot) "SPI flash is a really nice place if you can get there"

Layer:03 Hardware

- hardware is almost always absolutely trusted by the rest of the system, as it is not widely considered an attack surface (especially in the consumer space)
  - NSA has been caught hardware backdooring Cisco systems (Glenn Greenwald, "No Place to Hide"), and DoD, Apple suspect adversarial nation states may be doing this as well
- “if the hardware is compromised, then the whole machine is compromised”

(TS//SI//NF) Left: Intercepted packages are opened carefully; Right: A "load station" implants a beacon

hardware backdooring is real

Layer:04 Intel Management Engine

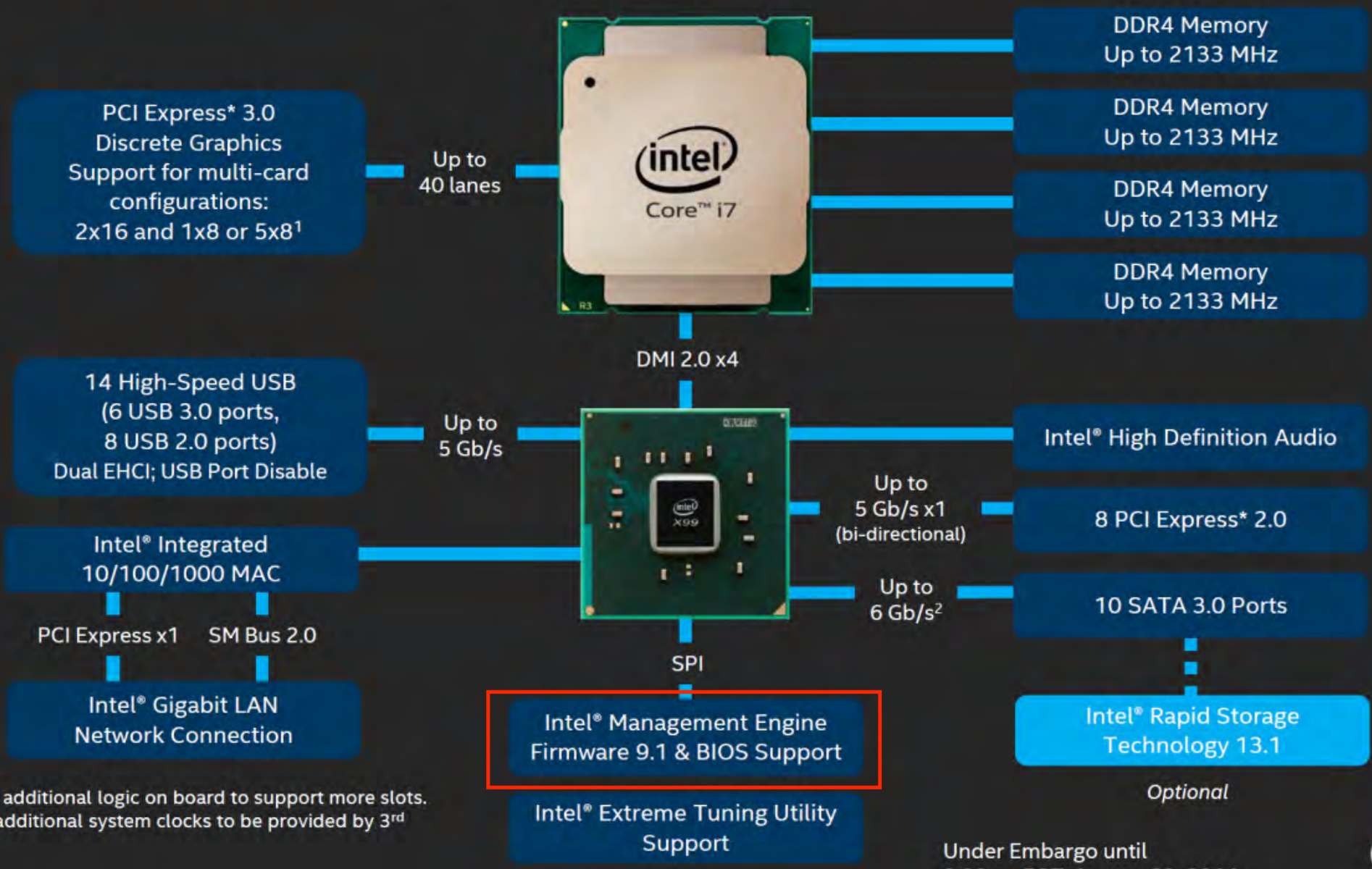
- Management Engine runs on a dedicated logic device within the processor and runs proprietary firmware and OS

- Intel ME has full network device access with the ability to intercept network traffic without the CPU’s knowledge

- system access at the lowest level

- remains functional in the background even if the system is shut down but remains on standby power

Intel® Core™ i7 High End Desktop Platform Overview



[1] 3 slots available, but need additional logic on board to support more slots. 5x8 configuration requires additional system clocks to be provided by 3rd party components.

[2] All SATA ports capable of 6 Gb/s.

Under Embargo until
9:00am PST, August 29, 2014

intel Look Inside.™

Management Engine might sound like a feature reserved for enterprise or server applications, but it everywhere

Intel ME Technical Overview

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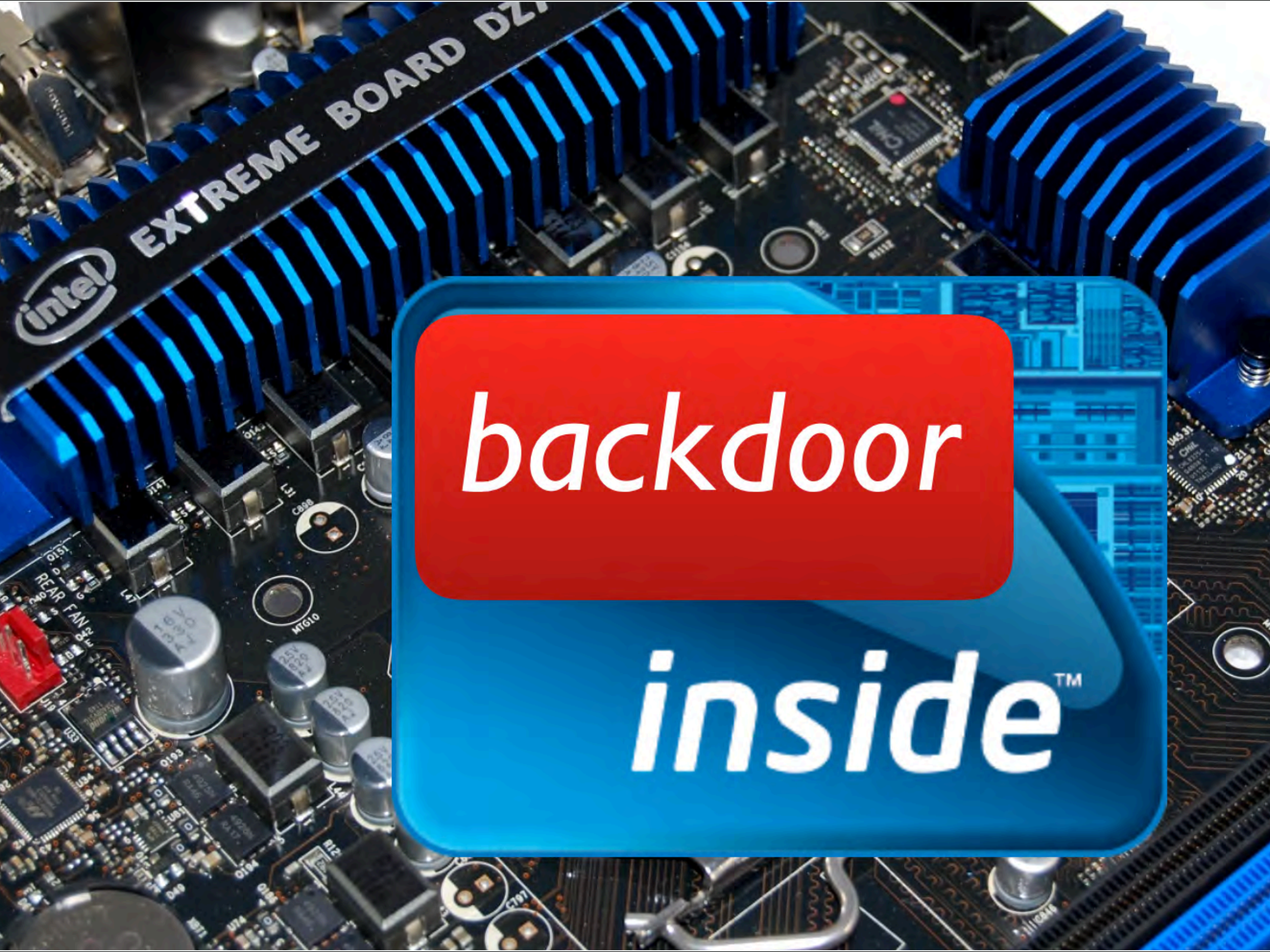
- multiple versions of IME exist using ARC, SPARC V8 and other instruction sets

Atmel Rad-hardened Sparc V8

ARC development platform

“In short, it’s a reverse-engineer’s worst nightmare.”

– hackaday.com


EXTREME BOARD
intel
backdoor
inside™

- effectively the perfect hardware backdoor, although ME is marketed as an IT out-of-band management tool

- present in all Intel systems since ~2008-2009, with no practical way to disable or audit

- handful of exploits exist for ME, with the number on the rise, requiring a firmware update from the manufacturer

Note:- AMD also has a similar black-box platform, called TrustZone / PSP, but it has not been well documented / researched (they haven’t made new CPUs until recently)

Bonus Round: Speculation

- If we’re discussing a worst case situation for hardware security, just how far can we go?

What About Nation States?

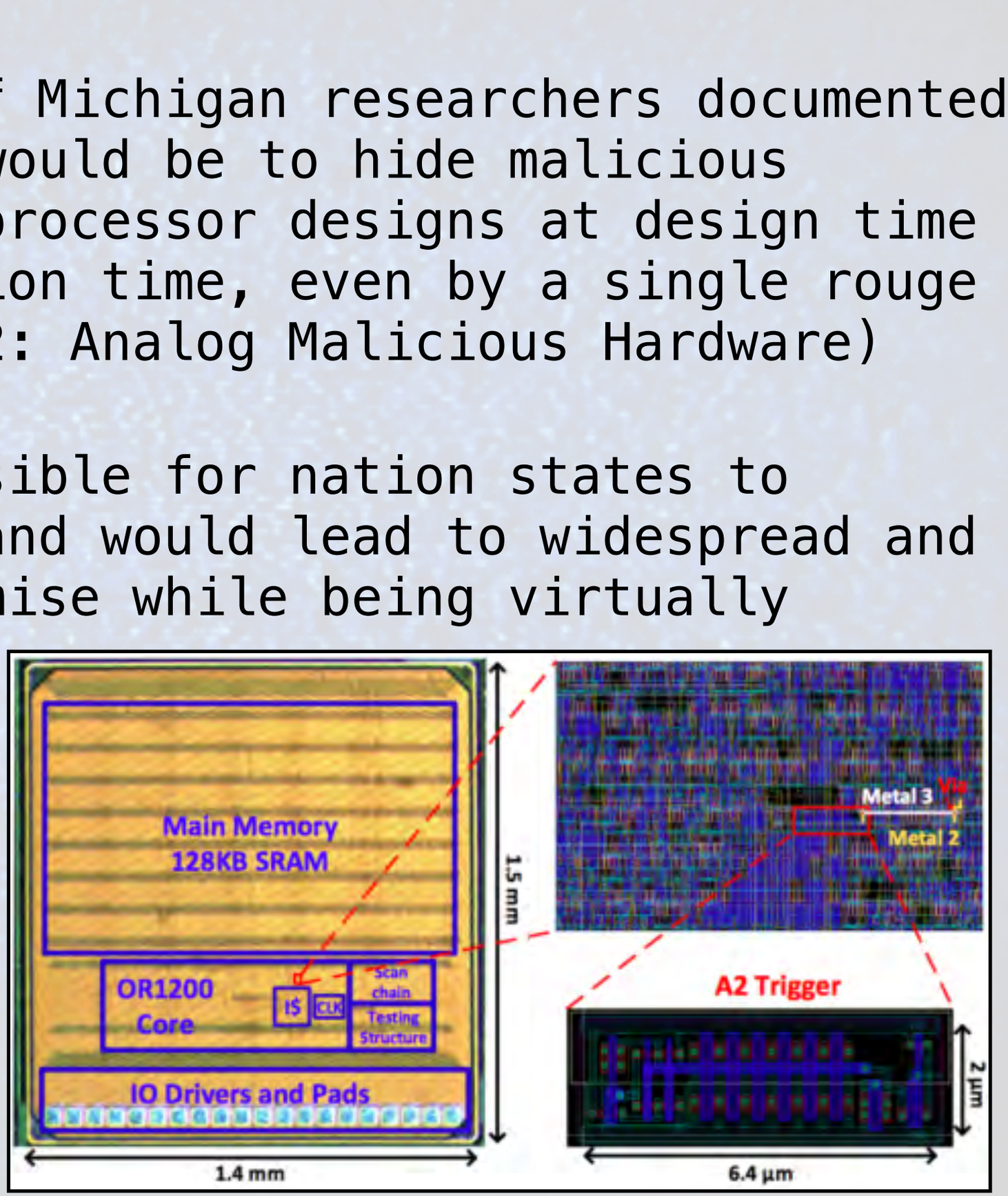
- Hardware backdooring has been documented as mentioned earlier is viewed as a viable threat by other state actors (DoD)

- nation states could backdoor product manufacturing with switched or additional components

- scarier yet, chips themselves (CPUs, chipsets, NICs, ROMs) could be backdoored at the fabrication center

- University of Michigan researchers documented how easy it would be to hide malicious features in processor designs at design time and fabrication time, even by a single rouge employee! (A2: Analog Malicious Hardware)

- entirely possible for nation states to accomplish, and would lead to widespread and total compromise while being virtually undetectable



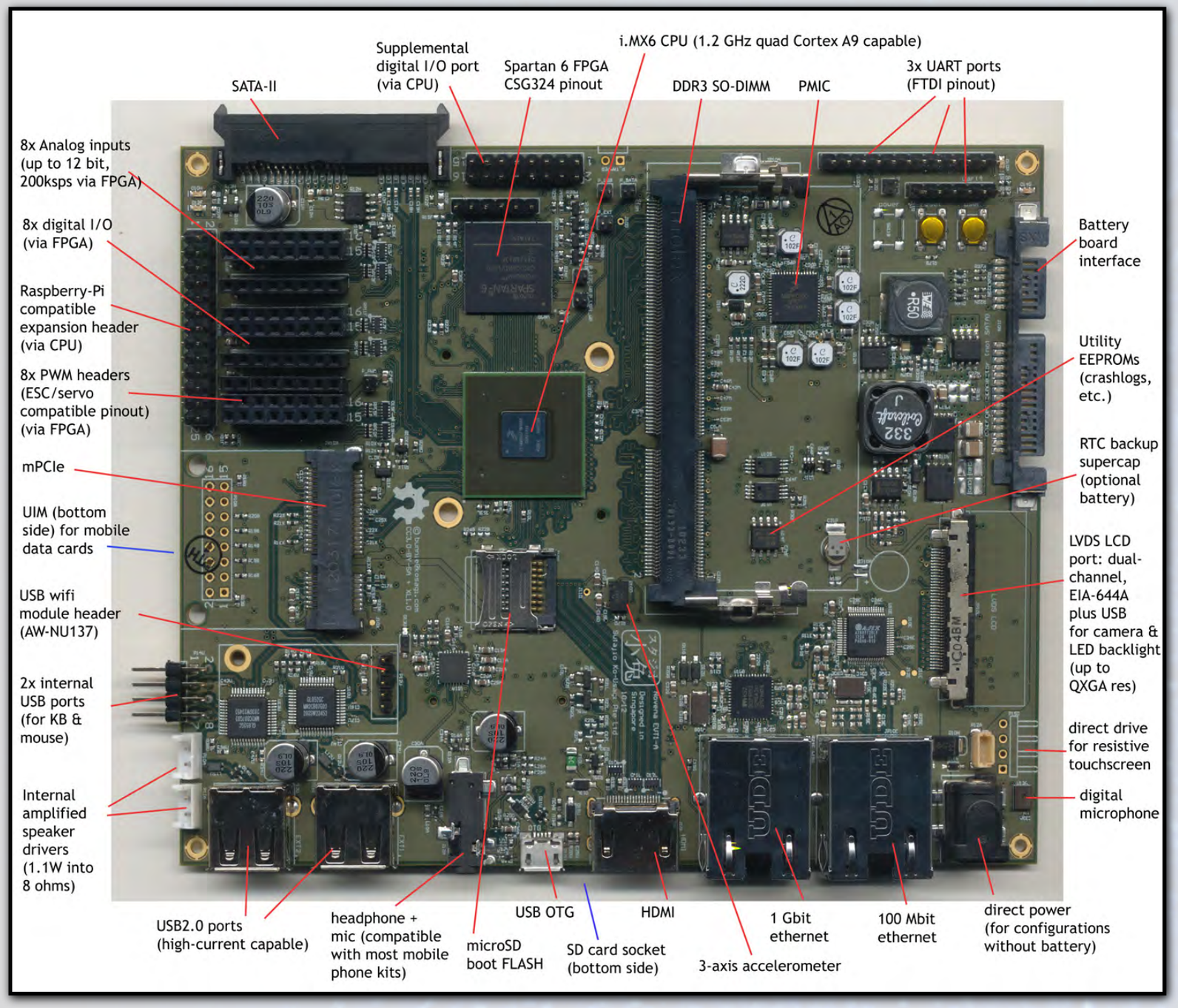
Credit: University of Michigan

Why can't we do for hardware what we did for software?

- open source OS is a good start, open source firmware (Libreboot, etc) is better along with open source hardware, "no blob" system is ideal

- some OSHW devices like Novena laptop are very close to this, but still require blobs for full functionality

- this also still leaves users trusting the chips



open source hardware

libreboot

What can be done for peace-of-mind private computation for critical situations and down-right paranoid users?

- Can we build a cost-effective low-level solution that offers open source software AND “open source logic” - a processor whose designs are publicly available for anyone to examine or change?

- on our platform, Linux and all programs run on the FPGA, so we know exactly what the CPU is doing

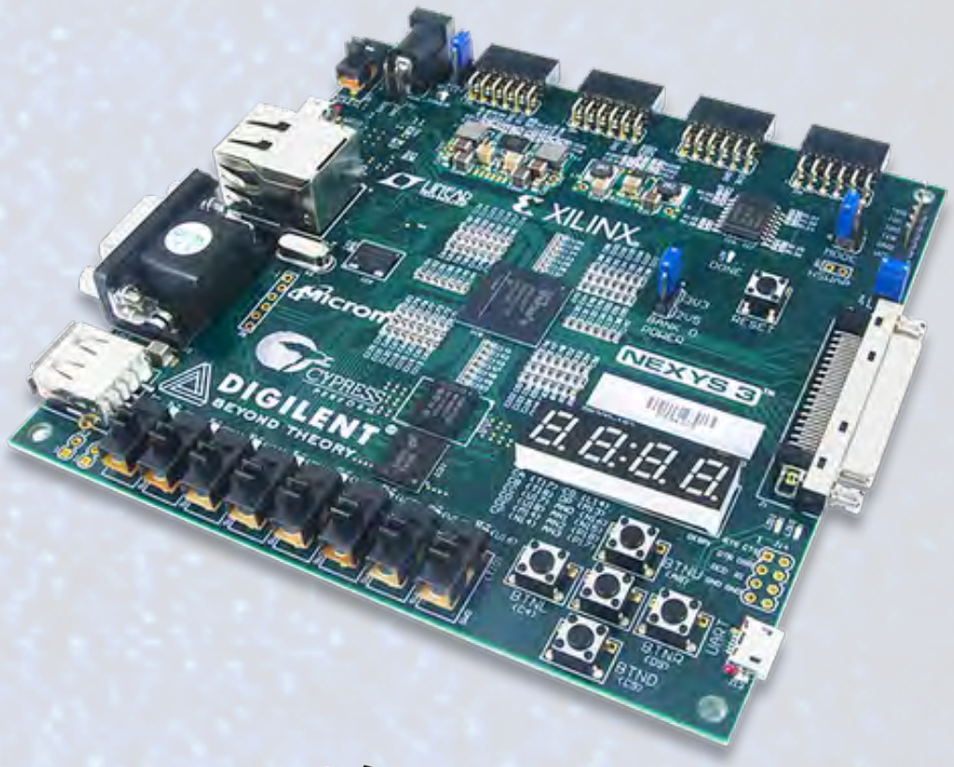
FPGA 101

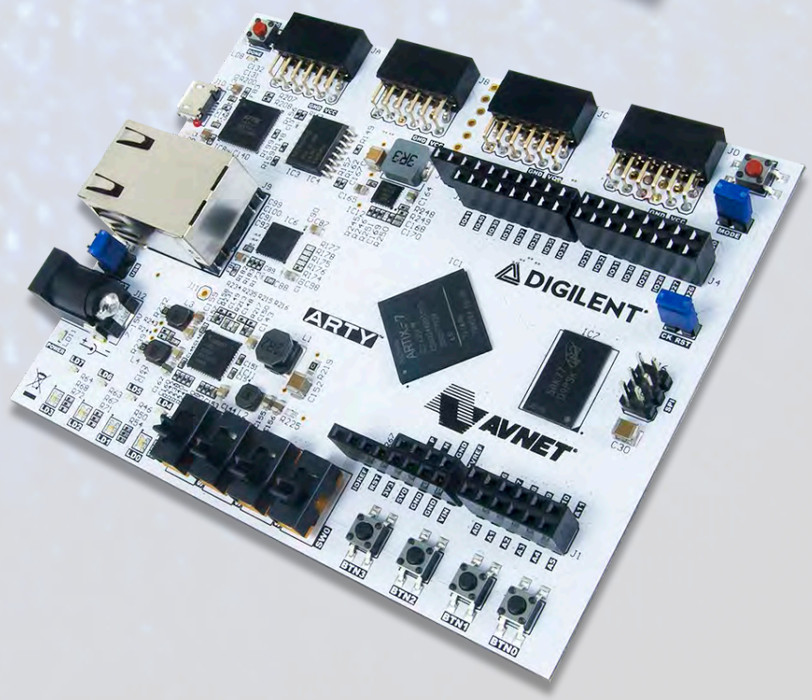
- FPGAs are large blocks of configurable digital logic gates

- chips are designed in special languages called HDLs (hardware description languages)

- bitstream generators read these files and program the gates within the FPGA to function as the HDL code dictates

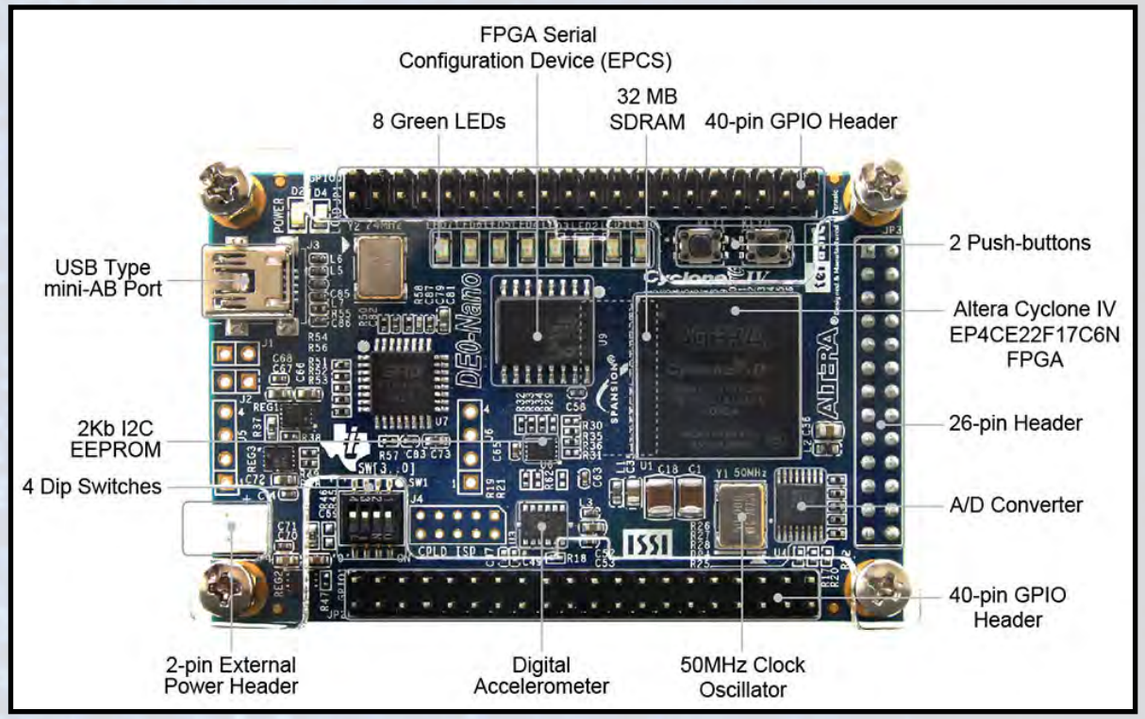
- most commonly used for chip design and testing, special hardware applications

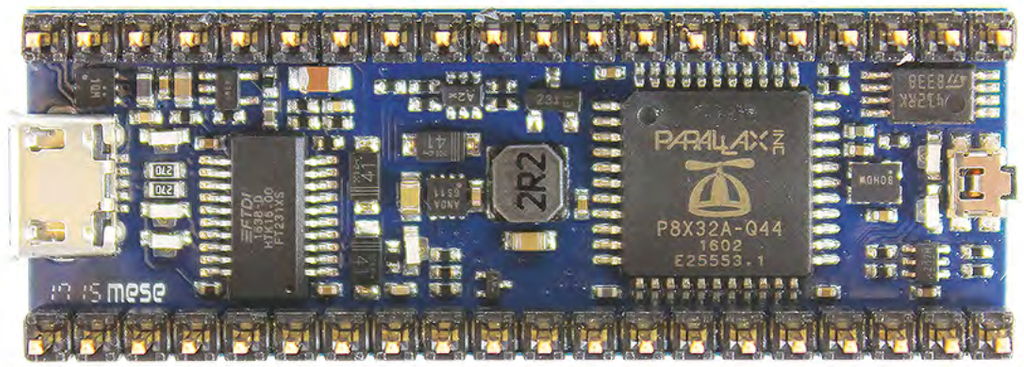




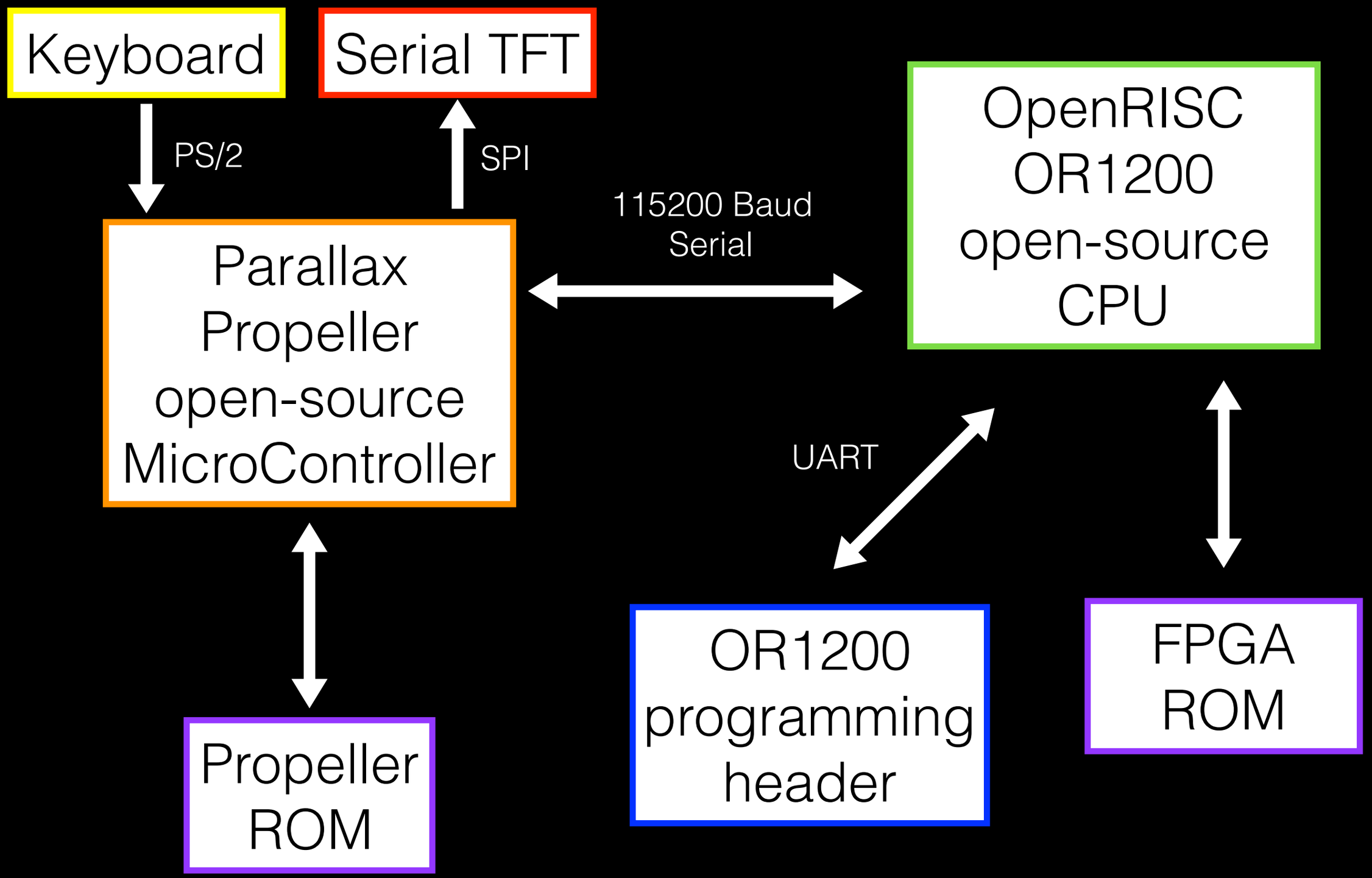
An Alternative

- Built around a cryptographic use case
- Runs GNU/Linux
- Fully open-source hardware and software down to the chip designs of both major components
- Parallax Propellor for IO, OpenRISC OR1200 CPU running OS and tools





block diagram:



Let’s Run Linux on Open Source Microprocessors!

One more thing(s)

- in a recent AMA on Reddit, AMD has publicly stated that they are “strongly considering” making the source code for their IME-equivalent, PSP / Trustzone **OPEN SOURCE**

- Changes to the PocketTerm project for integration with the SPI TFT we used will be available on GitHub alongside scripts for programming the DE0-nano

- Q/A

Further Reading and Additional Resources

- DEF CON 22: Summary of Attacks Against BIOS and Secure Boot: https://www.youtube.com/watch?v=QDSlWa9xQuA

- DEF CON XX: Hardware Backdooring is Practical: https://www.youtube.com/watch?v=8Mb4AiZ51Yk

- NSA shipment hijacking: http://www.theverge.com/2013/12/29/5253226/nsa-cia-fbi-laptop-usb-plant-spy

- Windows “golden keys” leaked: https://arstechnica.com/security/2016/08/microsoft-secure-boot-firmware-snafu-leaks-golden-key/

- NSA Cisco implant: https://arstechnica.com/tech-policy/2014/05/photos-of-an-nsa-upgrade-factory-show-cisco-router-getting-implant/

- Apple suspects hardware backdoors by state actors in server shipments: https://www.extremetech.com/extreme/225524-apple-may-design-its-own-servers-to-avoid-government-snooping

- NSA deploys low level / hardware backdoors against intercepted consumer devices: http://www.extremetech.com/computing/173721-the-nsa-regularly-intercepts-laptop-shipments-to-implant-malware-report-says

- Summary of Intel ME: https://boingboing.net/2016/06/15/intel-x86-processors-ship-with.html

- Detailed IME breakdown by Libreboot team: https://libreboot.org/faq/#intel

- REcon 2014: Intel Management Engine Secrets (Igor Skochinsky): https://www.youtube.com/watch?v=4kCICUPc9_8

- Hackaday: The Trouble with Intel’s Management Engine: http://hackaday.com/2016/01/22/the-trouble-with-intels-management-engine/

- Hackaday IME workarounds: https://hackaday.com/2016/11/28/neutralizing-intels-management-engine/

- A2: Malicious Analog Hardware: https://www.ieee-security.org/TC/SP2016/papers/0824a018.pdf

- Wired Summary of silicon backdooring: https://www.wired.com/2016/06/demonically-clever-backdoor-hides-inside-computer-chip/

- Power-based side channel attacks: https://www.rsaconference.com/writable/presentations/file_upload/br-w03-watt-me-worry-analyzing-ac-power-to-find-malware.pdf

- openRISC homepage: http://openrisc.io/

- getting started with openRISC: https://github.com/openrisc/tutorials