A Perspective on the Role of Open-Source IP In Government Electronic Systems

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RISC-V Workshop

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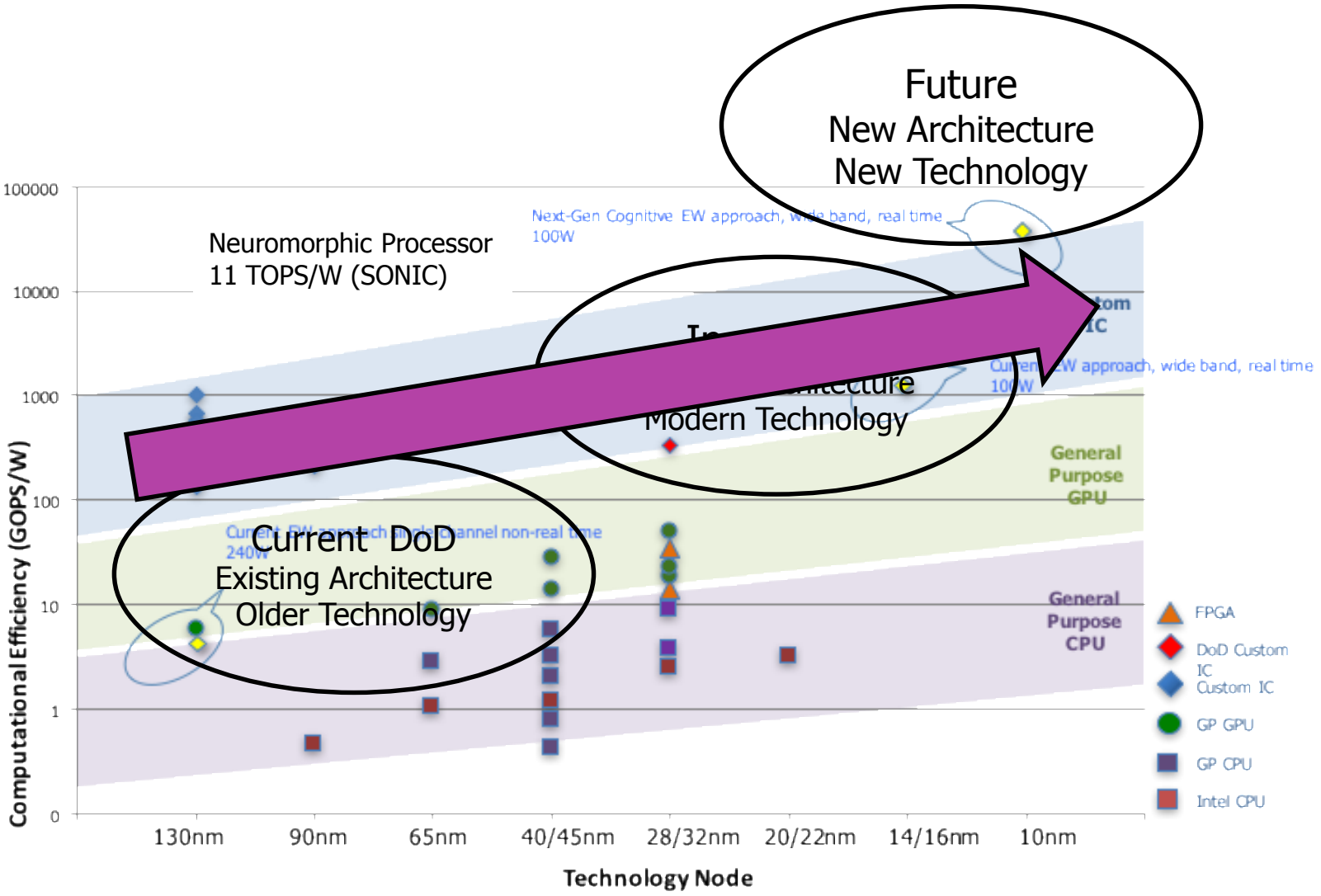
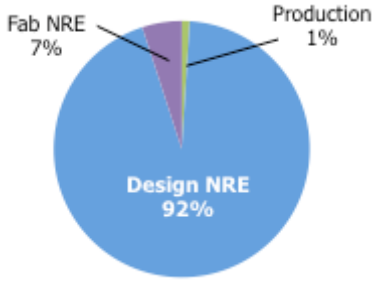
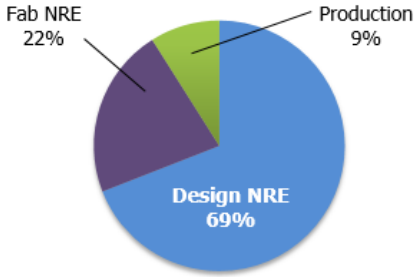
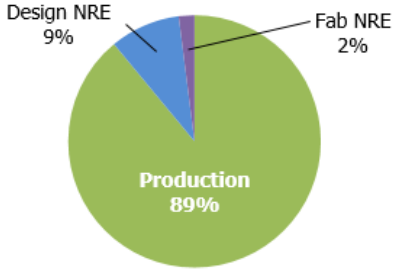
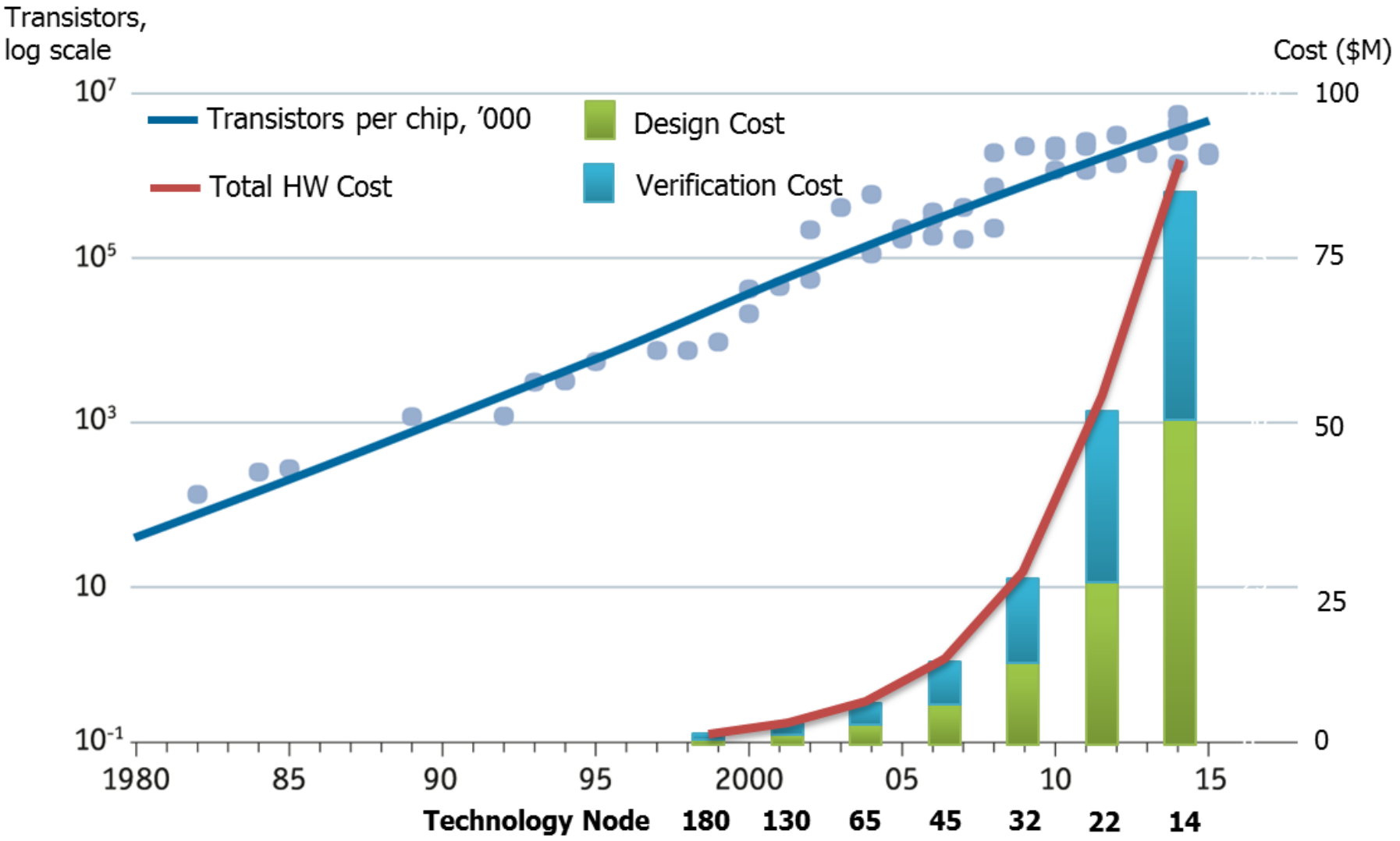
The US Department of Defense (DoD) Needs Custom SoCs



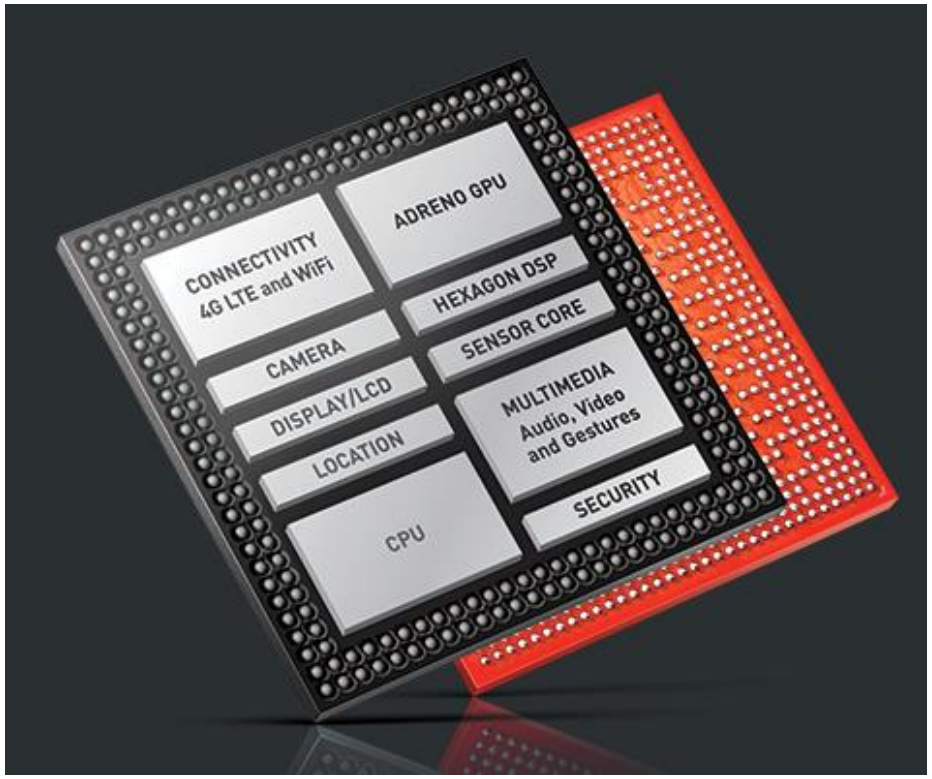
Most of the Cost for DoD Custom SoCs is in Design

	Low Volume	Moderate Volume Commercial	High Volume Commercial
			
Design Cost	Major contributor to total SoC cost	Major contributor to total SoC cost	Minor portion of total SoC cost
Fabrication Cost	Small contributor to total SoC cost	Significant contributor to total SoC cost	Major contributor to SoC cost
Volume	1k parts	1,000k parts	100,000k parts
Area	Not important	Relatively unimportant	Critical
Design Schedule/Risk	Critical	Critical	Critical
Performance at Power	Required	Required	Required

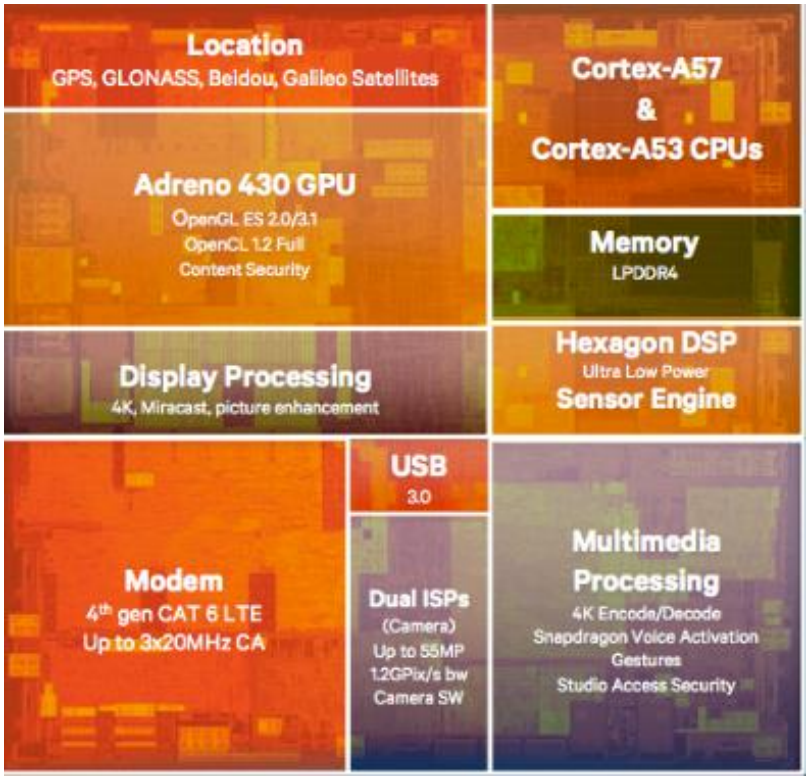
Design Costs are Skyrocketing



Current SoCs Reuse Existing IP To Address Complexity



Source: qualcomm.com web site

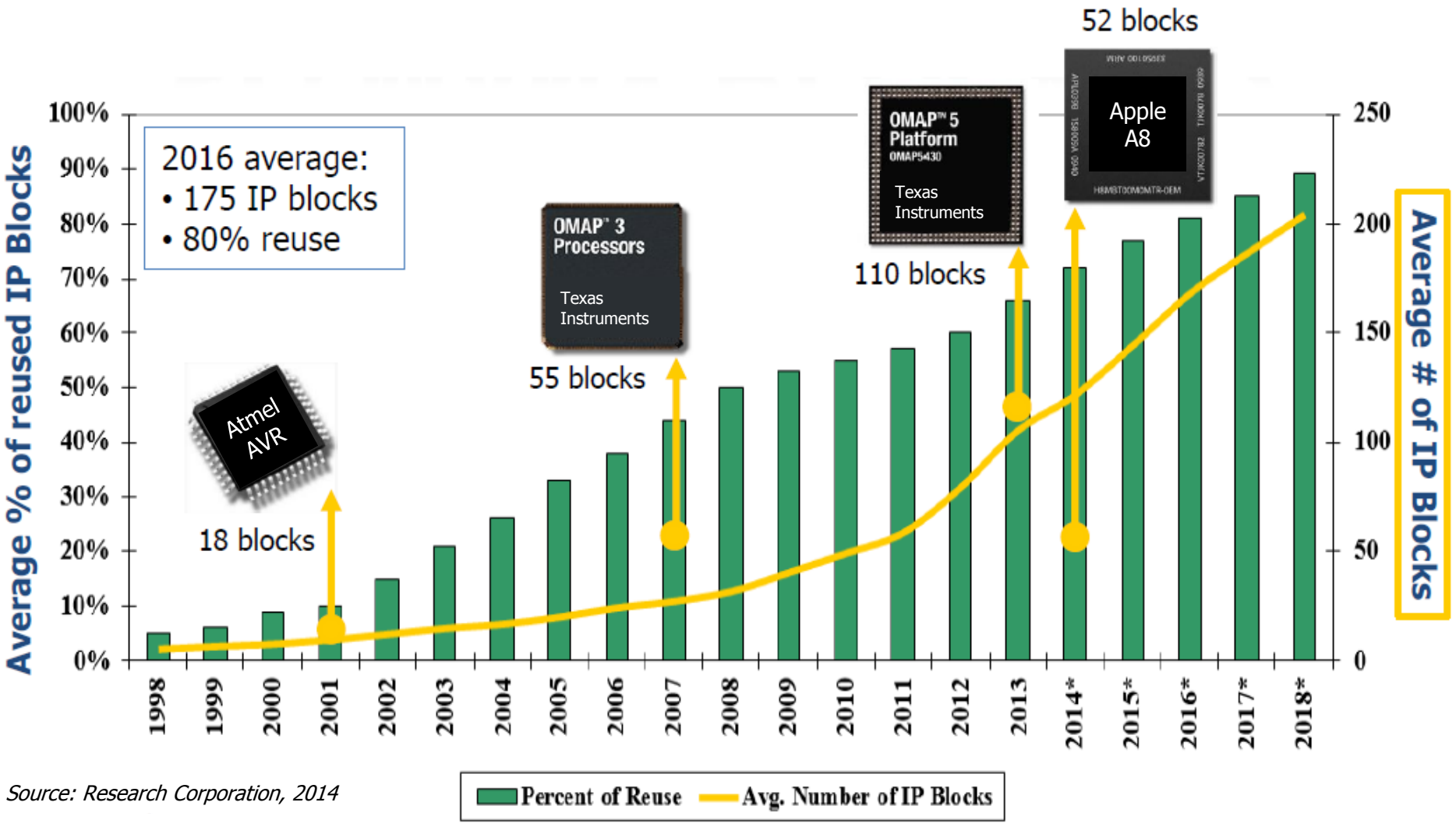


Source: qualcomm.com web site

Snapdragon is a compilation of designs from many sources

- Foundation IP (logic library, SRAM compiler, IO circuits)
- Internal IP (connectivity, DSP, GPU)
- Licensed IP (ARM CPU)
- 3rd party IP (Image processor)

Root Cause of Design Cost Growth is Complexity Growth



Source: Research Corporation, 2014

Is Open-Source IP the Answer?

Open-Source IP Provides Strong Benefits for DoD

Source: Linton Salmon

- Open-source IP can sharply reduce the resources, time, and complexity required for DoD custom SoC design
- Open-source IP can be easily used to design for unique DoD applications
- Detailed information available with open-source IP can enable greater trust
- Open-source IP permits increased use of unique DoD security approaches

The Challenge

Source: Wikimedia Images

- The Open-Source community needs to develop a complete infrastructure
- Open-source IP needs to be more robust than is currently the case
- The community needs to develop a model to fund infrastructure
- The support model must assure long term support and continued development of open-source IP

Open-Source IP Provides Strong Benefits for DoD

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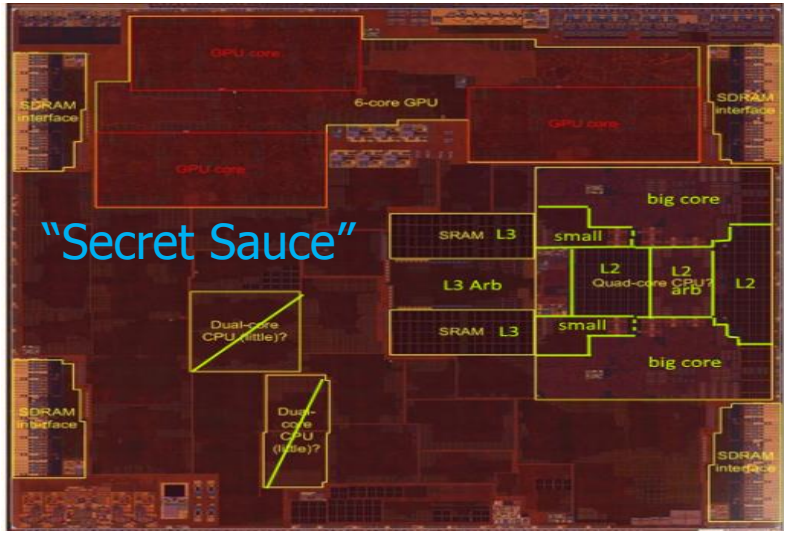
Reduction in Design Complexity with Open-Source IP



Source: TechInsights/Chipworks

- Unique differentiation doesn't require development of the entire platform
- Most of the content in custom DoD SoCs is composed of standard modules
  - The secret sauce is critical, but a small part of current design efforts
  - Low-volume DoD SoCs cannot support the commercial IP cost burden
- Open-source IP can address both the cost and availability of standard IP
- Open-source IP macros are a critical first step, but integration IP is also needed
- Widely accepted standards are required for distributed development

Open-Source IP Enables Specialization

Source: Wikimedia Images

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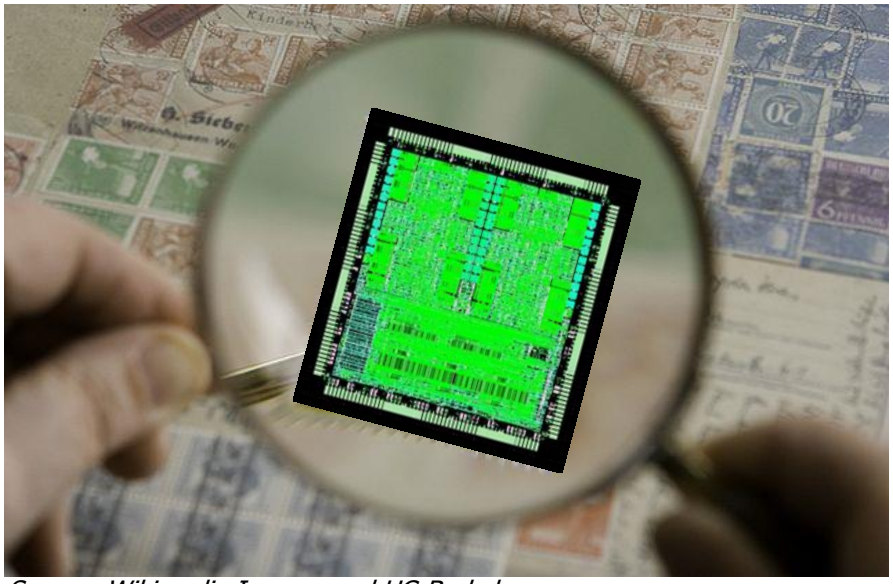
- DoD has a very wide variety of needs and applications
  - Wide differentiation in needs (large systems to IoT-like applications)
  - High-performance and low-power are the common characteristics
  - Die volumes are always low
- Open-source IP can provide the blocks and the standard infrastructure
- Differentiation is then easy and relatively inexpensive
  - Much of the design is already ready and can be reused
  - Design can focus on the areas requiring specialization
- Unique implementations are critical and specialization is required for success

Trust and RISC-V



Source: Wikimedia Images and UC-Berkeley

- Open-source IP enables greater scrutiny by the DoD to ensure trust
  - Assurance that the SoC will work is provided by robust IP
  - Assurance that the SoC will only do as specified is provided through inspection
- Design and chip can be inspected in complete detail because all of the IP data are available for inspection
  - Can inspect and lock the implementation at C++, RTL, and/or GDS
  - DoD can control the locked implementation
- DoD can own the entire chip

Increased Security

Source: Wikimedia Images

- Hardware security requires the ability to modify the SoC, including 3rd party IP
  - Security against tampering
  - Security against cyber-attack
- DoD generally requires more extensive security than commercial applications
  - More extensive security enabled by open-source IP
  - Security levels do not require agreement by an extensive commercial community
- Added security capabilities require a robust base and infrastructure

DARPA Interest in RISC-V

Source: www.riscv.org

- RISC-V is adaptable
  - ISA is open-source
  - Many implementations are open-source
- RISC-V is an open standard
  - Makes transition across the DoD easier
  - Standardization enables extensions to the open-source
- RISC-V processors can be built in a way that can be trusted
  - Since open-source, full visibility and inspection is possible
  - DoD can control the IP completely
- RISC-V can be used to enable increased security
  - Security extensions can be easily added
  - Security extensions can be close held as the core IP is standardized

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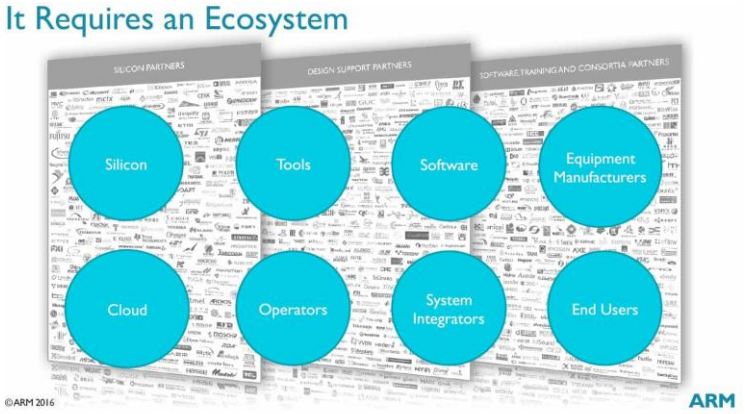
Needs: Full Ecosystem Intrastructure

Source: www.arm.com



Source: www.arm.com

- Required characteristics
  - The entire infrastructure – most of it is not enough
  - Robust infrastructure – must always work
  - Infrastructure must be easy to use
- Common infrastructure could be a great strength of RISC-V
  - ISA
  - Common processor implementations
  - Interconnect and associated IP
  - EDA design tools

Needs: Robustness and Dependability

Source: Wikimedia Images

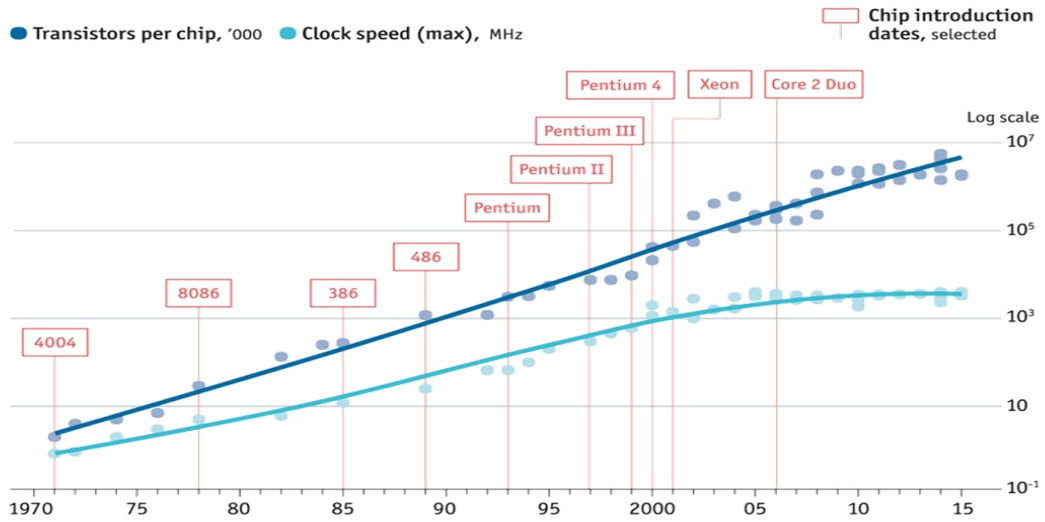
- DoD requires robustness and dependability of the open-source infrastructure
  - Verification complete
  - Clear documentation on how to use
  - Robustness validated through Si implementation and test
  - Not the role or a strength of universities
- Savings requires the ability to depend on the open-source IP
- Savings require the robustness of the IP across extended performance ranges

Needs: Model to Fund Long-Term Infrastructure

Source: Wikimedia Images

- A successful open-source infrastructure requires a lot of work
  - Work to design the correct IP modules
  - Work to maintain, upgrade, and facilitate use of the infrastructure
  - One reason the current model is so expensive
- This large amount of work must be compensated in someway
  - Money
  - Other types of value
  - Not the role of DARPA – we fund projects, not infrastructure
- Much of the work is difficult, but not exciting

Needs: Improvements over Time



- Open-source IP effort requires continual maintenance and improvement
  - Moore's law has driven the expectation of continual improvement
  - A static technology will no longer be used
- Must update regularly
  - Performance
  - Architecture
  - Fabrication technology
- DoD time scales are 10-25 years

DARPA Programs Driving Open-Source IP

- Power Efficiency Revolution for Embedded Computing (PERFECT)
  - PM – Andreas Olofsson
- Circuit Realization at Faster Timescales (CRAFT)
  - PM – Linton Salmon
- System Security Integrated Through Hardware and Firmware (SSITH)
  - PM – Linton Salmon
- Posh Open Source Hardware (POSH)
  - PM – Andreas Olofsson
- Intelligent Design of Electronic Assets (IDEA)
  - PM – Andreas Olofsson

Circuit Realization at Faster Timescales (CRAFT)

CRAFT aims to provide solutions to the three major obstacles restricting custom IC design and fabrication for DoD systems.

DESIGN

- Design requires 18-24 months of effort
- Design verification takes far too much effort
- Fab cycles are too long and too uncertain
- Access to leading-edge CMOS is difficult

CRAFT aims to create new design flows that will reduce custom IC design cycle time by ***10x*** and increase design robustness through object-oriented design techniques

PORT/ MIGRATE

- Designers are limited to one foundry
- Migration of designs from one node to another is difficult and expensive

CRAFT aims to use new design flows to ensure multiple sources of supply and reduce node migration effort by 80% to keep DoD out of "the Silicon Ghetto"

REPOSITORY

- Severe lack of IP reusability for DoD designs
- Current audit model for custom IC design/hardware security is broken

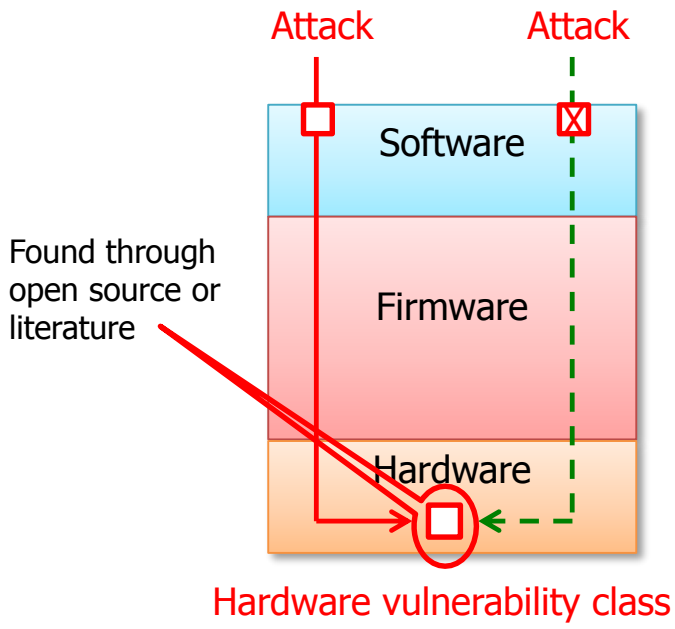
CRAFT aims to establish a data location and methodology to ensure 50% IP* reuse by DoD performers

CRAFT 's goal is to enable more efficient custom IC design/fabrication to enable HIGH performance electronic solutions FASTER and with more FLEXIBILITY

System Security Integrated Through Hardware and Firmware (SSITH)

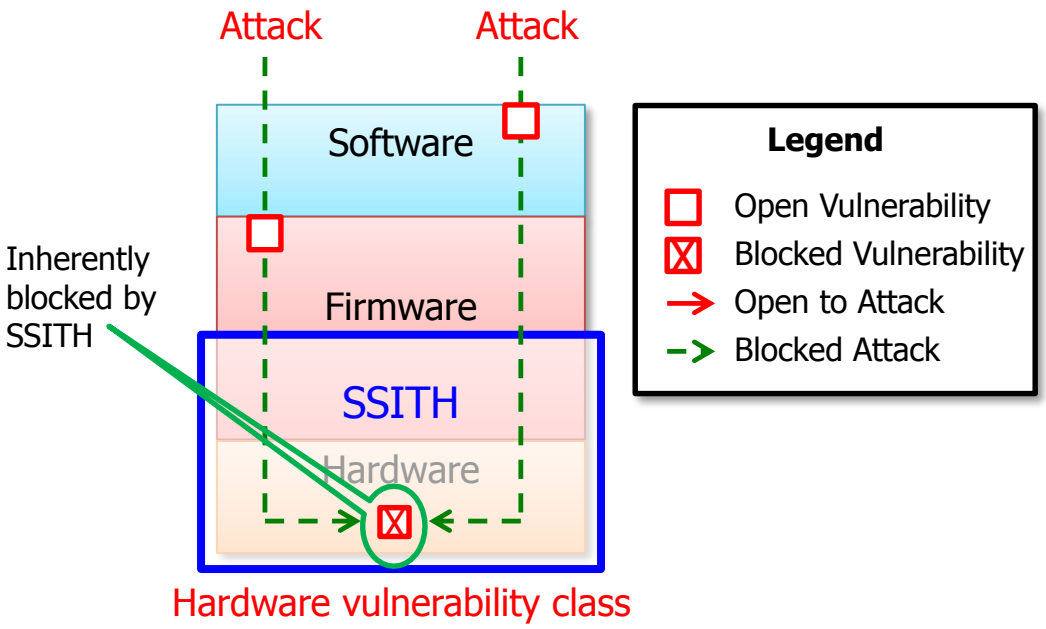
Today: Patch and Pray

*2800 vulnerability instances
2800 software patches



Future: SSITH

SSITH will protect against all 7 hardware classes

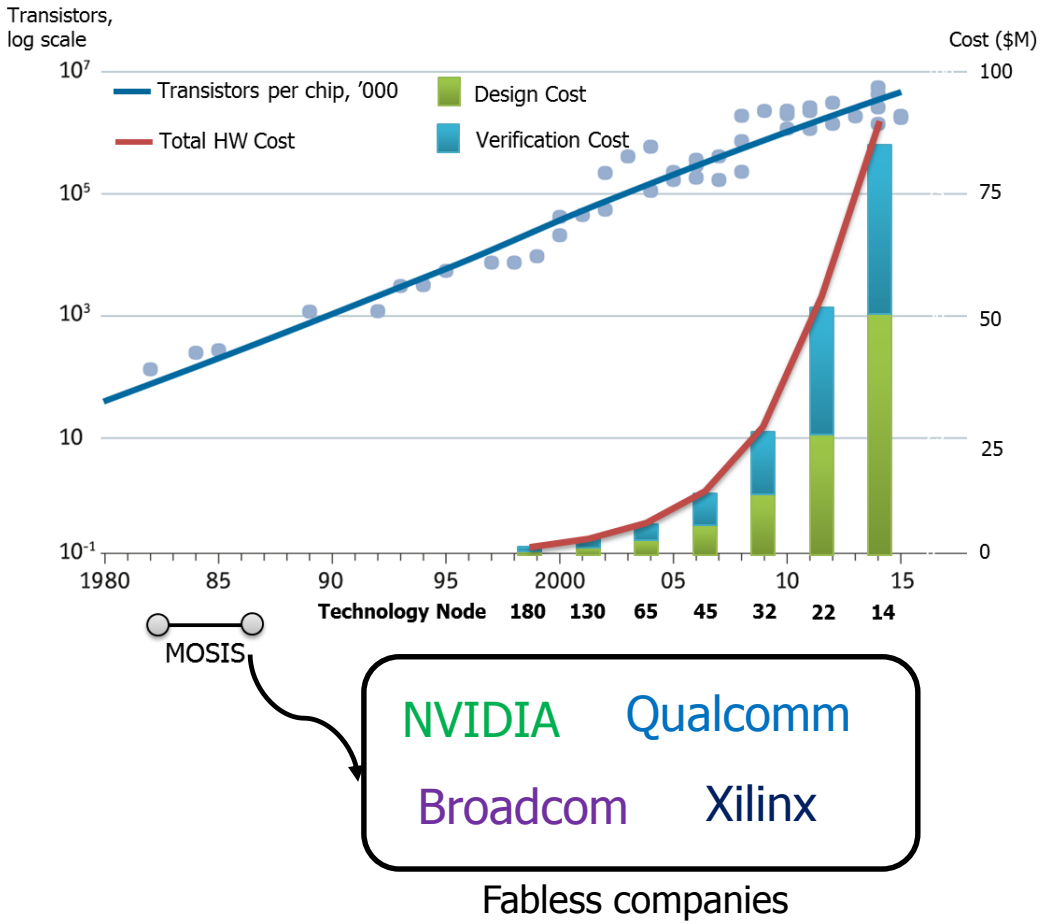


*7 vulnerability classes
7 hardware solutions

Develop hardware design tools and IP to provide inherent security against hardware vulnerabilities that are exploited through software in DoD and commercial electronic systems.

*2015 MITRE-recorded hardware vulnerabilities (CVE)

IDEA and POSH



New procedures for physical design and verification will lower the design barrier, enabling rapid specialization

Design

Intelligent Design of Electronic Assets (IDEA)

- No human in the loop" 24-hour layout generation for mixed signal integrated circuits, systems-in-package, and printed circuit boards.Machine generated layout of electrical circuits and systems

Verification

Posh Open Source Hardware (POSH)

- An open source System on Chip (SoC) design and verification eco-system that enables cost effective design of ultra-complex SoCs.

The 1980's DARPA MOSIS effort removed fab cost and fab access barriers and launched the fabless industry. The ERI Design effort will address today's design complexity and cost barriers, creating the environment needed for the next wave of US semiconductor innovation.

www.darpa.mil