EE260 Architecture/Hardware Support for Security

Nael Abu-Ghazaleh

Department of Computer Science and Engineering
Department of Electrical and Computer Engineering
University of California at Riverside
naelag@ucr.edu

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Overview

- Why Architecture Support for Security? Two (and a half) stories

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  1. Computer system evolution

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- Reading (and writing!) papers

Trend 1: Architecture and Systems

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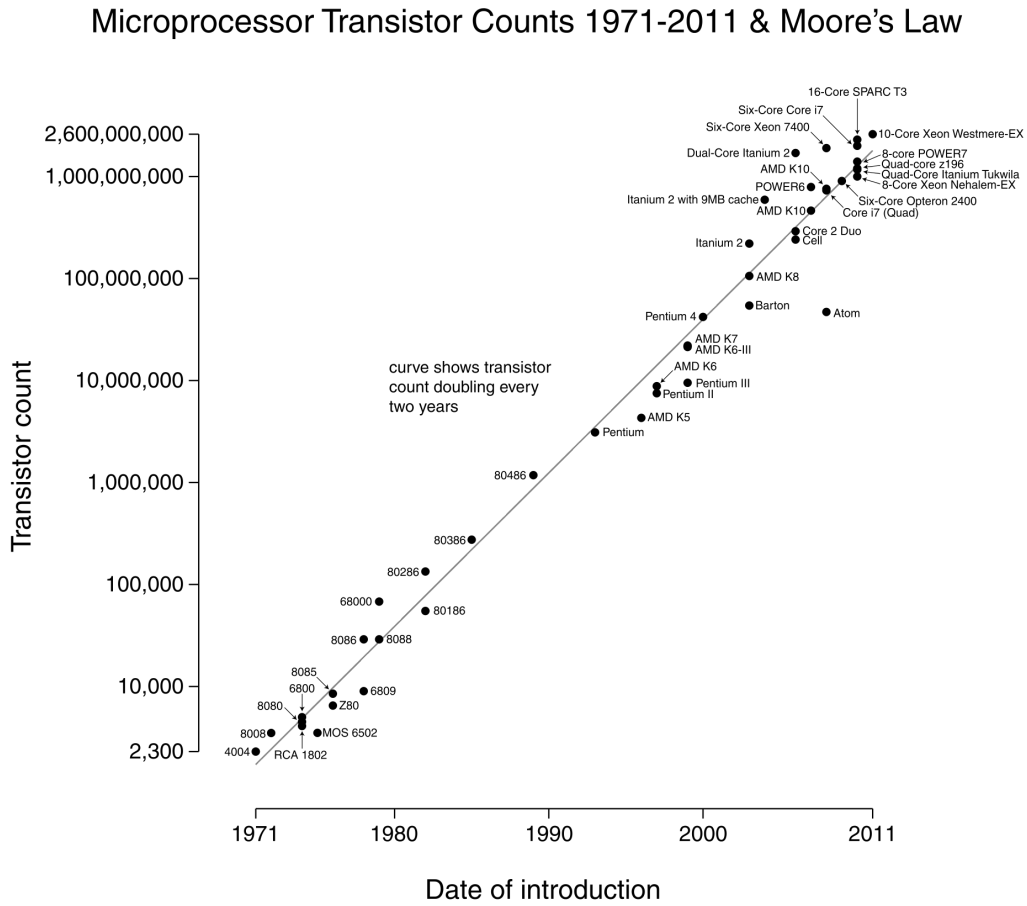
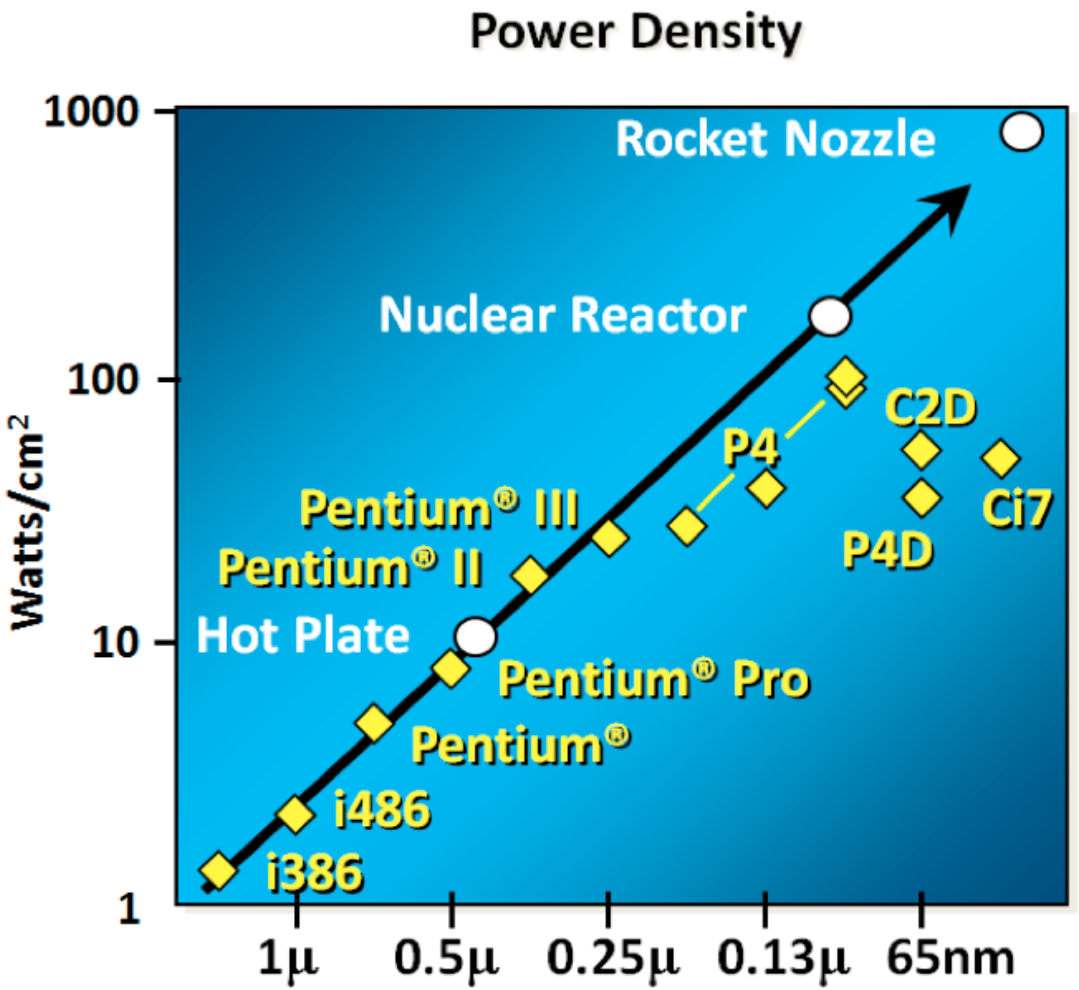
- Unfortunately, Dennard's scaling stopped. Power wall is here.

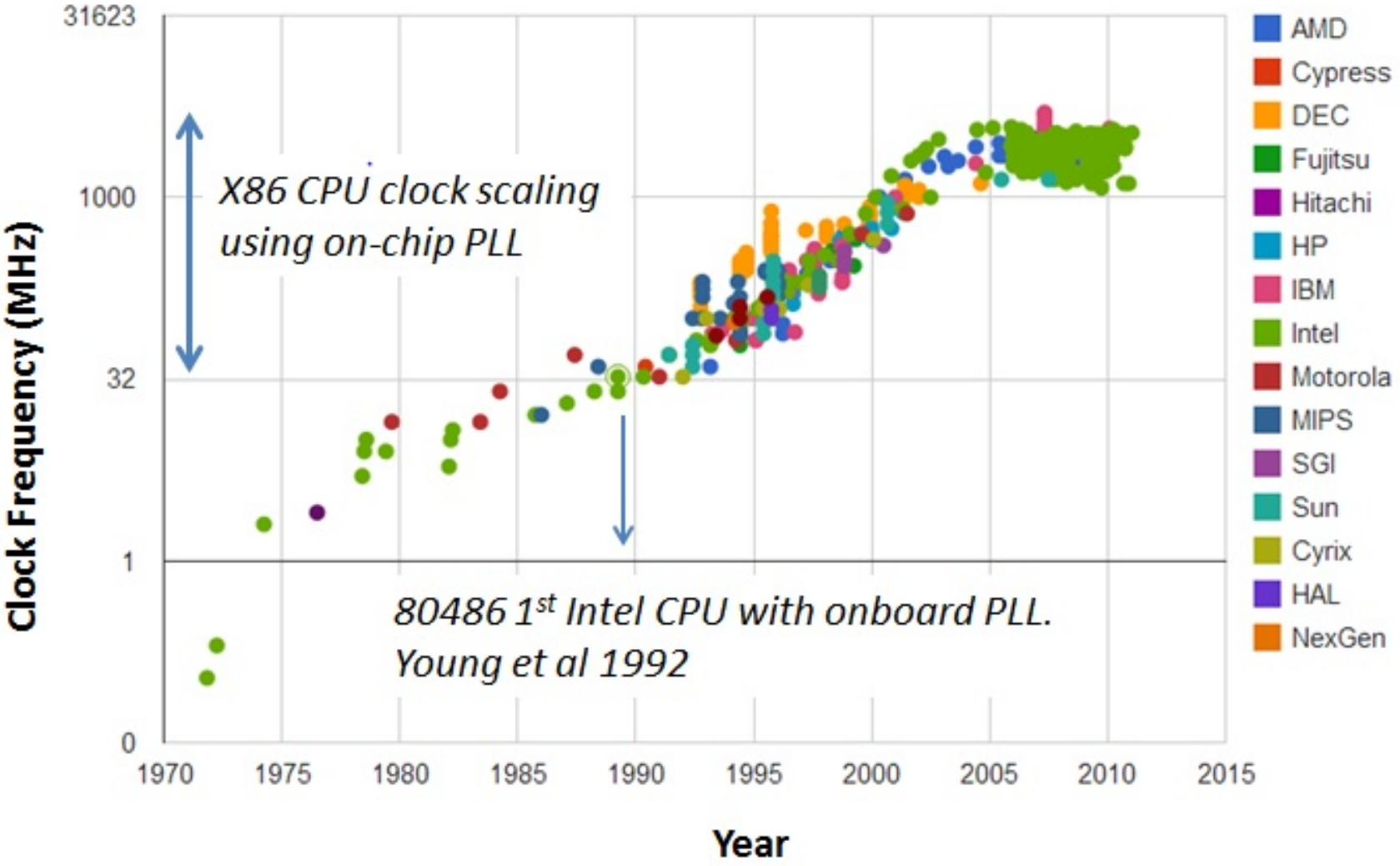
Transistor count still increasing



Power Wall


Power Density
1000
100
10
1
Watts/cm2
Rocket Nozzle
Nuclear Reactor
Hot Plate
Pentium® III
Pentium® II
Pentium® Pro
Pentium®
i486
i386
P4
C2D
P4D
Ci7
1µ
0.5µ
0.25µ
0.13µ
65nm

Power Wall (2)


31623
1000
32
1
0
Clock Frequency (MHz)
X86 CPU clock scaling
using on-chip PLL
80486 1st Intel CPU with onboard PLL.
Young et al 1992
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
AMD
Cypress
DEC
Fujitsu
Hitachi
HP
IBM
Intel
Motorola
MIPS
SGI
Sun
Cyrix
HAL
NexGen

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- What to support in hardware?
  - "To achieve long battery life when playing video, mobile devices must decode the video in hardware; decoding it in software uses too much power." – Apple on Flash
- Innovation needed (not just in architecture–the whole system stack)

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- Cloud computing, smart devices, smart grids, national infrastructure
  - New security and privacy concerns
  - New threat models and novel attacks

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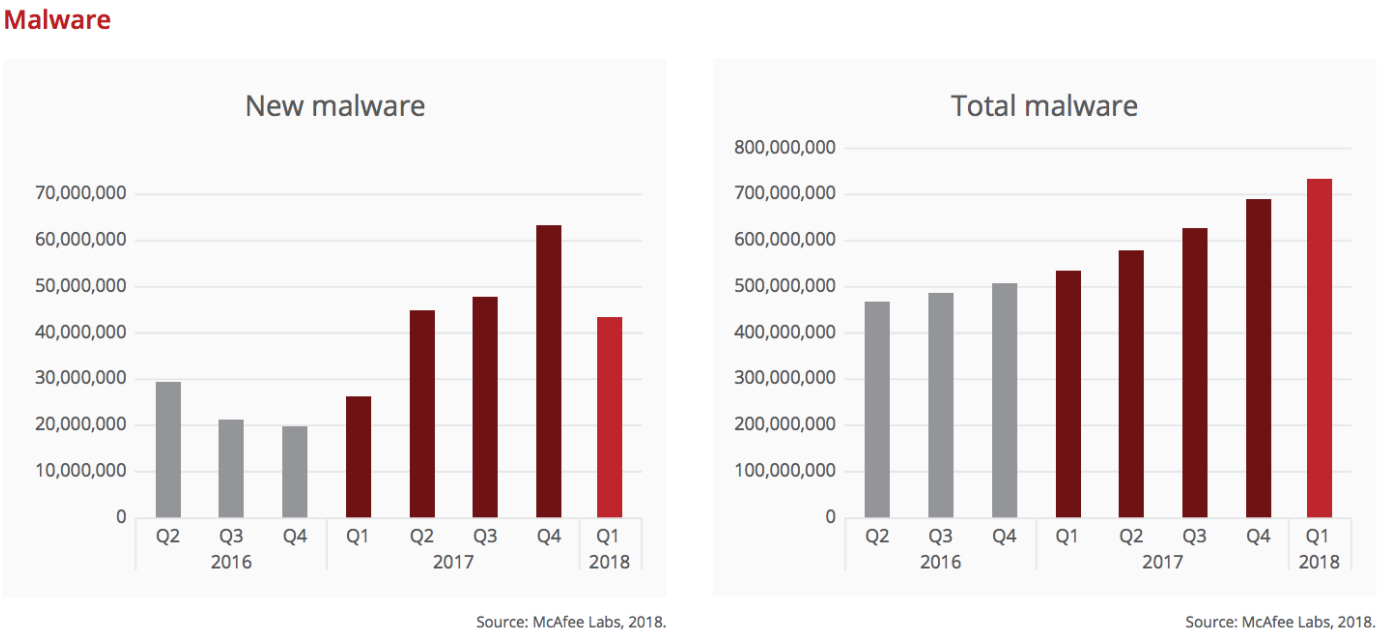
- CPU manufacturers investing in security
  - Trusted Platform Module (TPM)
  - No Execute bit (NX-bit)
  - Supervisor Mode Execution/Access Prevention (SMEP/SMAP)
  - AES Encryption Extensions
  - SHA Hash Extensions
  - MPX: Memory Protection Extensions
  - SGX –Software Guard Extensions (Isolated Execution)
  - IPT –Identity Protection Technology
  - ARM Trustzone; Amazon CloudHSM ...

Trend 2: Malware is Brewing



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  - Over 40 mil new samples this period
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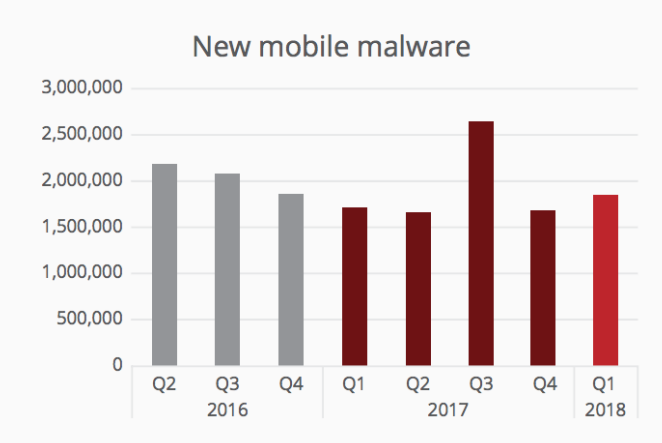

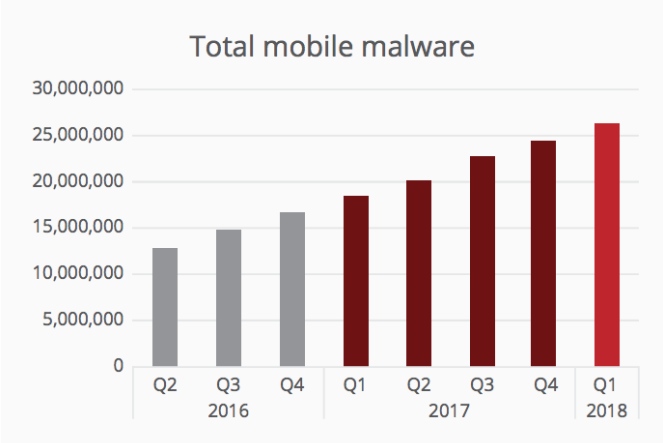

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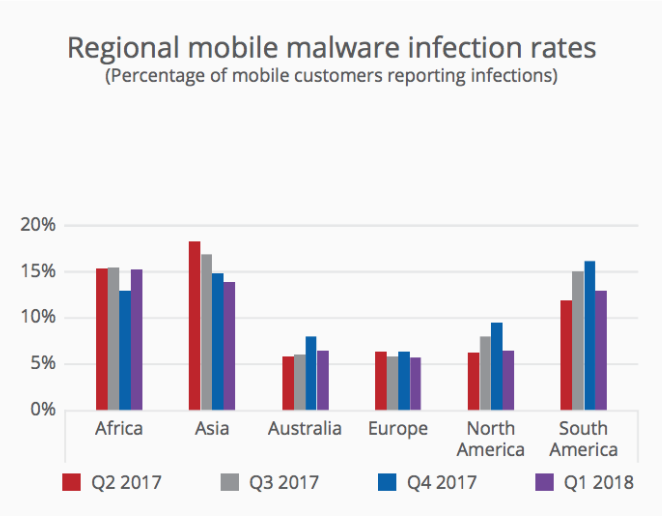

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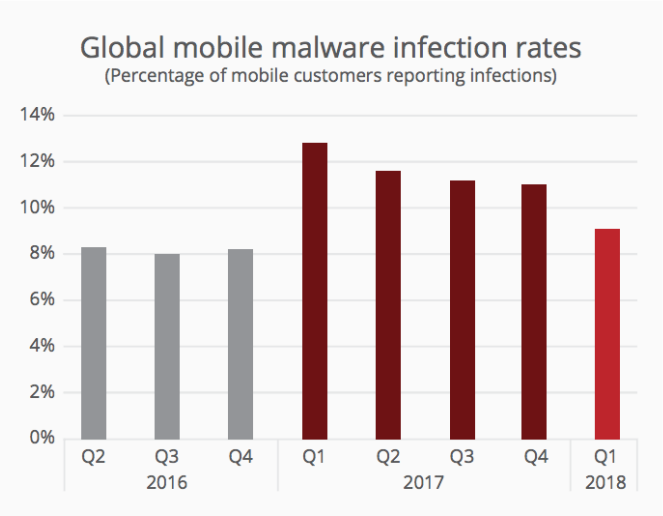

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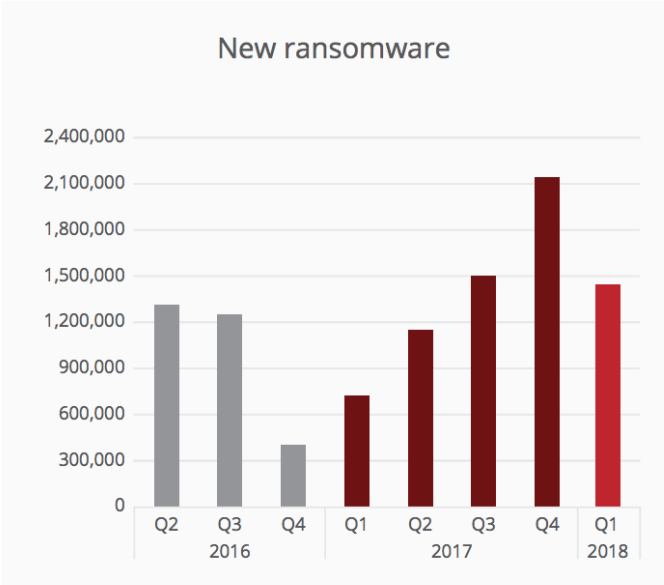

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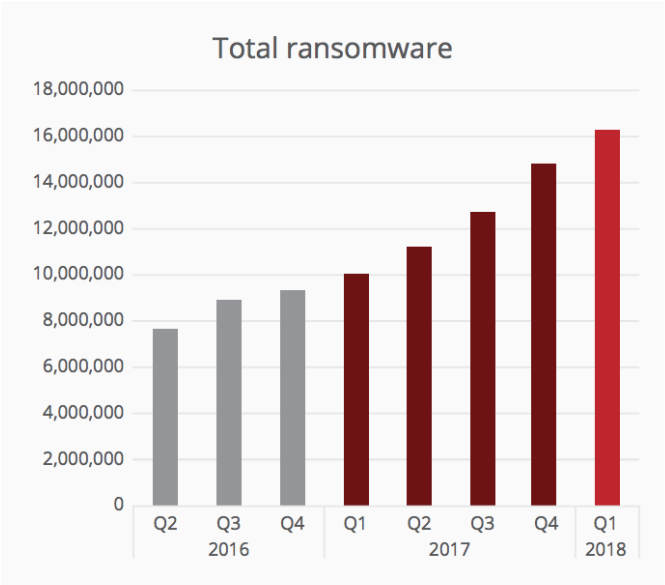

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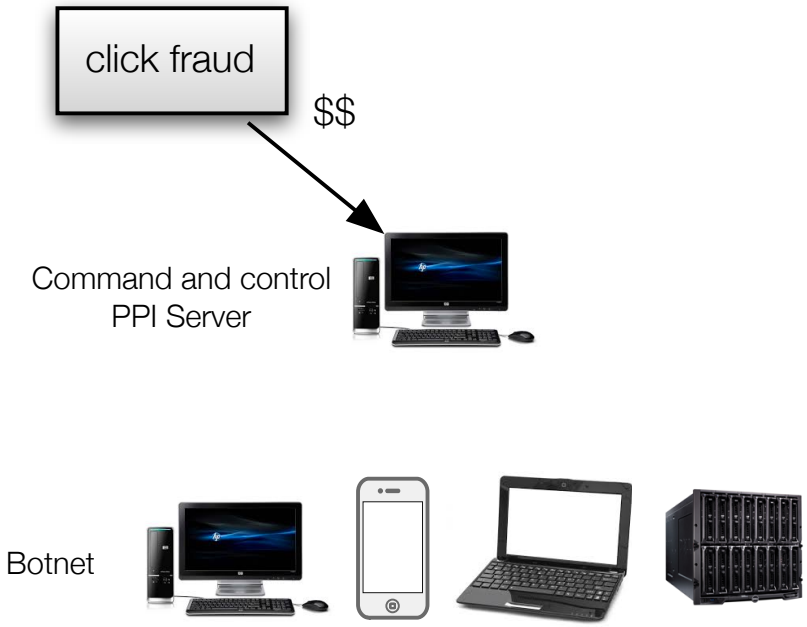

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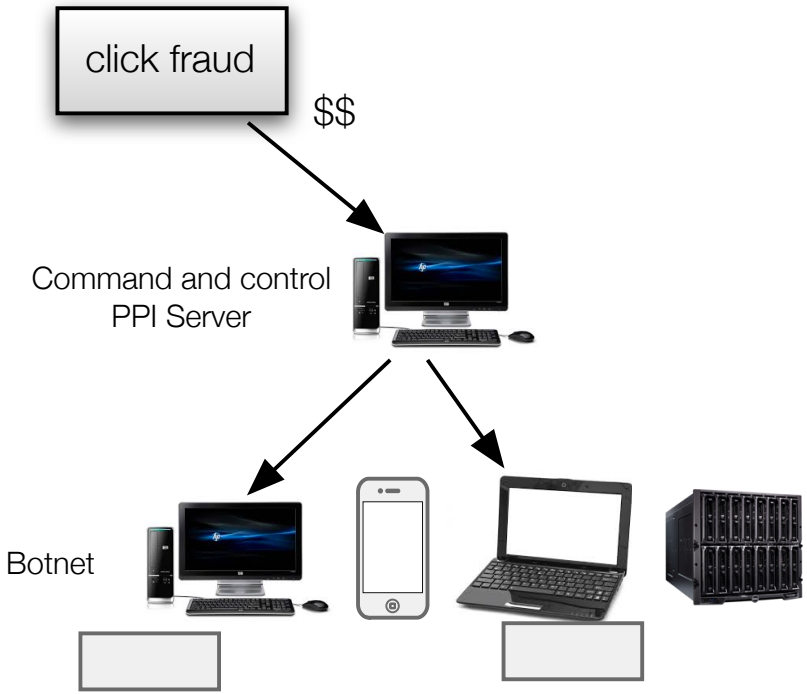

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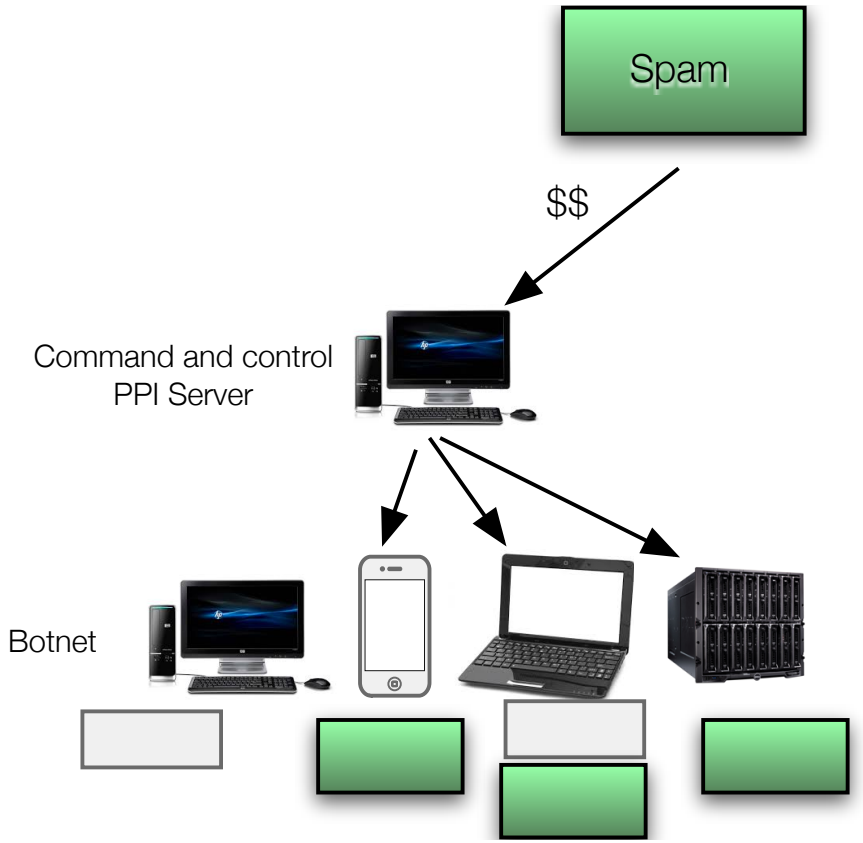

- Installs: 80-100 USD per 1000 machines (US); 7-8 USD per 1000 machines (Asia)

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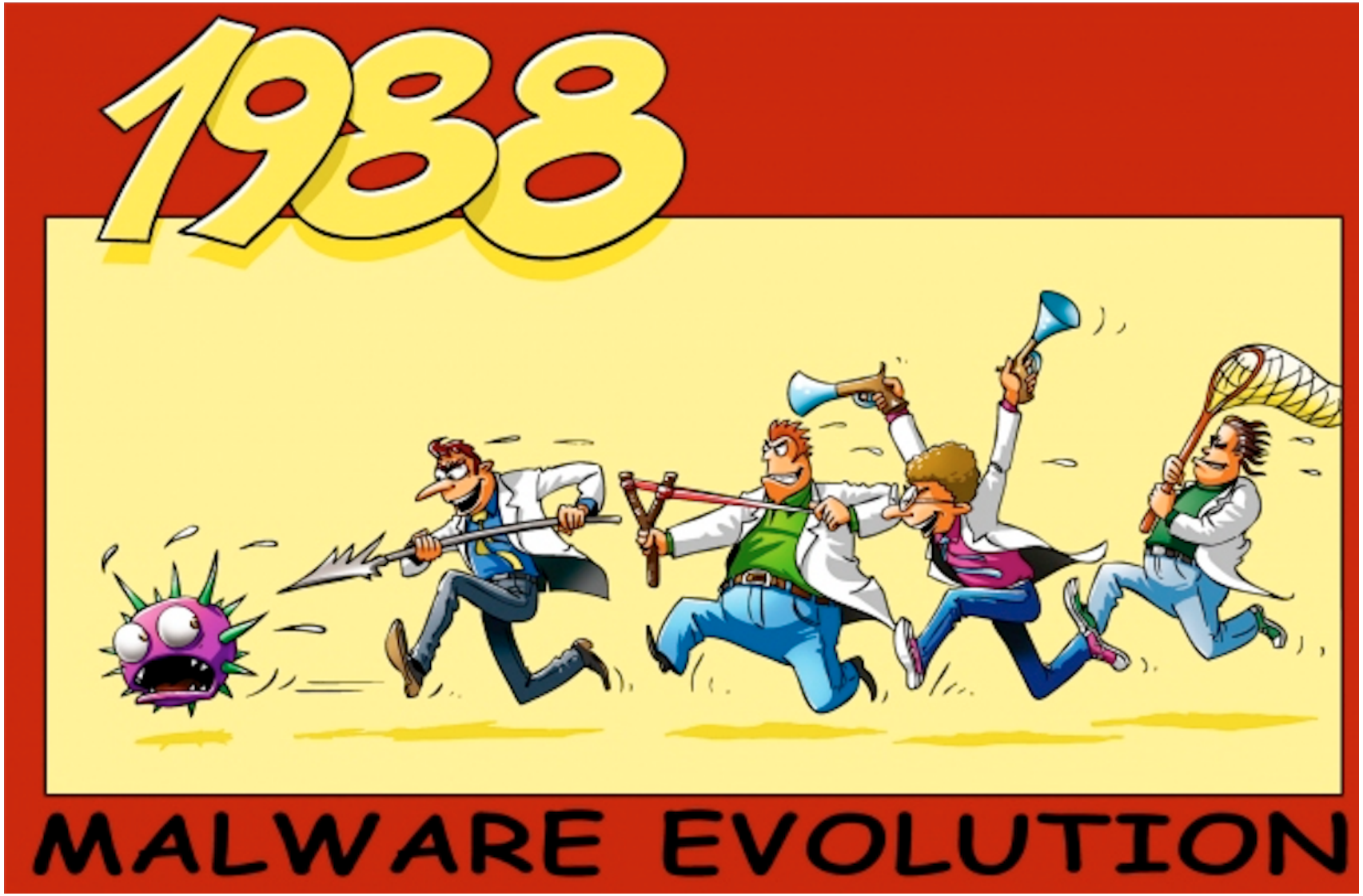
Malware: Summary



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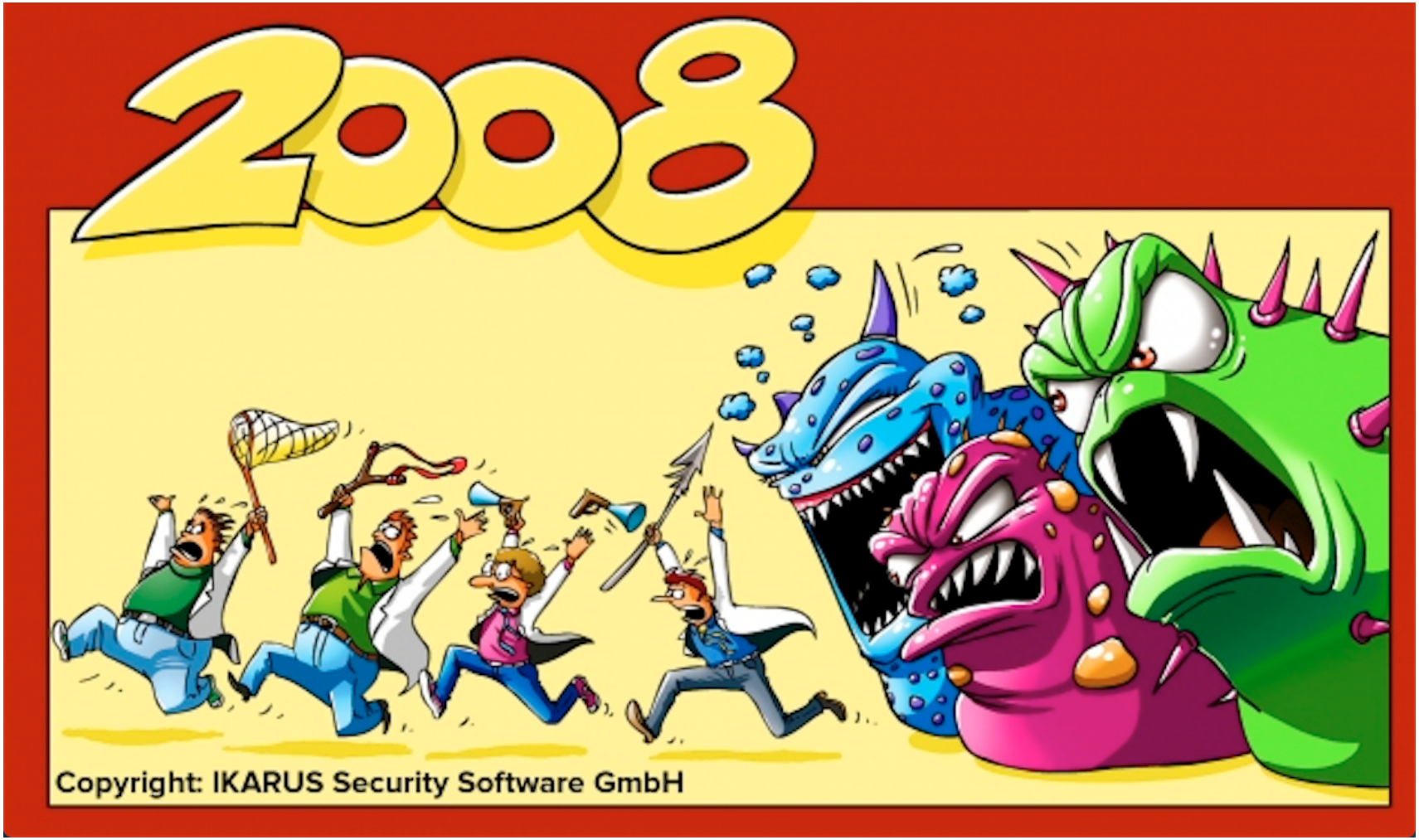

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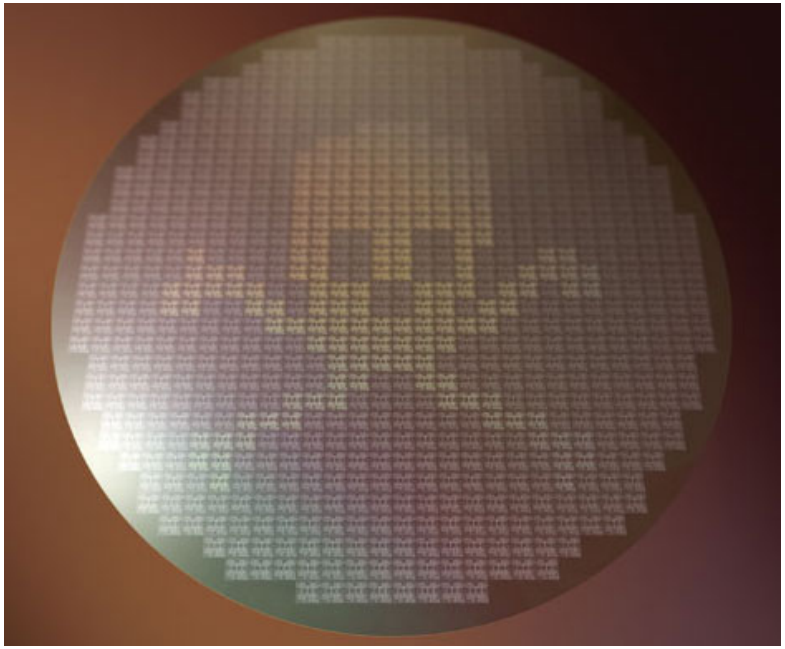

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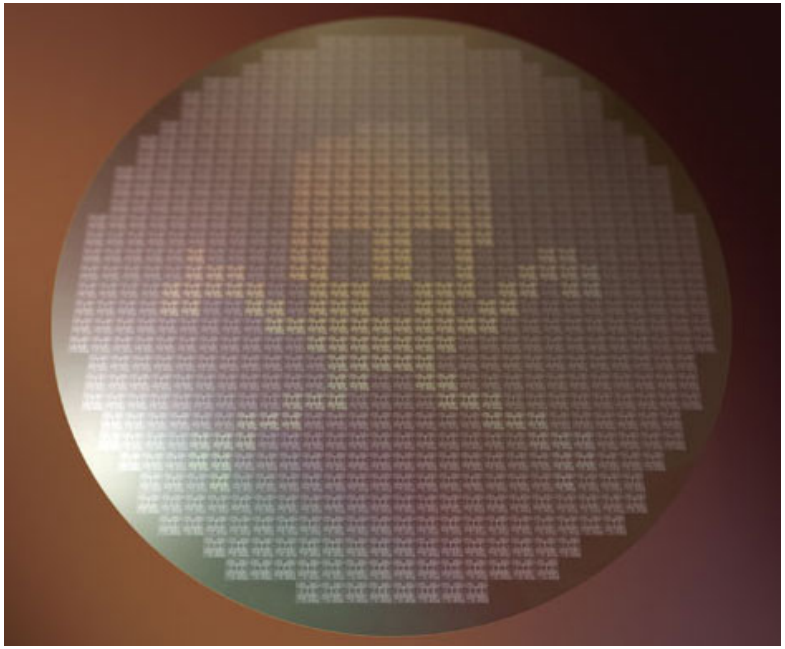

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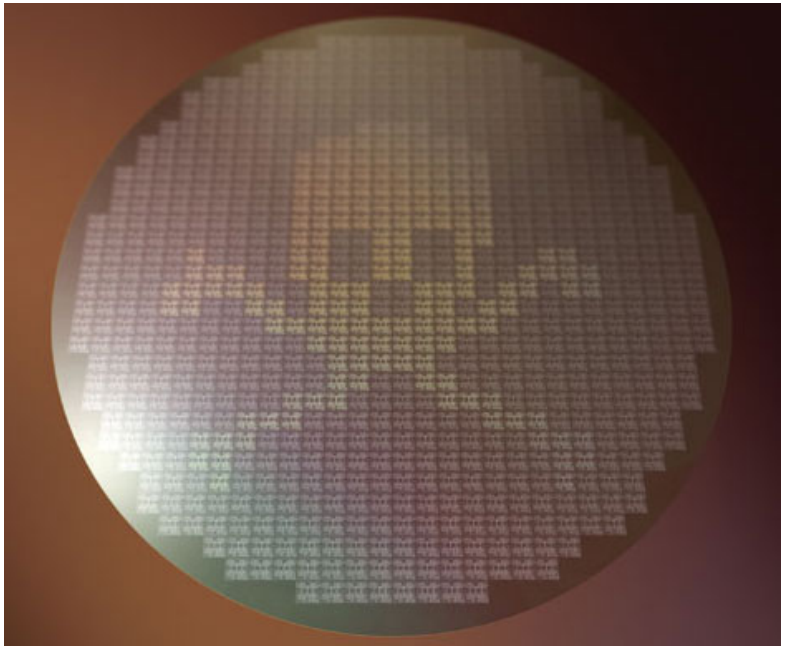

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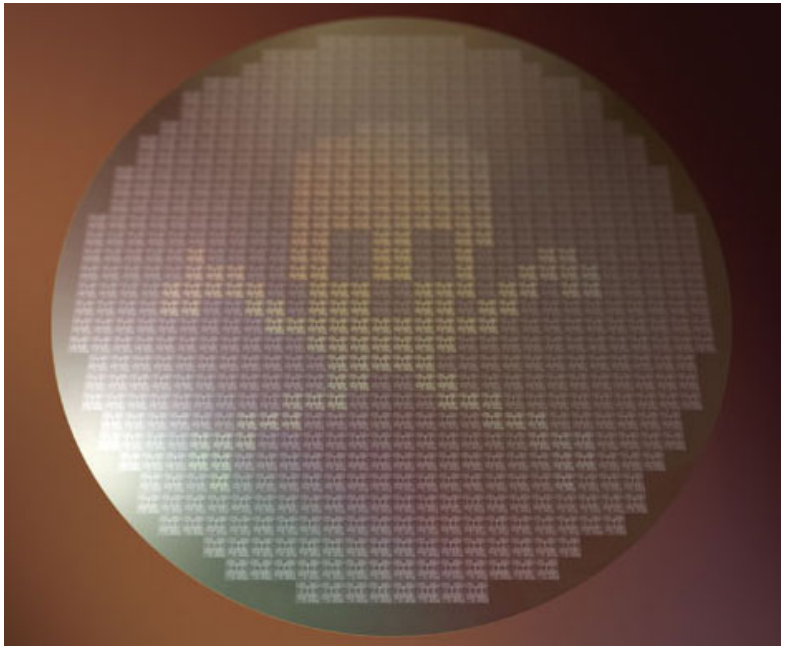

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- How to solve this problem?

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- Many others...

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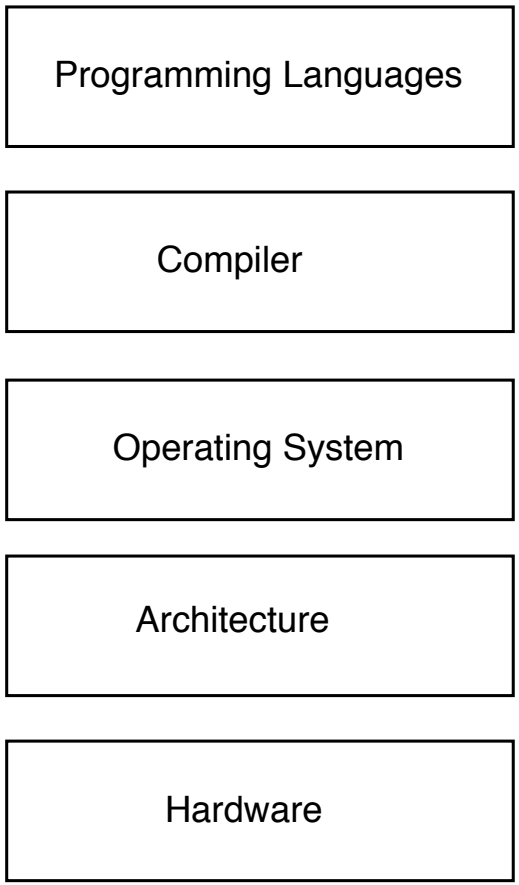

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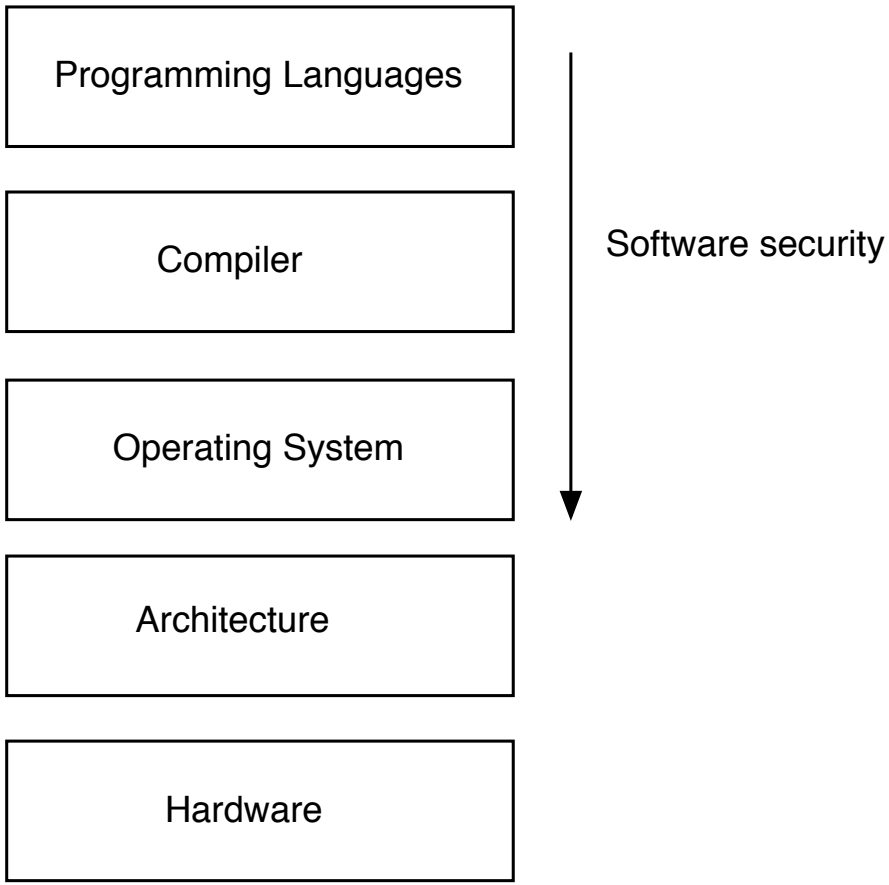

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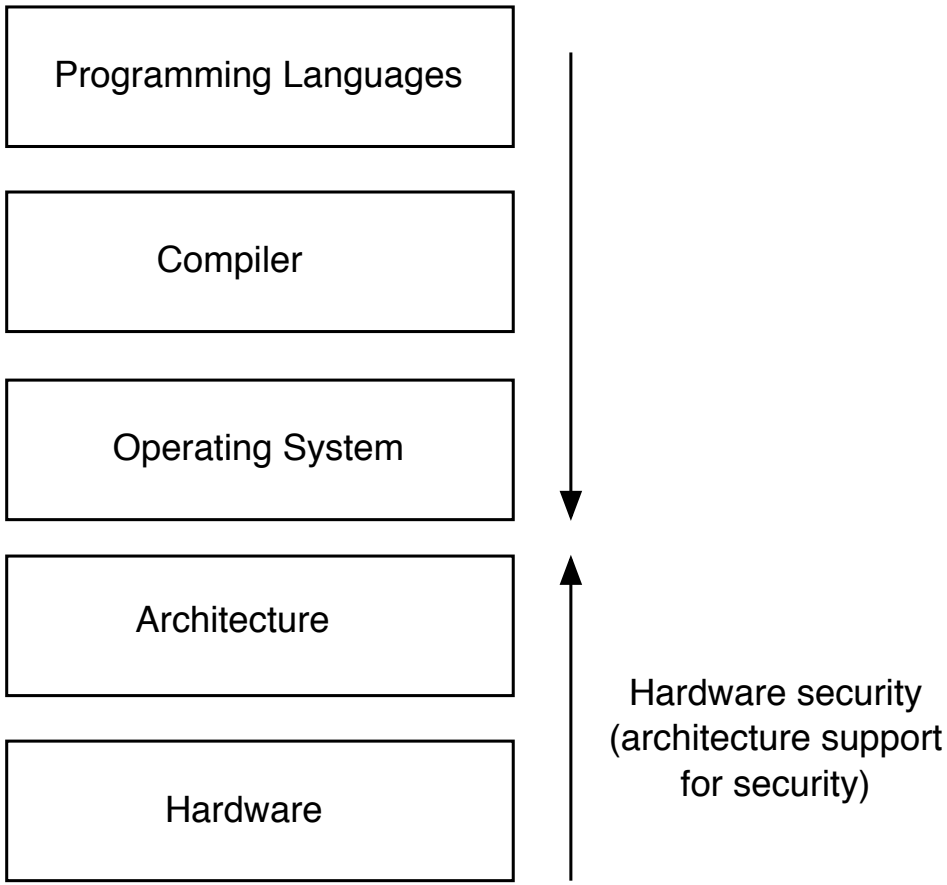

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     - Privilege tussles: protection software can be disabled by attacker
     - Detection (and some prevention) is difficult (computational problem)

- Other attacks: physical attacks; hardware-sourced attacks; side-channel attacks; ...

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- What are some weaknesses?
- Confused: what is the difference?
  - Hardware is software? Hardware description languages
  - Hardware is software? FPGAs? Emulation

Intersection of Architecture and Security?

- Vulnerabilities originating in architecture
  - Side and covert channels
  - Speculation attacks
  - Fault injection
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- Defenses rooted in architecture
  - Do no harm
    - Avoid vulnerabilities in architecture/HW
  - Help software
    - Security abstractions/mechanisms
    - Computational support for expensive defenses

Role of Hardware in Supporting Security

1. New models for supporting security; forget ambient authority
   - Access control models; capabilities; isolated execution
   - Trusted computing base
2. Computational Side of security
   - Support for reference monitors
   - Support for intrusion detection
   - Exploit new security primitives
3. Protection against Physical, Hardware and Microarchitecture based attacks
   - Hardware Trojans and counterfeit chips
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4. Security support for emerging platforms
   - NVMs; embedded systems; cyberphysical systems

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Lets take a look at the tentative schedule

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  - One or two presentations (i.e., you lead the discussion of a paper)
  - Could be on a topic that will become either a mini-survey or a project
  - Come up with discussion points

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- What are the tools of the trade?
  - Simulators such as Gem5, MarSSx86, Wattch, GPGPUSim, DRAMSim, etc...
  - Hardware description languages and open cores; get your hardware to run on FPGA
  - Experimentation for attacks
  - Software analysis tools (PIN, IDAPro, ...)
  - Security analysis

How to read a research paper?

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  - Pay attention to the threat model
  - Why hardware/architecture?
  - Evaluation: performance, complexity, practicality/deployment, security