# Secure Systems: Hardware is the Answer

Secure, Trustworthy, Assured and Resilient Semiconductors and Systems (STARSS) Workshop

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# 18 years of Internet as we know it

```
Network Working Group                                     T. Berners-Lee
Request for Comments: 1945                                       MIT/LCS
Category: Informational                                       R. Fielding
                                                               UC Irvine
                                                              H. Frystyk
                                                                 MIT/LCS
                                                                May 1996


                Hypertext Transfer Protocol -- HTTP/1.0

Status of This Memo

   This memo provides information for the Internet community.  This memo
   does not specify an Internet standard of any kind.  Distribution of
   this memo is unlimited.

IESG Note:

   The IESG has concerns about this protocol, and expects this document
   to be replaced relatively soon by a standards track document.
```

**RFC 1945: HTTP 1.0 (May 1996)**

**Al Gore**

# Complexity and Security

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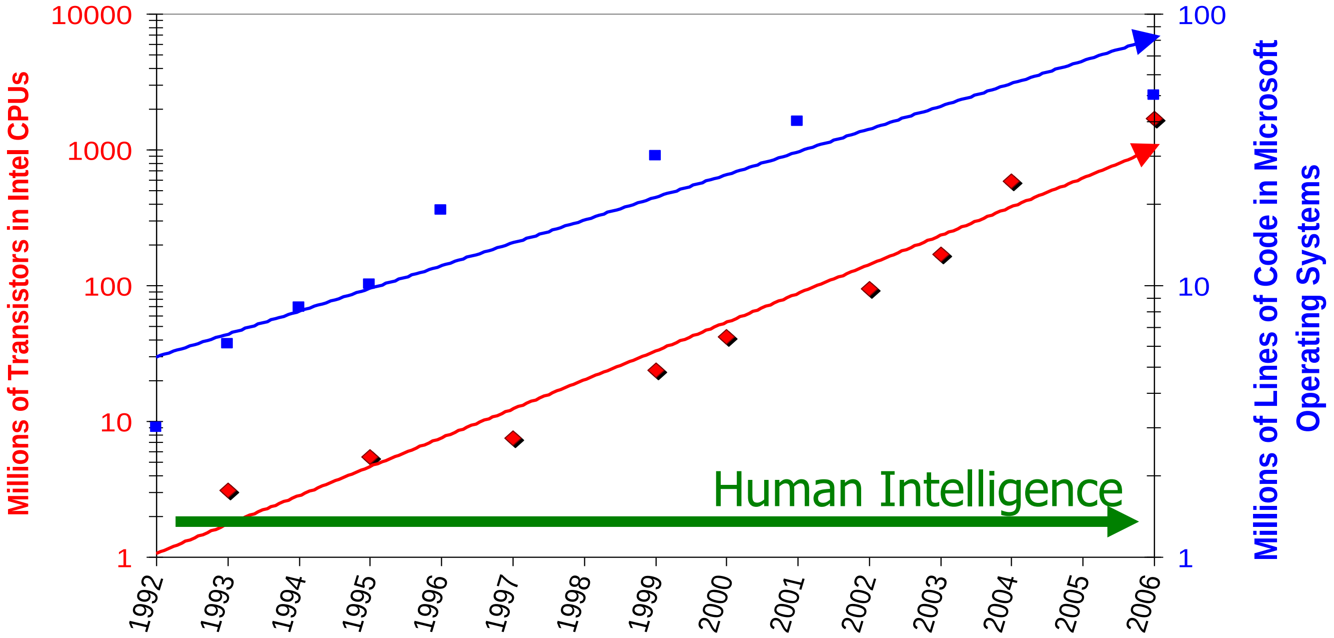
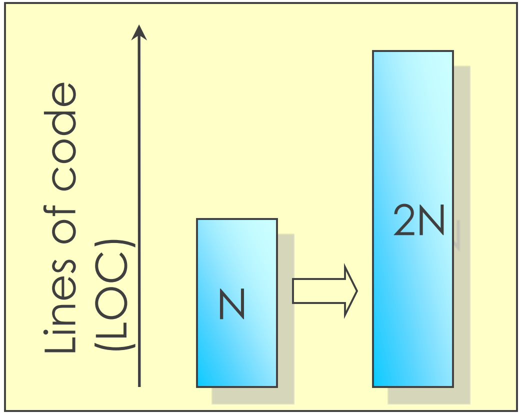
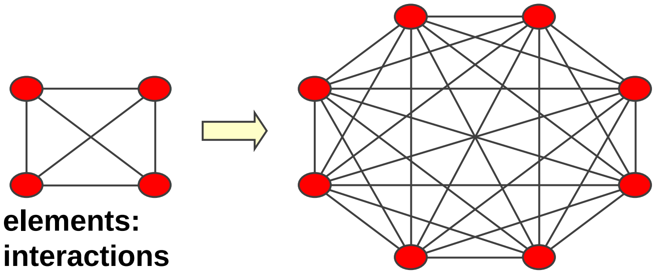
# Life with Moore’s law




CPU data courtesy Intel Corp.

# What happens as complexity increases?



**4 elements:**
**6 interactions**

**8 elements:**
**28 interactions**

## What if the number of elements doubles?

- 2X more opportunities for bugs
  - Odds of having zero catastrophic weaknesses <u>*squared*</u> (e.g., 20% -> 4%)
- Number of interactions increases as the *square* of complexity
  - Odds of having zero catastrophic weaknesses raised <u>4th power</u> (e.g., 20% -> 0.016%)

# About software…

"… the tape can be moved back and forth through the machine, this being one of the elementary operations of the machine. Any symbol on the tape may therefore eventually have an innings."

-- Alan Turing, "Intelligent Memory", 1948

Even in the original Turing machine, any piece of code could wreck security of the entire system.

**Pointers**

# Coping strategies can help…

- Various strategies:
  - Security training
  - Design/code reviews
  - Safer languages
  - Code scanning tools
  - Better components/libraries
  - Additional layers of abstraction
  - Anomaly detection
  - Assertions
  - Monitoring/canaries

```
4.  Heartbeat Request and Response Messages

   The Heartbeat protocol messages consist of their type and an
   arbitrary payload and padding.

   struct {
      HeartbeatMessageType type;
      uint16 payload_length;
      opaque payload[HeartbeatMessage.payload_length];
      opaque padding[padding_length];
   } HeartbeatMessage;

   The total length of a HeartbeatMessage MUST NOT exceed 2^14 or
   max_fragment_length when negotiated as defined in [RFC6066].

   type:  The message type, either heartbeat_request or
      heartbeat_response.
```

**RFC6520 → Heartbleed**

- But complexity overwhelms everything

# About hardware…

- The first rule about hardware: try to make silicon shippable even when there are bugs
- The art of using "free" transistors
  - Multi-core
  - Complex memory hierarchies
  - Half-baked stuff + chicken bits
  - Functionality gaskets and ways to fix in-field
  - Explosion of fuse maps
- RTL looks like code, but is concurrent + subtle
  - …just read published CPU errata!
- Hardware tools are built for 1/1000th the number of users
  - Tool problems created a cottage industry: Formal equivalence checking

# Platform Trust

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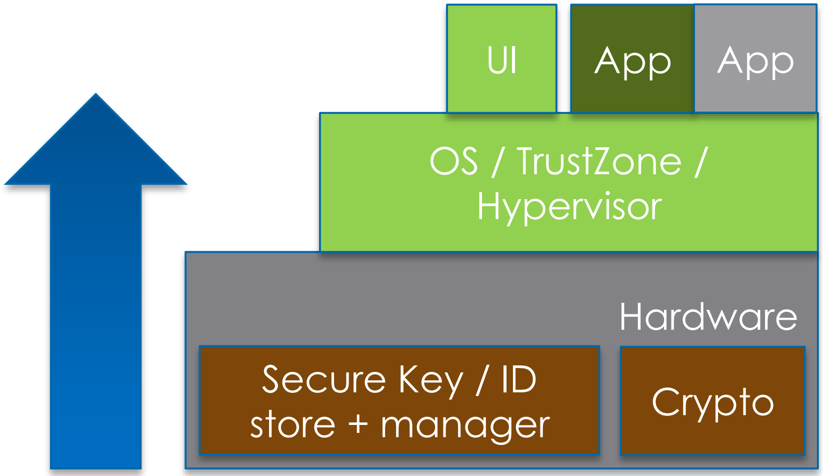
# Apps require a secure, reliable foundation

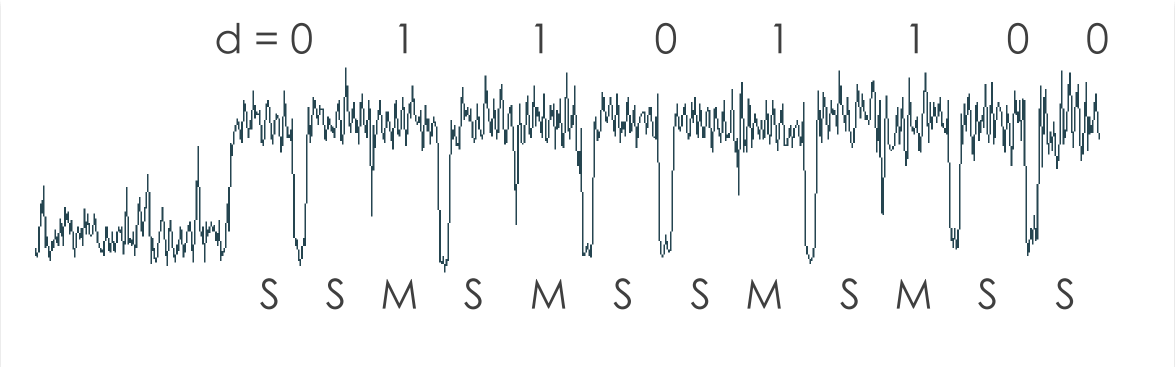
- What gets to run on the platform?
  - Boot / code authentication
  - Secure debug lock
- Am I in the real world or the matrix?
  - Environment attestation
  - Peripheral authentication
- Do my secrets remain opaque?
  - Application partitioning
  - Hardware-based secure key storage



# Example: EM analysis of an RSA implementation

- Android app with RSA implementation on modern 4G phone
- Magnetic field pickup coil
- Measurements collected during computation of $M^d$ mod N




CF = 36.99 MHz | Acq BW = 500 KHz | Filt BW = 250 KHz | Smoothing = 10

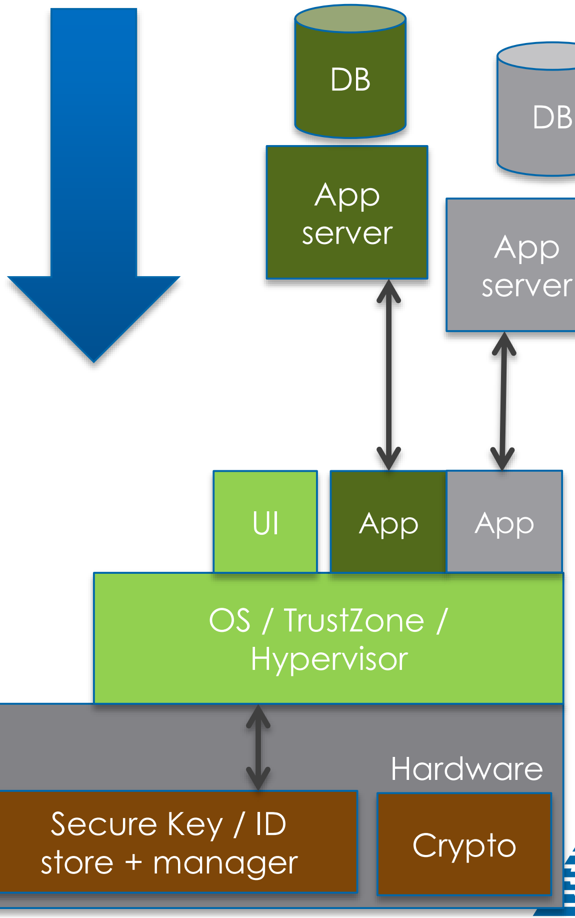
Commercial standards requiring side-channel resistance

- PCI
- Movie Labs
- FIPS 140-3
- Common Criteria

# Trust from the top down

- Device enrollment
- System auditing & risk management
- Online revocation
- Remote management & updates



# Lifecycle considerations for “Internet Things”

***“Direct to field”***

***Limited UI for administration steps***

**Device Manufacture** → ~~**Deployment**~~ → **Active** → **Device Enrollment** → **User/Domain Change**

**Early provisioning of dev. credentials**

- Inject keys, certificates
- Enroll device
- May be done before OS load
- Often an outsourced (faraway) manufacturing site

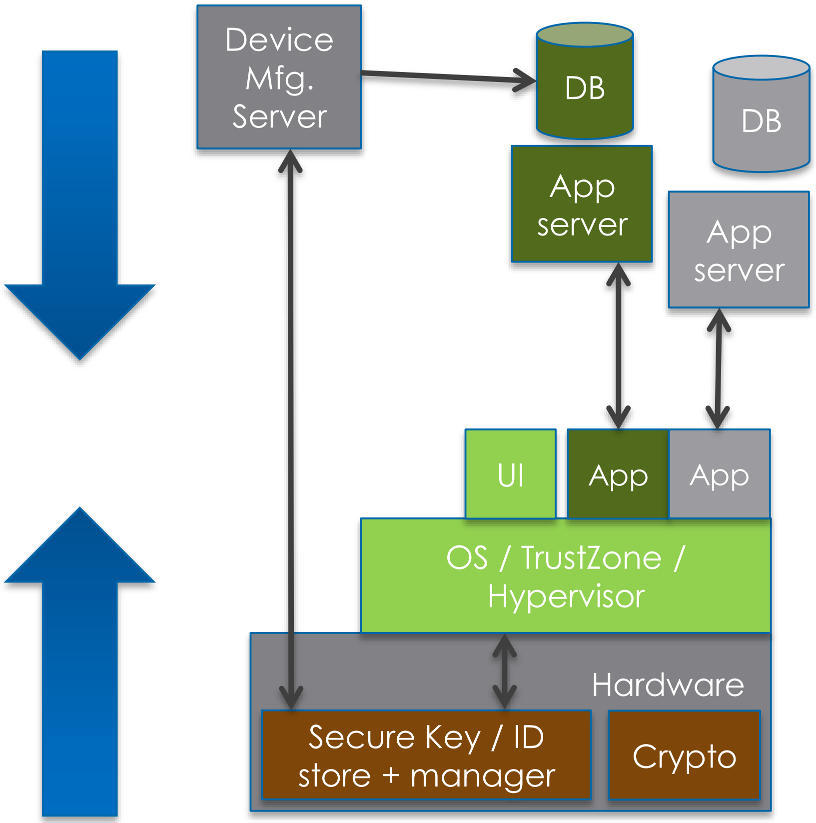
**Device administration secured by base credentials**

- In-field challenge/response authentication
- Add/update user credentials
- Send signed updates

# Trust meets in the middle

*Identity + key provisioning*
*Authentication service*
*Secure session management*
*Security updates*

*Identity + key management*
*Sandboxed secrets*
*Partitioning of critical state*
*Reliability & integrity*



# Trust Boundaries

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# Security for command & control

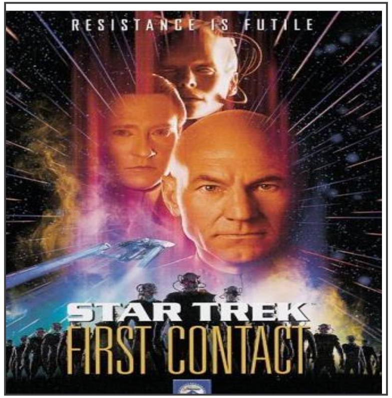
- Egyptian signet ring
  - Used by pharaohs & officials
  - ~500BC

- Mark of the fisherman
  - Individualized for each pope
  - On death, Cardinal Carmerlengo to locate ring & destroy seal
  - Earliest note in 1265

Images courtesy British Museum, flikr:favoritethings

# Security for command & control

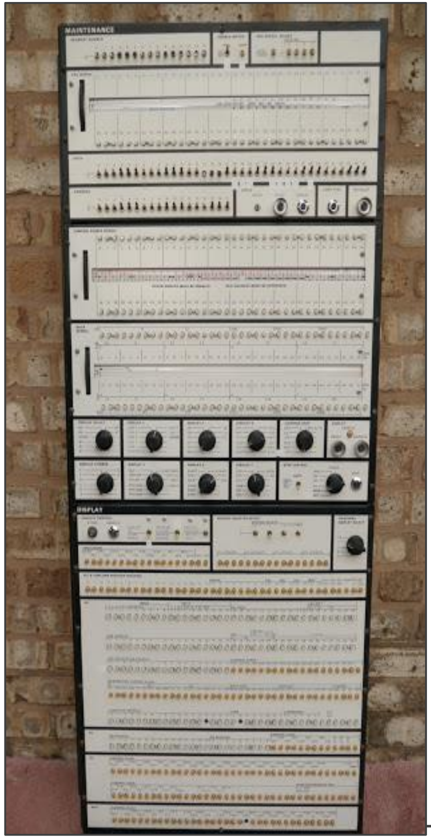
US nuclear "football"




Starfleet auto-destruct procedure

**...but most security problems are not this clean or well funded!**

# Things got more complicated



US NIKE missile site
Angel Island, San Francisco

Honeywell 6180 (1973)
Multics w/Hardware ring 0

American EP-3E returns from
Hainan, China (7/2001)

# Real life control and responsibility: Mobile

*Can we really aggregate trust to "Hypervisor"?*

**"SENSITIVE STUFF"**

- Application
- Application marketplace
- User
- Device owner
- Carrier / System operator
- OS vendor
- OEM device manufacture
- OEM code
- Outsourced chip assembly and test
- Semiconductor fab
- SoC designer

*Platform "Owners" with different control, responsibility domains*

*Privacy?*

*"The Supply Chain"*

*really?*

*It takes a village!*

# Let's get to work!

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