Embedded Systems Security

March 2025

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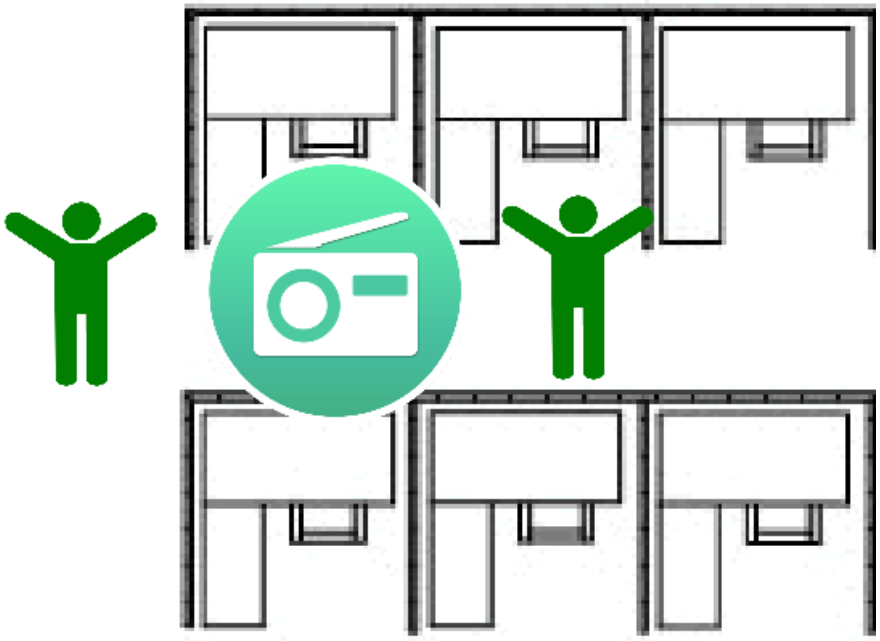
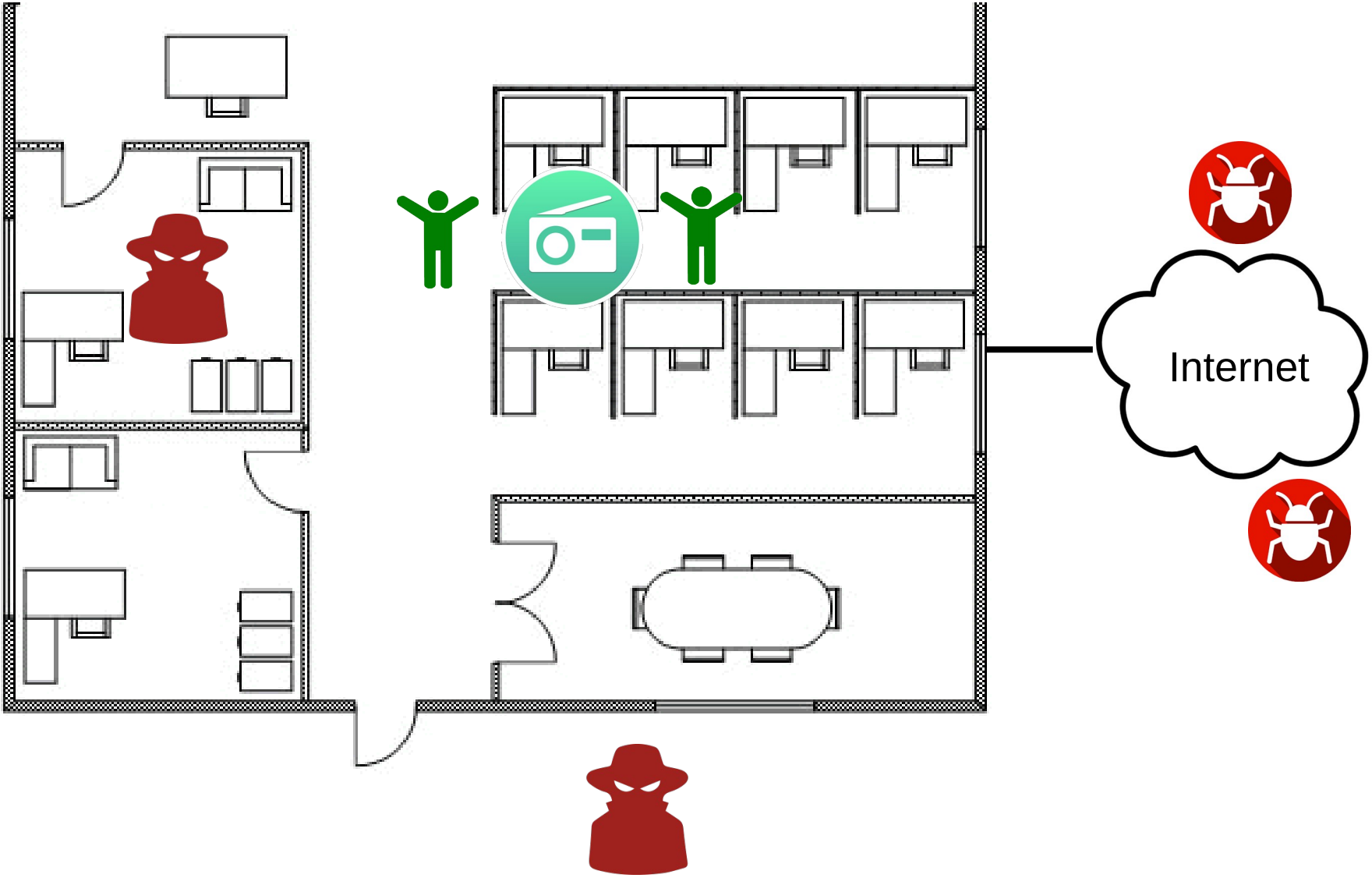
What we see



There’s more around you!



Types of Attacks

Eavesdropping

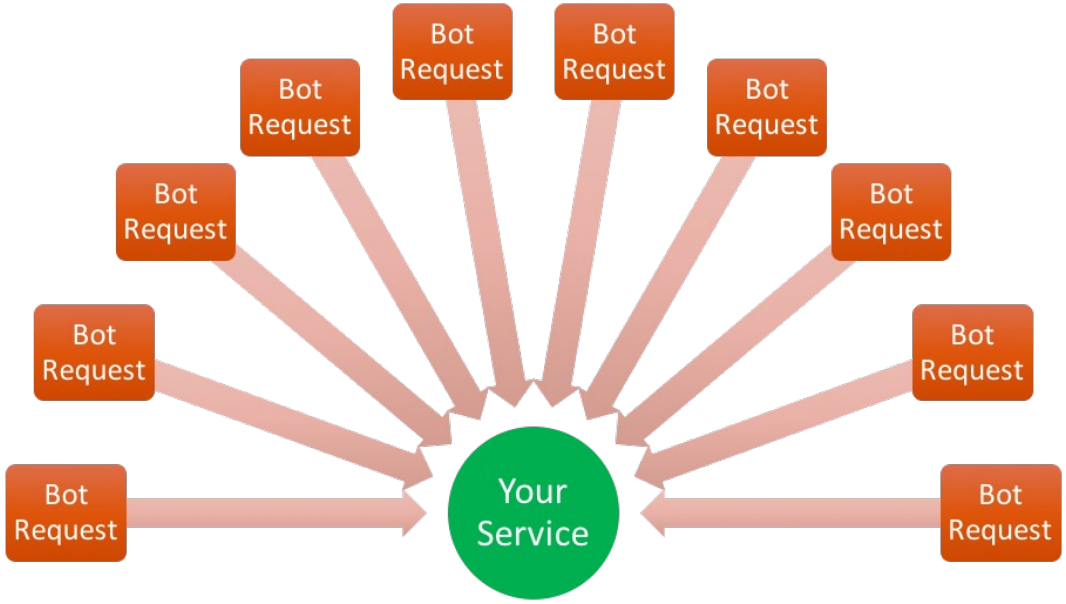
- Someone intercepts or “sniffs” data packets
- Can expose or steal sensitive data

Solution:

Use WPA2 or WPA3 wireless security,
Use SSL/TLS to encrypt traffic

Denial of Services (DoS)

- Someone floods your devices with requests
- Tries to slow down or disable the service

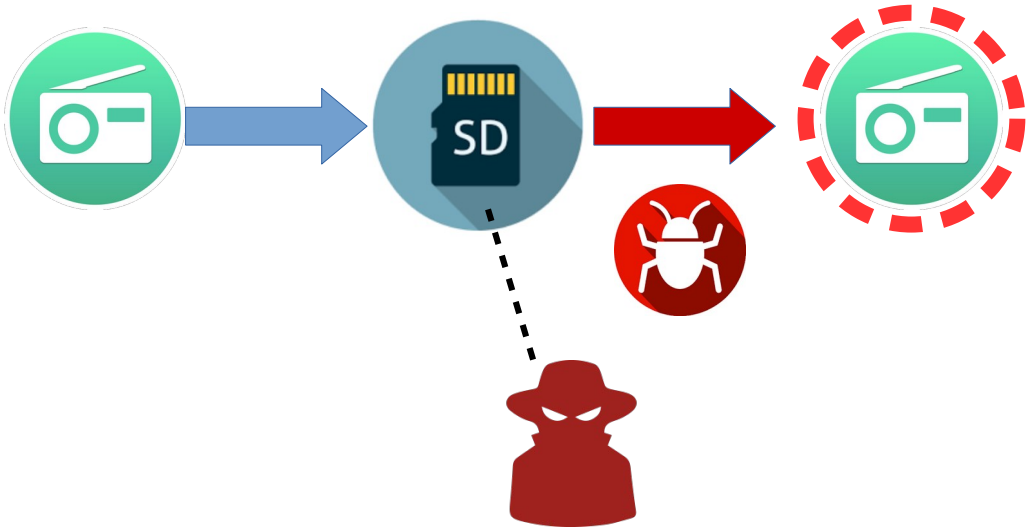


Solution:

Implement rate limiting, or auto-ban malfunctioning clients

Device Tampering

- Someone accesses the disk and reads the files
- Or modifies the embedded software



See “Industrial Grade Concerns”

Compromise or Hack

- The device is infiltrated
- Someone (or software) takes control

```
root@host$ ls /
bin    dev   initrd.img      lib64       mnt   root  snap  tmp   vmlinuz
boot   etc   initrd.img.old  lost+found  opt   run   srv   usr   vmlinuz.old
cdrom  home  lib             media       proc  sbin  sys   var
root@host$
```

Common Vulnerabilities

(Frequently occur!)

Common vulnerability #1

- **Open service ports allowing logins**
  - ssh, telnet, http: login prompt
- *Plus* weak/default passwords

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1. Discovers telnet service

2. Start trying default logins
   admin : (no password)
   admin : admin
   ... brute-force search ...

3. If success, loads software

Common vulnerability #2

- **Unauthenticated open services**
- Anyone can connect!

See: “Avast Hacked a Smart Coffee Maker All Kinds of Ways”

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Common vulnerability #3

- **Outdated OS and software**
- Everything needs patching eventually
- Can’t just leave a device alone for 5 years
- Design your product to *support* updating

Common vulnerability #4

- **Malicious re-pairing / physical takeover**
- Someone pairs the device (again)
  - But doesn't own the device
- Physical access

See: "$30 doorbell cameras can be easily hijacked, says Consumer Reports"

Wireless Security

Wi-Fi Modes

- **Open**: no password, anyone can connect, unsafe
- **WEP**: old standard, broken, unsafe
- **WPA**: old standard, broken, unsafe
- **WPA2-TKIP**: uses old algorithm, unsafe
- **WPA2-AES**: next best option to WPA3
- **WPA3**: the newest standard, best option

Wi-Fi Security Tips

- Use WPA2 (AES) or WPA3
  - With a good password
  - Traffic will be encrypted
- Disable the “WPS” feature
- Remember:
  - SSID (hotspot name) is visible to everyone

Wi-Fi Can Be Risky

- “KRACK” was a very severe WPA2 attack from 2017-2018
- Old embedded/IoT devices were vulnerable
- Attackers could intercept traffic
  - even with WPA2

- HTTPS (aka TLS) helps protect against this

Ideally, use SSL/TLS!

HTTPS (aka TLS) – simplified

- Client makes an encrypted HTTP request to Server
- Server provide a Certificate
- Client verifies that Certificate is valid
  - Makes sure we're talking to the real Sever

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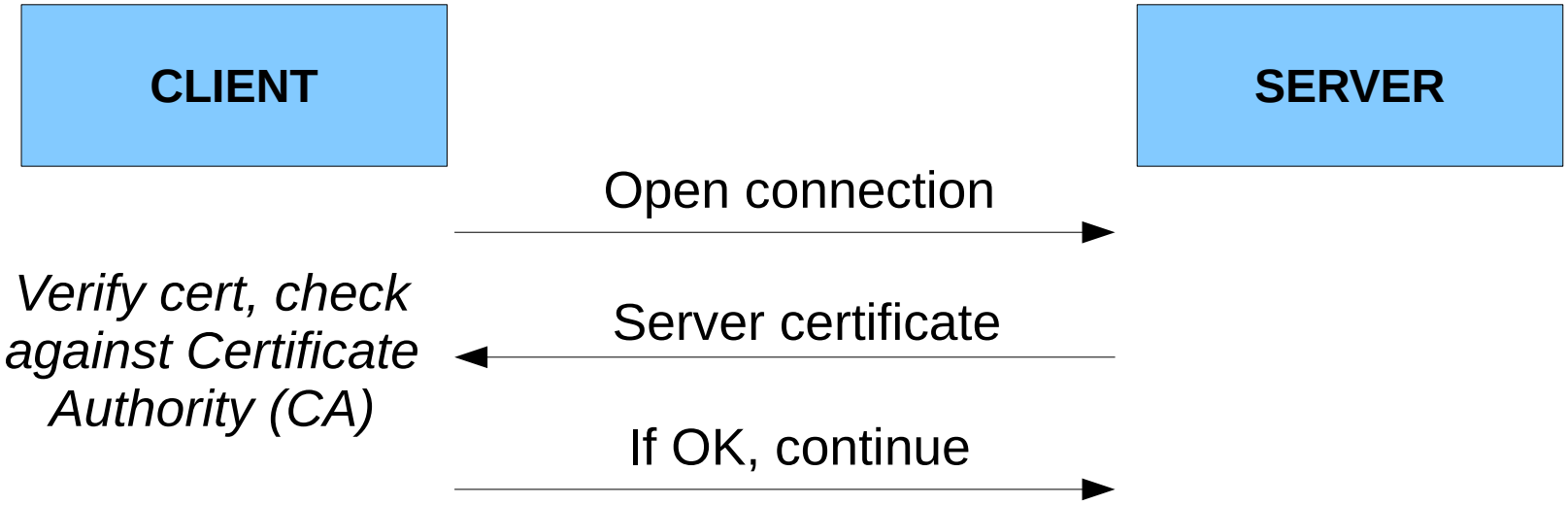
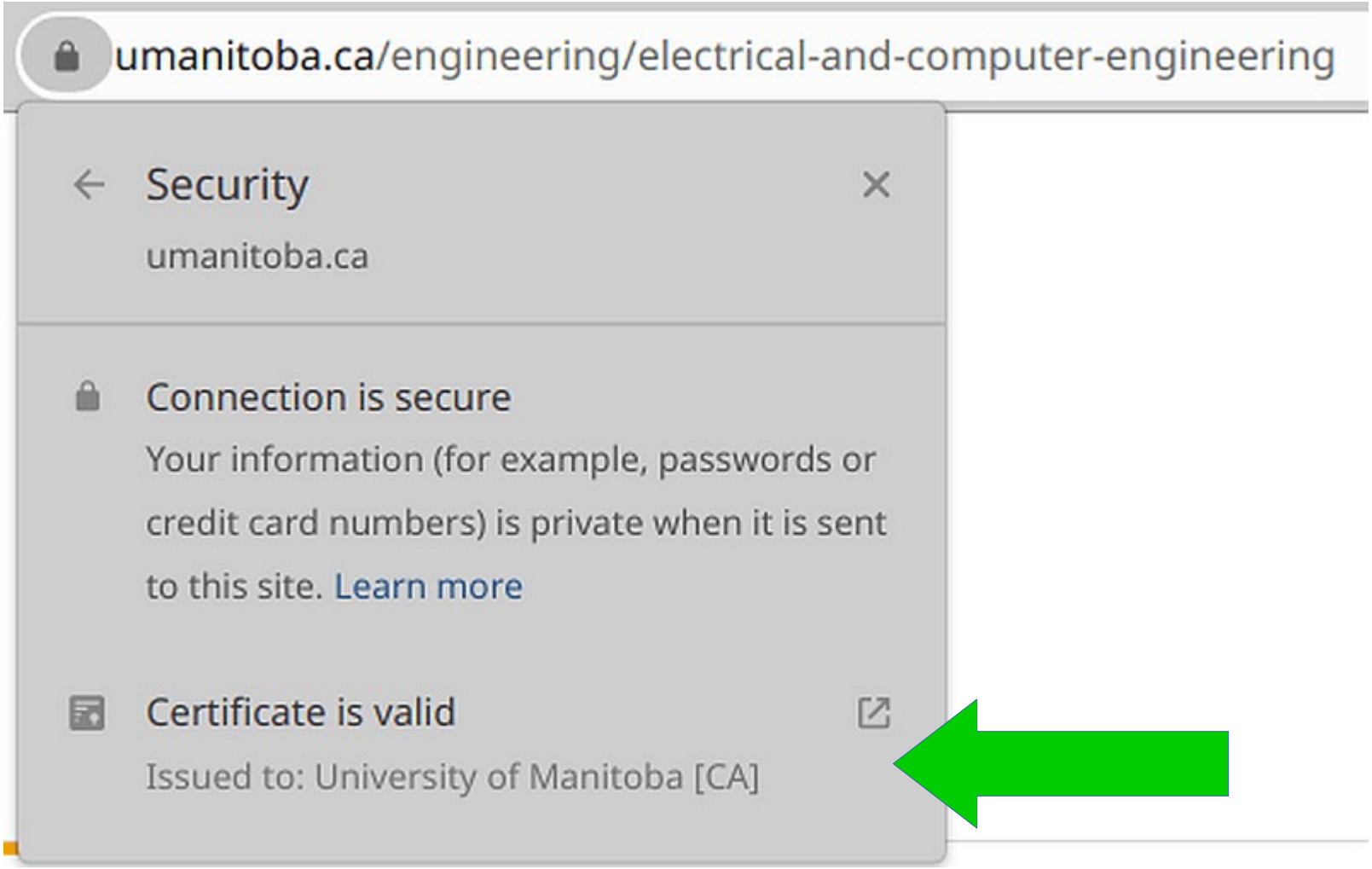


Certificates



Certificates

Certificate Viewer: www.umanitoba.ca

General Details

Issued To

Common Name (CN)	www.umanitoba.ca
Organisation (O)	University of Manitoba
Organisational Unit (OU)	<Not part of certificate>

Issued By

Common Name (CN)	GlobalSign Extended Validation CA - SHA256 - G3
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Validity Period

Issued On	Thursday, 11 June 2020 at 14:06:02
Expires On	Saturday, 23 July 2022 at 08:41:09

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Certificate Authority

Validity Period

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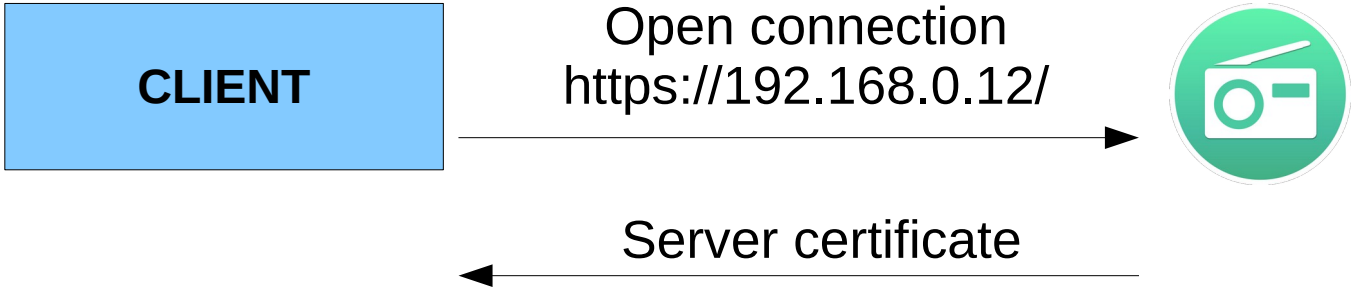
Certificate Authorities (CA)

- This becomes an issue with embedded systems
- Say your embedded device runs a web server



Problems!

- The server address is some IP address
- There’s no “domain name”
- Can’t confirm certificate validity

Private CA method

- Create your own Certificate Authority (using OpenSSL)
- Install your own “root” CA cert on all clients
- Also called a Private CA
- Each of *your* devices can then recognize each other
  - But someone else (e.g. smart phone) will still get an “invalid certificate”

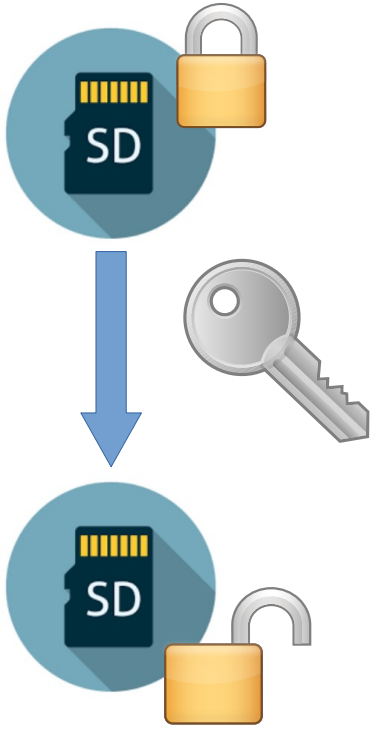
“Industrial Grade” Concerns

Physical Tampering

- People have physical access
- They could break open the device
  - Remove SD card
  - Connect to disk interface
- Don’t want people tampering with your embedded sys

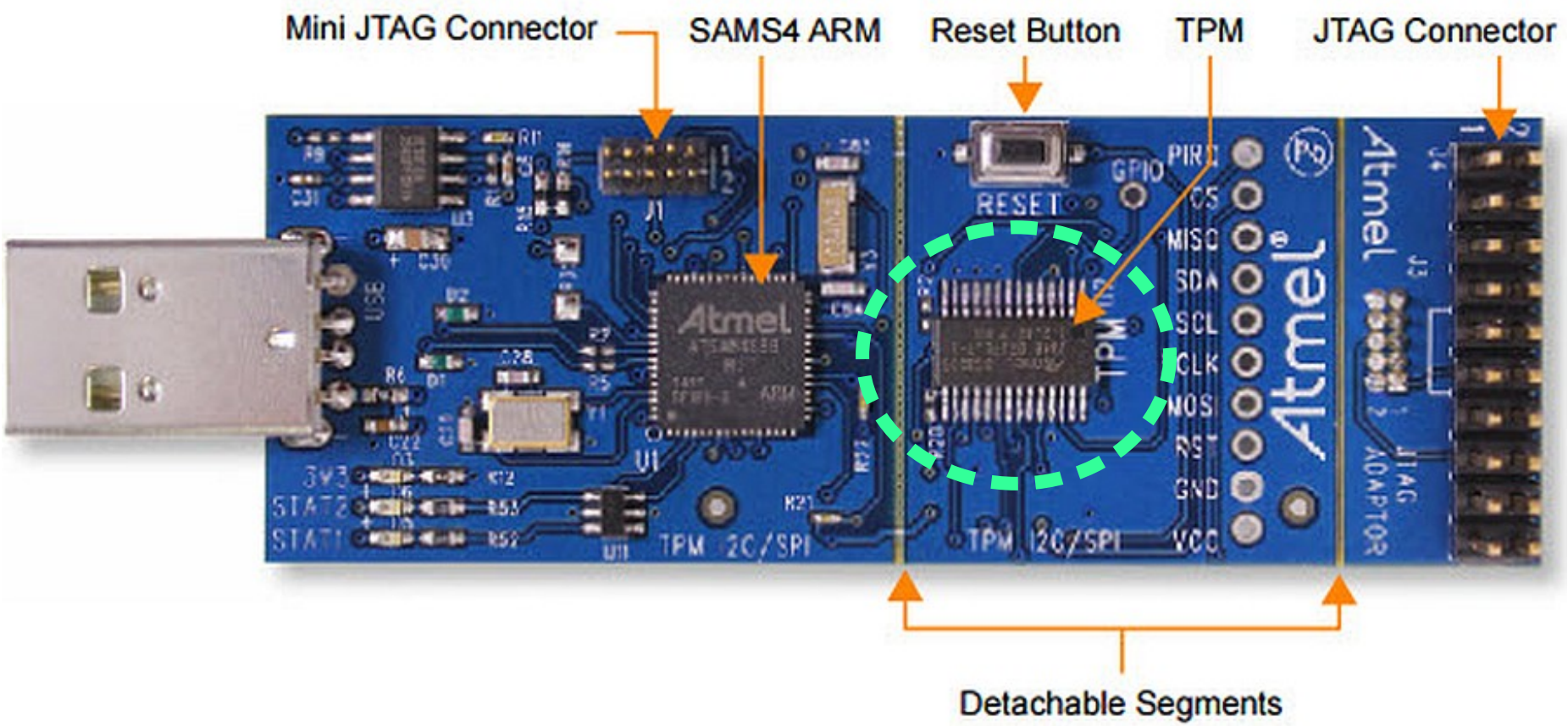
Protecting System Integrity

- Generally requires more feature-rich processors
- Use full disk encryption (FDE)
- “Encrypted at rest”



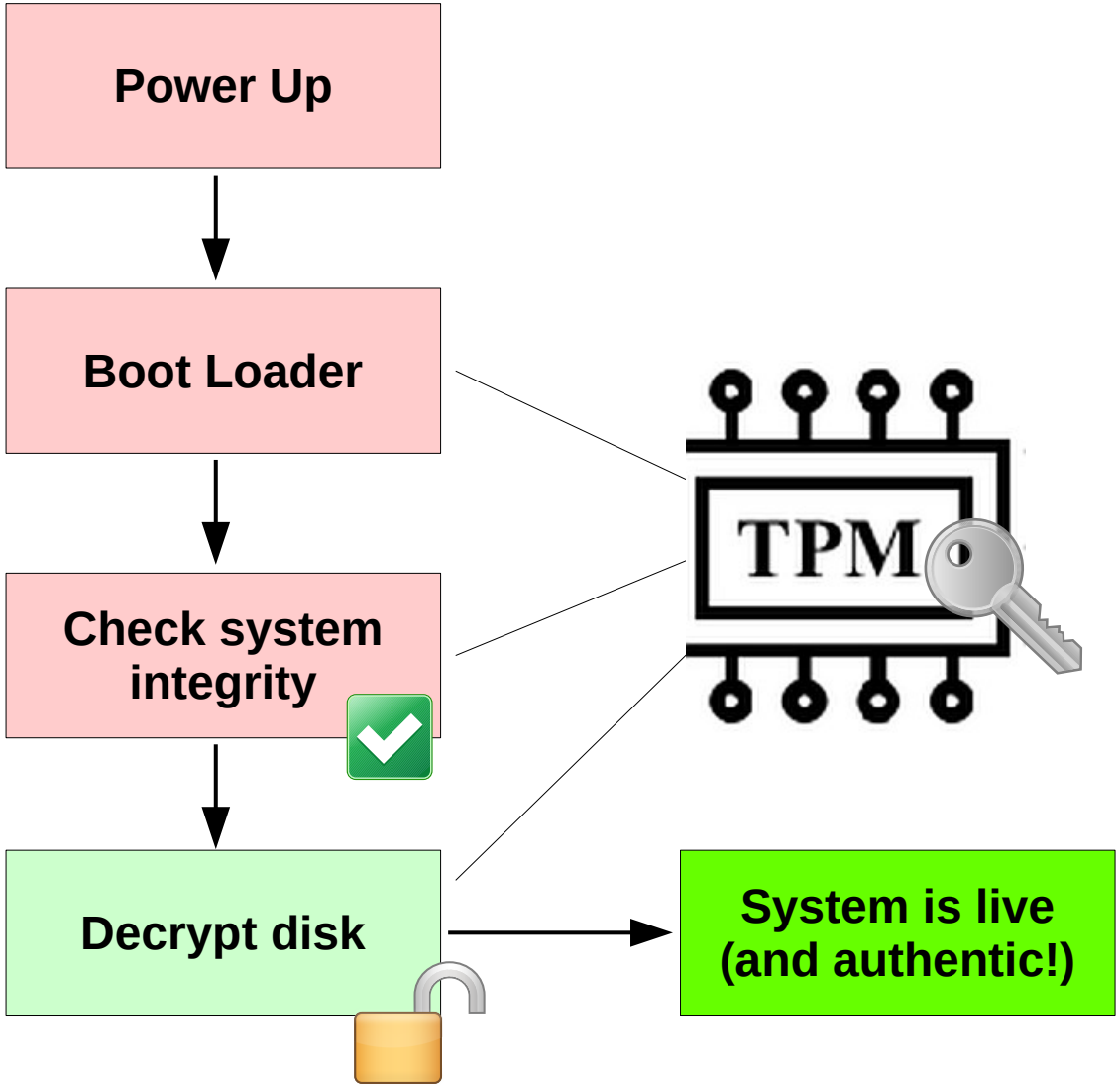
But the key is exposed and readable, right?

Secure Cryptoprocessor (e.g. TPM)



Atmel TPM Development Kit (ARM)

Secure Boot & Cryptoprocessor



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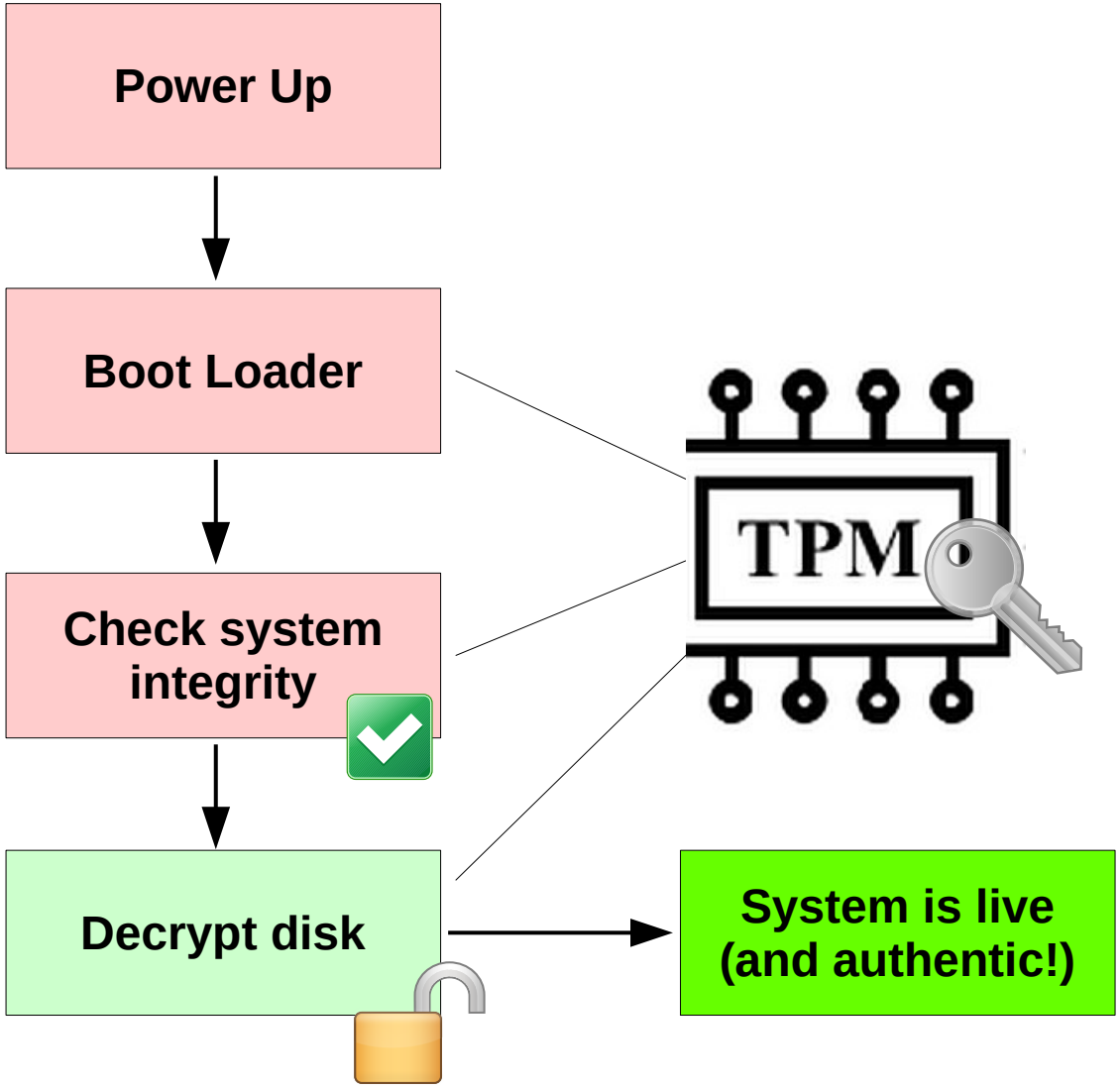

- Detects tampering
- Ensures integrity
- Protects the key
- “Root of Trust”

Trusting the Source Code

- **Social engineering** might introduce malicious code
  - XZ Utils received code from a developer
  - Contributions over 2 years
  - This developer introduced a “backdoor”

- **AI-generated code** might not be safe
  - Might introduce vulnerabilities / bad code
  - Researchers believe it’s riskier than typical code
  - Engineers may not understand the code!