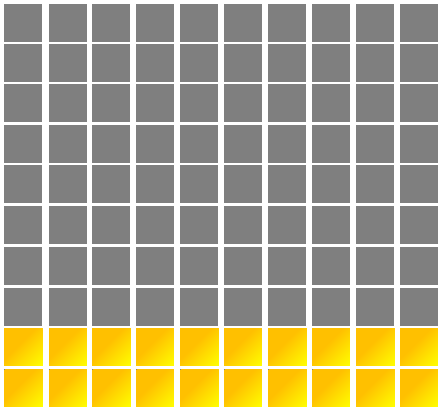
Designing Cost-Effective Ethernet Automotive E/E Architecture Against Security Threats

2017 IEEE-SA Ethernet & IP @ Automotive Technology Day

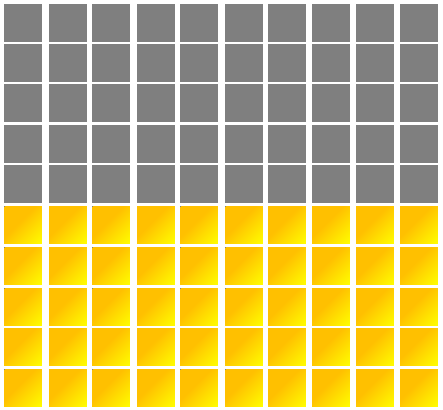
Agenda

- Connected vehicle attack surfaces
- High level security needs
- Hardware security protection
- Ecosystem management
- Network Partitioning for security
- Hardware-secured TLS
- Ethernet switching requirements
- Example of secure Ethernet IVN

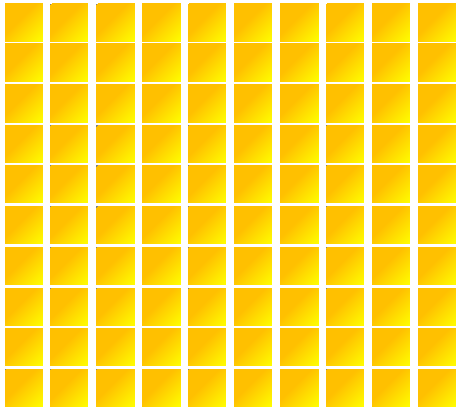
Cars Are Already Connected



More than 20% of vehicles sold worldwide in 2015 included embedded connectivity solutions



More than 50% of vehicles sold worldwide in 2015 to be connected (either embedded, tethered or smartphone integration)



Every new car to be connected in multiple ways by 2025

The new question:

- ***Will these cars be connected with a foundation of security in mind?***

Forbes

Sources: Oliver Wyman, M2M Now, Booz & Company, IHS Automotive Center of Automotive Management, Capgemini, GSMA

High Visibility Hacks Influencing Market Trend

- Resulting in new regulations and OEM cybersecurity specs

Attack Surface Keeps Growing

- **Increasing remote attack interfaces**
  - On-board diagnostic port
  - Telematics
    - Wi-Fi® hotspot & long-range wireless connectivity
      - 3G, 4G, LTE
    - Bluetooth® connections (smartphones)
    - Passive entry / keyless systems
  - Infotainment
    - Storage media (CD, USB, SD card)

- **Attack scenarios**
  - Safety critical (Brakes, engine control…)
  - Obstructive (Instrument reading, lights, infotainment…)

- ***No security on CAN2.0 & limited bandwidth to implement***
- ***Ethernet VLANs for traffic separation not security***

High-Level Security Needs

- **Ease of integration into existing architecture & Engine Control Units (ECUs)**
- **Scalable across platform models**
- **Flexible migration to next-generation architecture**
- **Common methodology across all types of In-Vehicle Networking (IVN)**
- **Intrusion detection and OTA updates**

- ***Cost effective total solution!!***

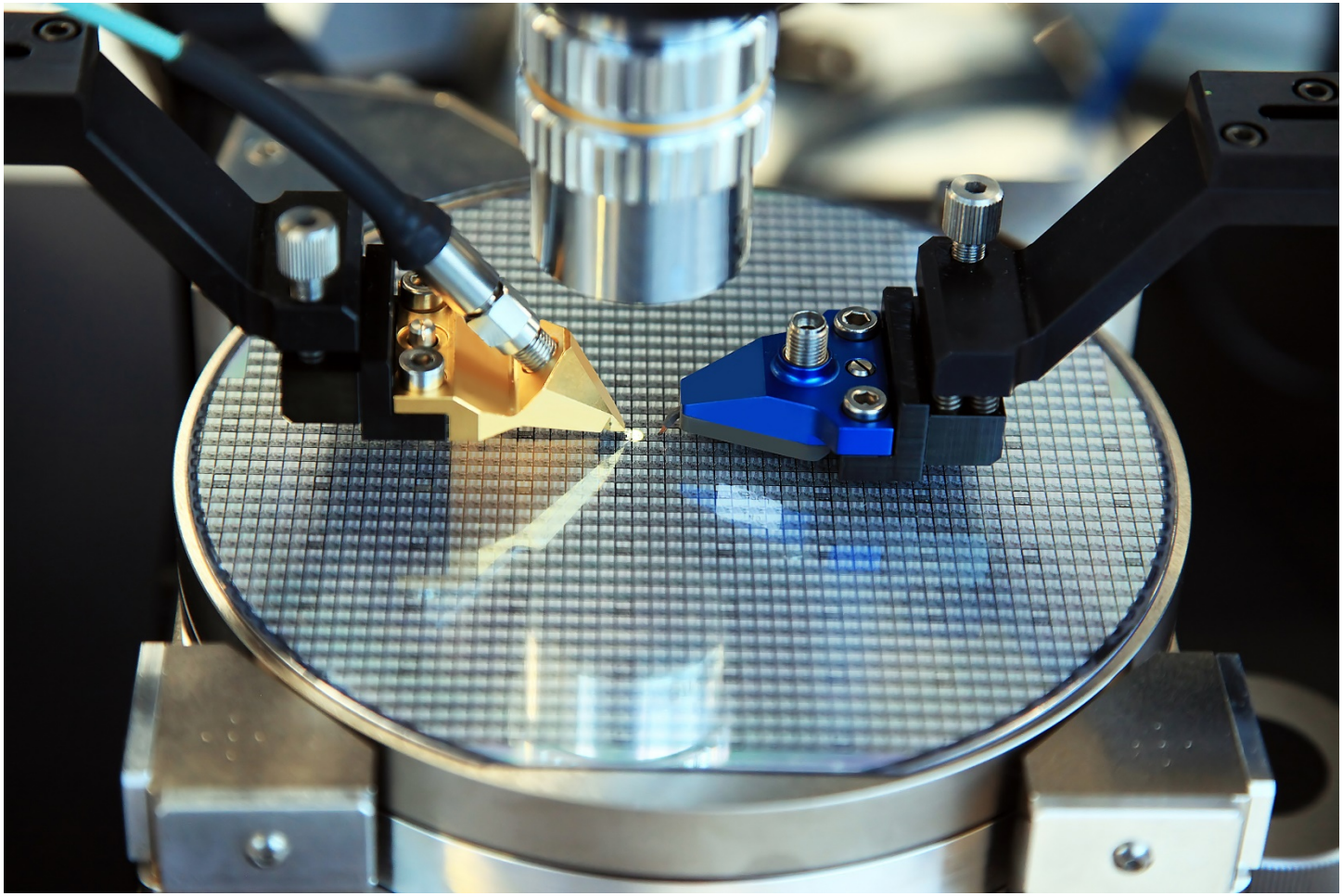
Attributes of Automotive Hardware Security Devices

- **Secure Key Storage**
  - Trusted Ethernet nodes with secure boot & firmware update
  - TLS key protection
  - CAN communication keys & certificates storage
  - CAN communication session key(s) storage
- **Ease of Integration**
  - Less code = lower cost
  - Minimal code updates on node microcontroller (MCU)
- **Node Authentication & Key Agreement**
  - ECU authentication & key agreement scheme
  - Encrypted and authenticated command sessions
- **Hardware Crypto Accelerators**
  - Symmetric and asymmetric algorithms
  - High quality random number generators
  - HMAC & CMAC for serial communication protection
- **Automotive Grade-1**

High-security storage

Unprotected Hardware Attack

Microprobe to See Internal Device Nodes and Extract Keys

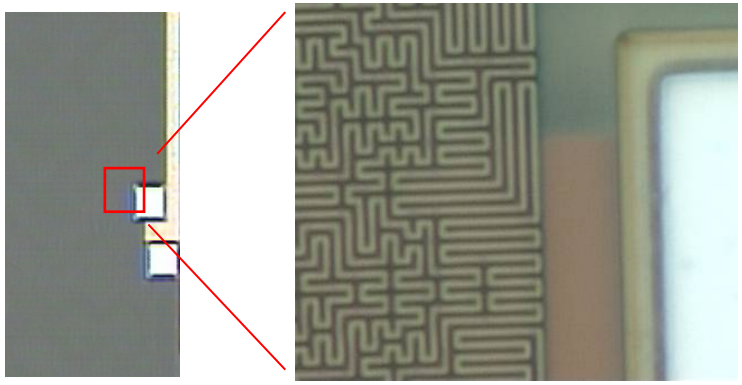


- ***Software can <u>NOT</u> protect private keys!***

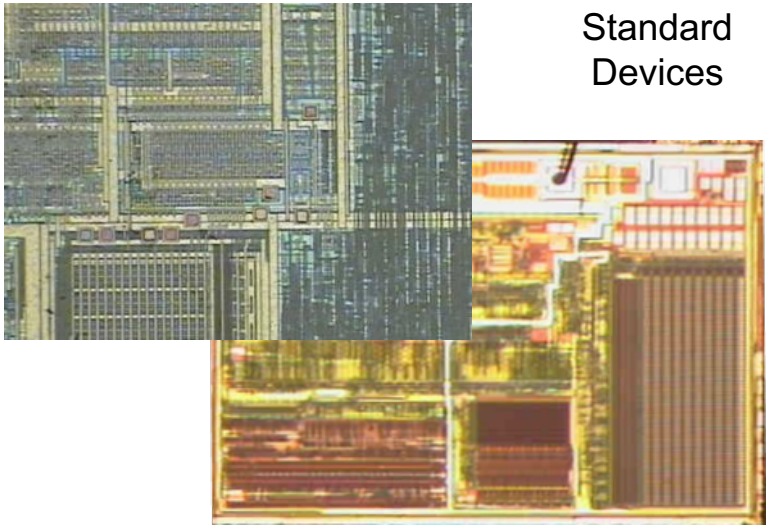
How Keys are Protected Matters!

- **Strong Multi-Level HW Security**
  - Starts with active shield
  - Plus a multitude of environmental tampers
  - Protection modes
  - Ability to erase keys
- **Designed to Defend Against**
  - Microprobe attacks
  - Timing attacks
  - Emissions analysis attacks
  - Fault , invalid command attacks
  - Power cycling, clock glitches

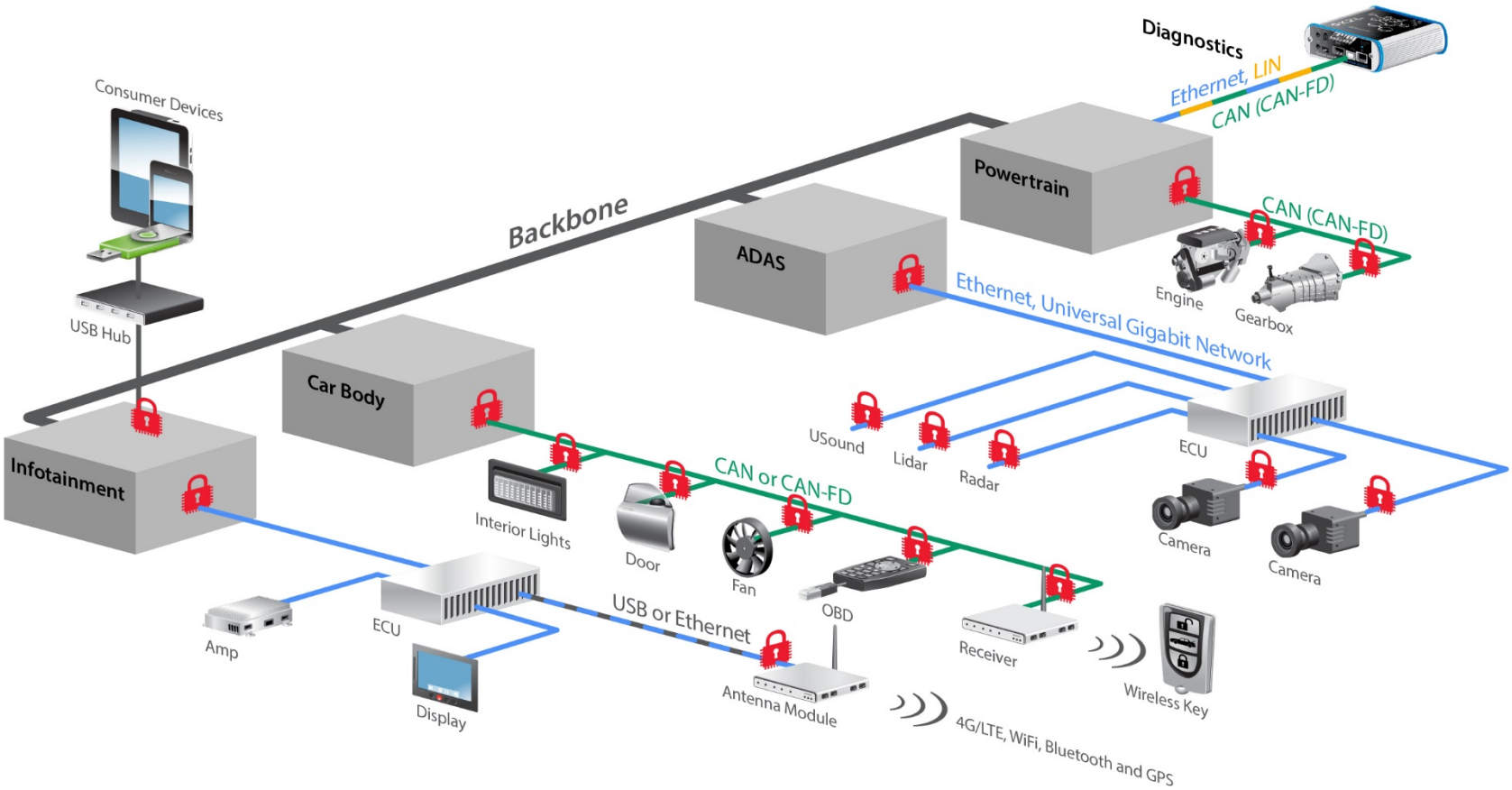
HW Crypto Devices



Standard Devices



Security Considerations at every Node in the Vehicle



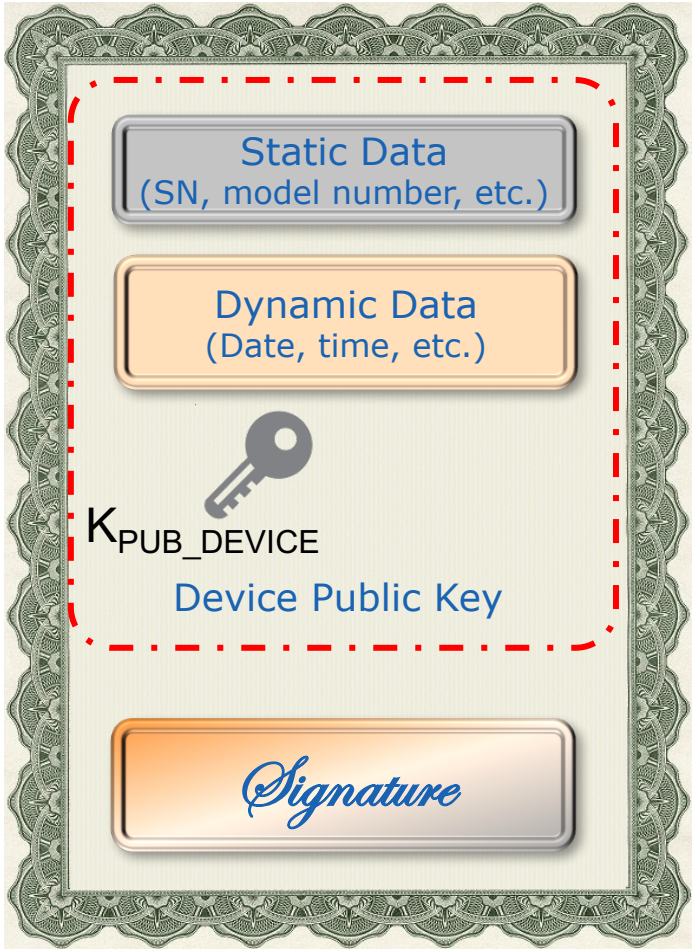
- ***SAE J3061*** Consider risks associated with each vehicle system

Ecosystem Management

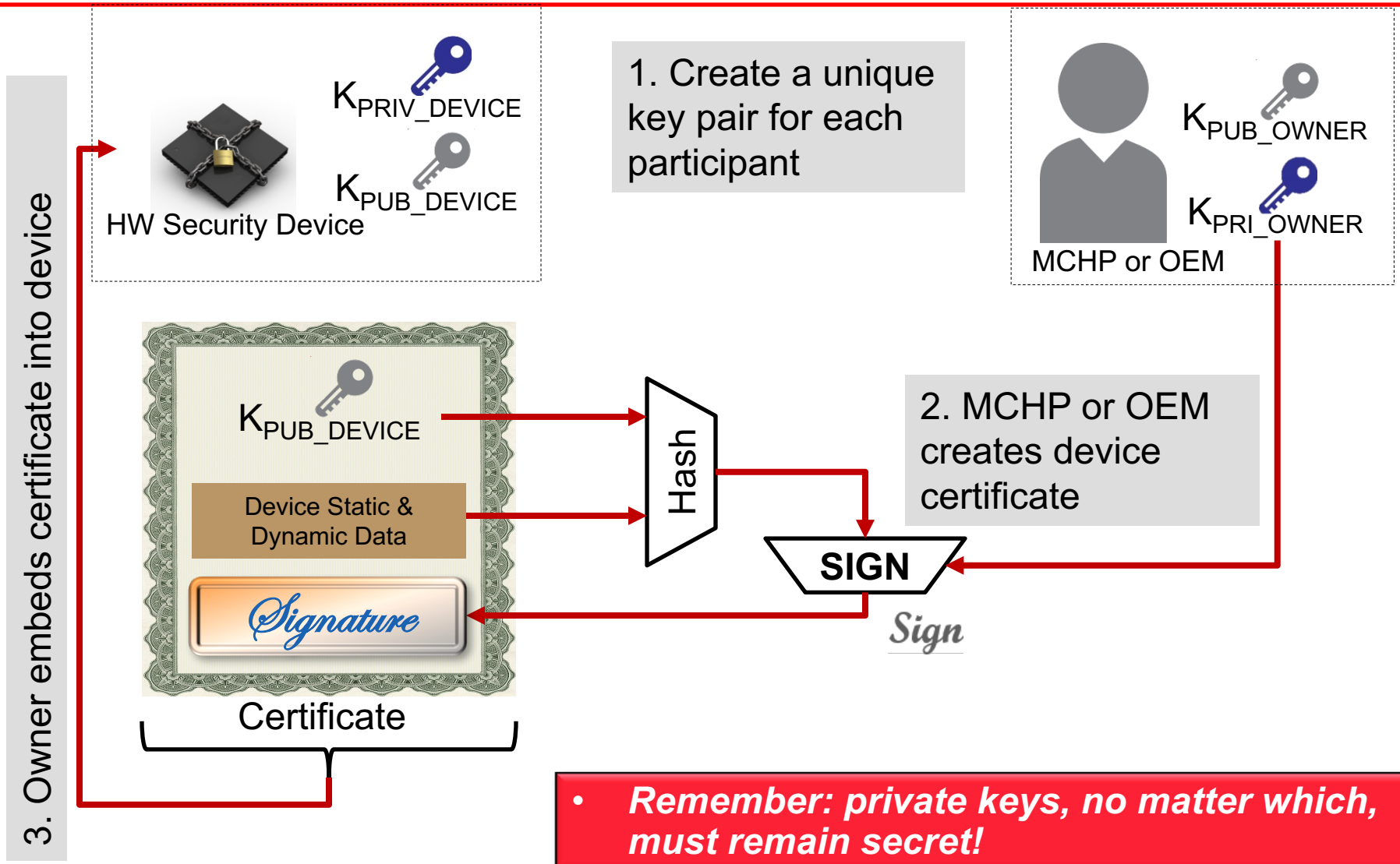
- Protect your brand
- OEM's can manage approved suppliers for each node
- Only approved safety critical nodes operate in the vehicle
- X.509 certificates can help in authentication genuine components

Digital Certificates

- **The x.509 Digital Certificate is a *unique* *verifiable* form of identity for the node**
- **It comprises three main components:**
  - The device public key
  - A signature to enable verification of the authenticity
  - Data capturing any attributes the owner intends as part of the identity
- **Certificates are standards driven forms of identity for the Internet**

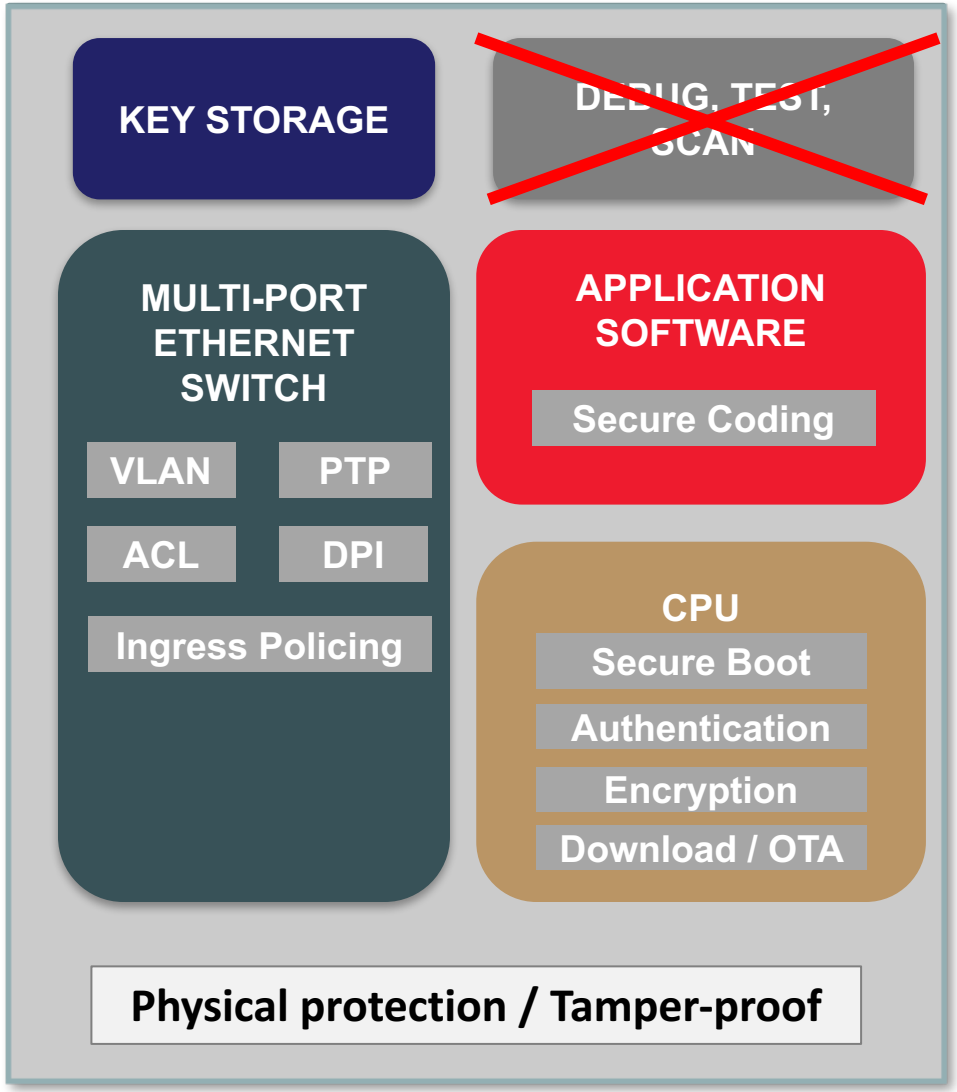


Creating a Certificate
(Provisioning)



- ***Remember: private keys, no matter which, must remain secret!***

Monolithic Approach to Securing Ethernet



- ✓ Complex
- X Flexible
- X Scalable
- X Common methodology
- X Existing architecture
- ? Cost effective
- ? Secure

→ *Impractical*

→ *Partition network*

Partitioning Network for Security

- **Separate common network security from data traffic processing**

Security IC

Common Network Functions

- Physical defence mechanisms
- Secure boot & download
- Authentication
- Key management
- Ecosystem and certificate chain management

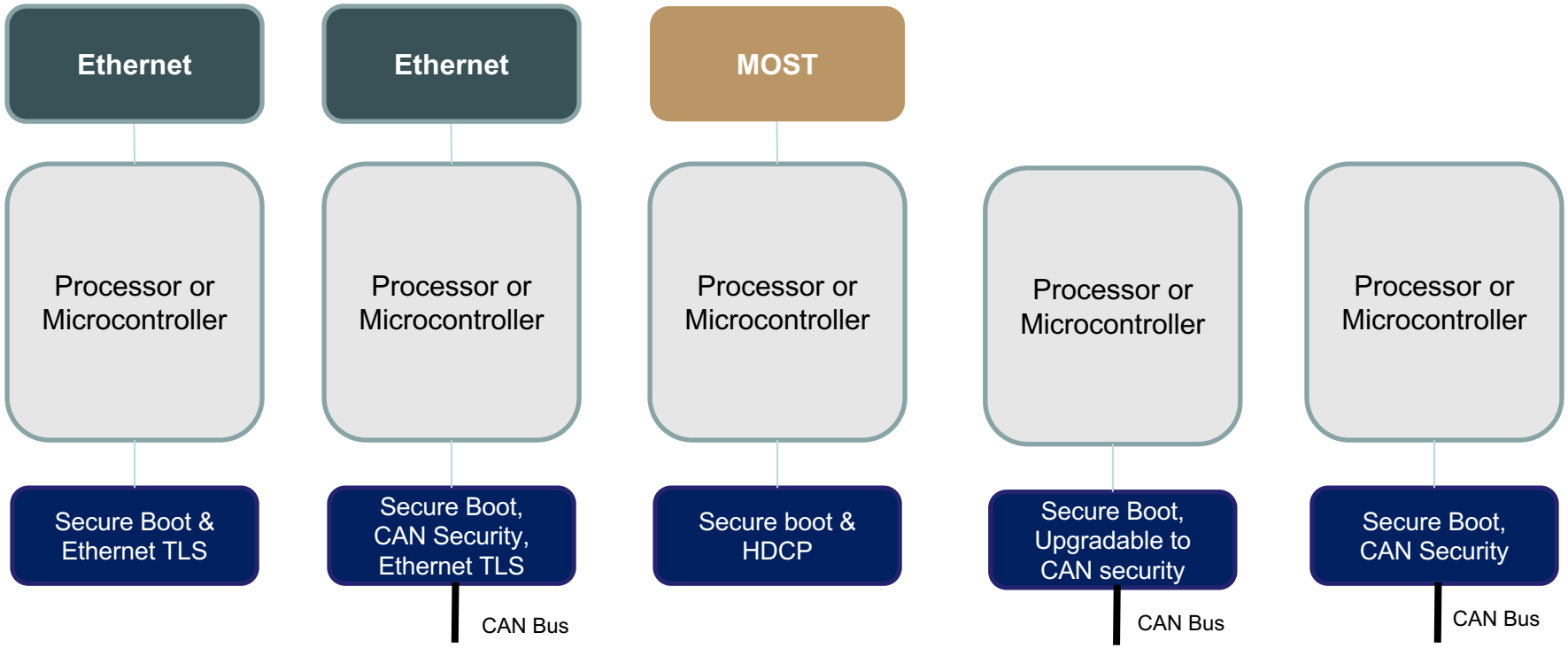
Smart Switch

Network Specific Processing

- Virtual LANs
- Access control
- Deep packet inspection
- Ingress / egress policing
- Intrusion detection / protection

- ***Optimizes security performance, flexibility and cost***
- ***Any ECU, any architecture, any configuration, any bus***

Scalable Security for IVN

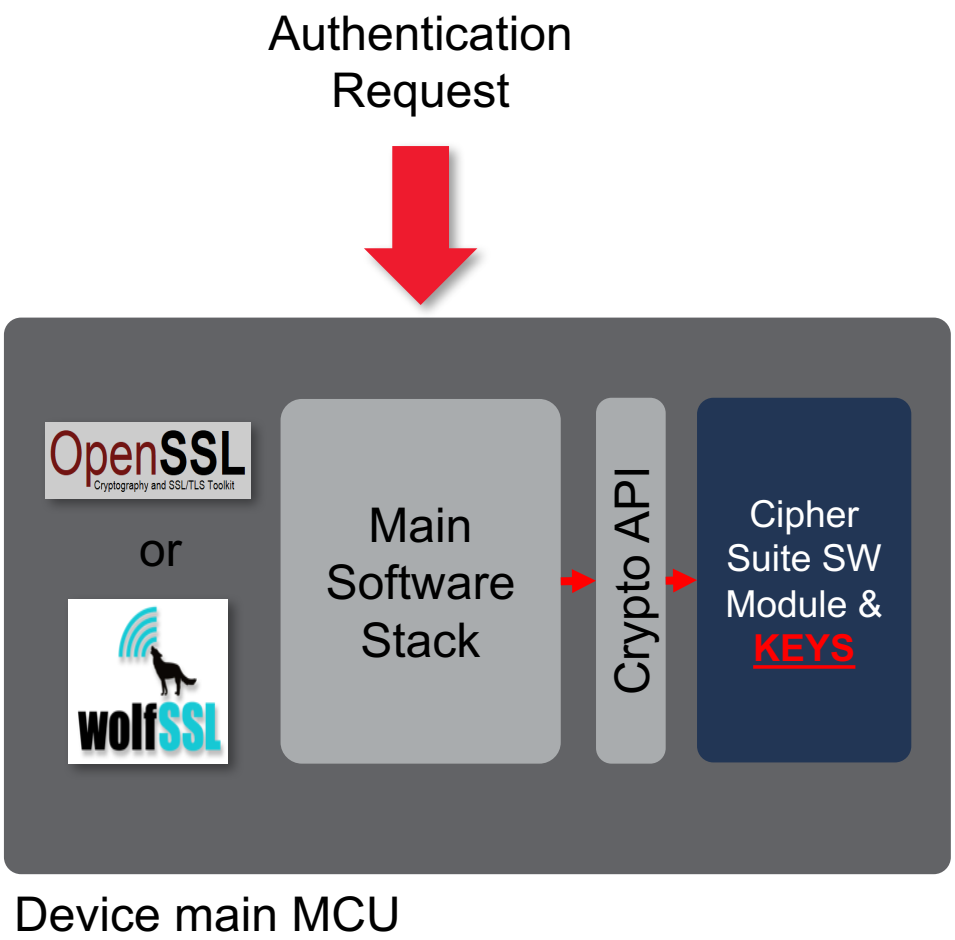


- ***Addresses large number of ECU architectures***
- ***Secure Boot at each node***

Security IC

Software-Only TLS

Authentication

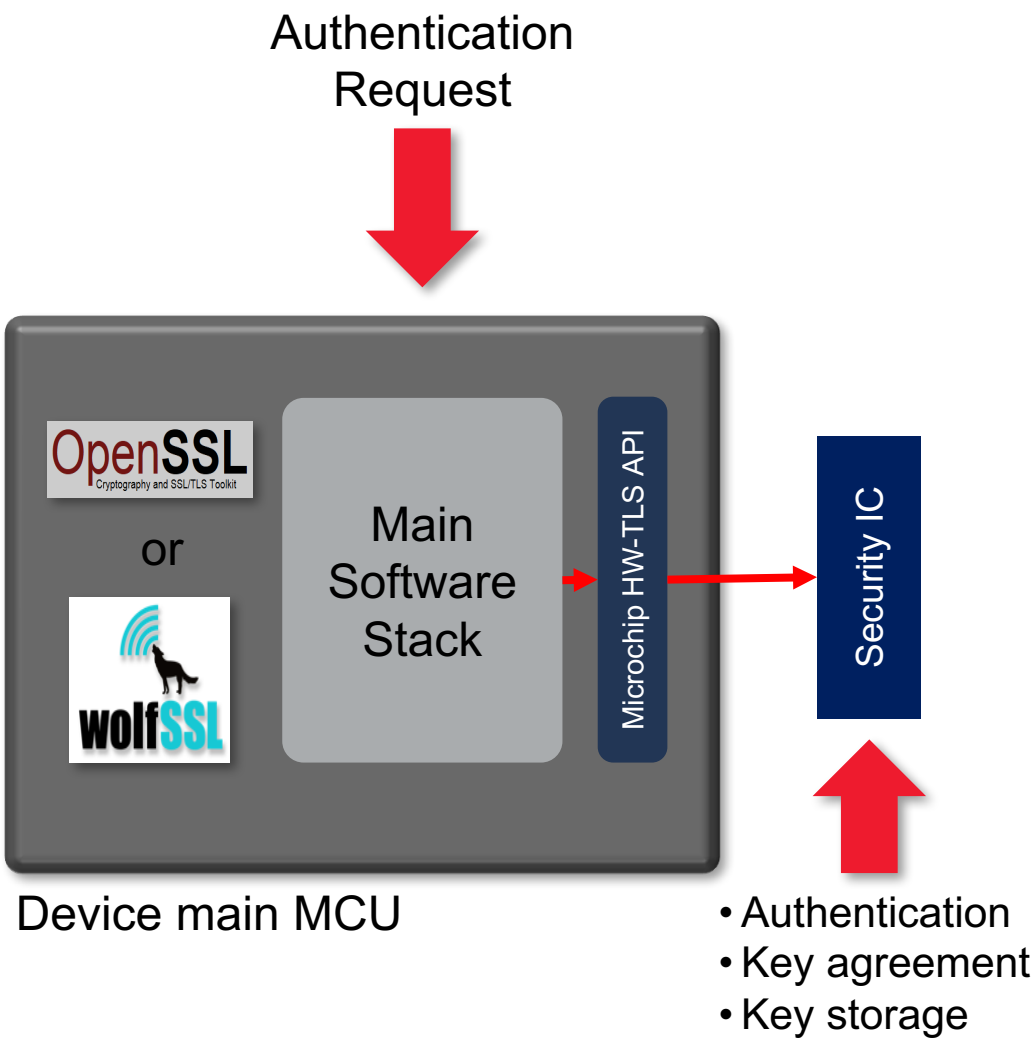


- **Performs cryptographic functions in software in the device MCU**
  - Requires more code space
  - Requires more processing load
  - ***Houses keys in software and unsecured memory***
- **Small nodes with low-end processors are too slow**

- ***Software-only TLS is vulnerable!***

TLS = Transport Layer Security

Hardware Secured TLS
Authentication

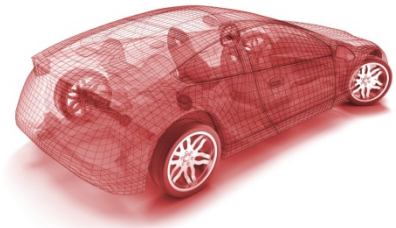


- **Hardware-TLS offloads cryptographic functions from the device MCU**
  - Access via HW-TLS API
  - Security IC handles all computation
  - Minimal code space & computational load
  - ***Keys are generated & protected in secure hardware***

- ***Keys are secure!***

Exploiting Automotive Ethernet Network Characteristics

- **Fixed star / hybrid network topology**
- **Typically maximum eight network ports on ECU**
- **Applications, traffic flows are known and pre-determined**
- **Network configuration is static (MAC, IP addresses)**
- **Broadcast, multicast and unicast traffic**
- **Limited use of protocols**
  - TCP/UDP, DoIP, PTP, SOME/IP ….

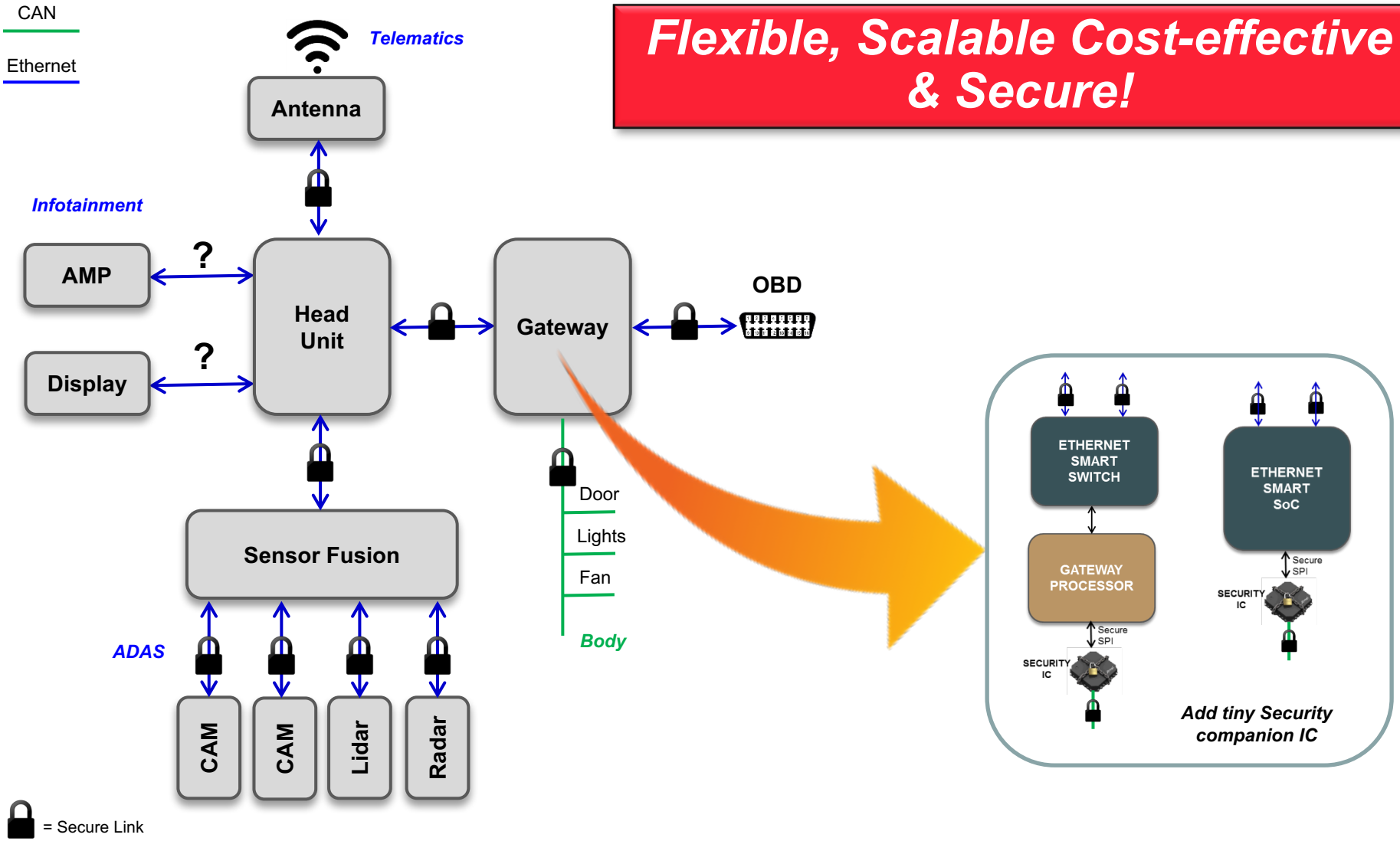


- ***Well-defined and bounded network***
- ***Exploit to deploy intrusion detection / protection***
- ***LEARN → MODEL → ANALYSE → ACT***

Ethernet Switch Security Requirements

- **Requires hardware features to support intrusion detection / protection**
- **Prevent typical attacks; spoofing, flooding, misuse / failures**
- **Dynamically update to adapt to changing network behavior**
  - 802.1Q VLAN
  - AVB (time synchronized)
  - 802.1Qci Ingress policing and filtering (per stream per port)
  - Extensive network statistics gathering (metadata)
  - TCAM-based layer 2,3,4 deep packet inspection
    - Forward, drop, mirror
    - Time stamp
    - Count
    - Modify packet
    - Rate limit
  - 802.1x Port and MAC authentication
  - Enhanced diagnostics (harness defect detection)
  - Seamless redundancy

Example Secure Ethernet IVN



Flexible, Scalable Cost-effective & Secure!

Come and visit us at Booth #2 ☺

- **Ethernet Gateway Security Demonstrator**
- **Ethernet AVB Streaming Demonstrator**

Thank You!