technica engineering
Member of KPIT Group

AUTOMOTIVE REQUIREMENTS FOR MKA

Dr. Lars Völker

AUTOMOTIVE REQUIREMENTS FOR MKA

TABLE OF CONTENT

#1 AUTOMOTIVE REQUIREMENTS IN GENERAL

WHY IS AUTOMOTIVE DIFFERENT?

INTRODUCTION

technica engineering
Member of KPIT Group

- Modern vehicles are becoming moving Ethernet networks.
  - Automotive PHYs: 100BASE-T1, 1000BASE-T1, 10G/5G/2.5GBASE-T1, 25GBASE-T1.
  - Also: 10BASE-T1S – supporting shared medium for low-cost use cases

- Automotive OEMs produce many Ethernet networks per minute.
  - Fully automated production processes (e.g., key and certificate install) needed.
- Lots of multicast communication.
  - That’s why many OEMs are introducing MACsec.
- Lots of safety critical and real-time communication.
- Vehicle startup performance is very critical!

WHY IS AUTOMOTIVE DIFFERENT?

VEHICLE STARTUP IS CRITICAL.

technica engineering
Member of KPIT Group

- How long should your car take to be ready to drive?
  - Typical target to achieve type approval: 1.5s – 2s (from touching car to driving off).
  - Critical features must work already (driving, breaking, steering, …)
  - Mandatory Backup Cameras (e.g., US) needs to work, which may use Ethernet.

- 1.5 – 2s sounds like a lot but you need to:
  - Detect car is being unlocked
  - Power-Up/Wake-up and boot Electronic Control Units (ECUs) – think small computers.
  - Start stacks, middleware, applications, etc.
  - Get Ethernet links up (that's why T1 PHYs link up in 20-120ms).
  - Switches need to start too.
  - Start Secure Communication (e.g., MACsec for all links).

WHY IS AUTOMOTIVE DIFFERENT?

EVEN WORSE: STARTUP HAPPENS OFTEN…

- For power saving (= fuel saving) reasons, ECUs may go to sleep
  - And wakeup again, when needed --> think another startup

- Undervoltage when cranking a combustion engine
  - Multiple ECUs are knocked out and restart after a very short time.
  - Very fast restart needed as you need to drive soon.
  - Restarting your car on train tracks as a train gets closer…

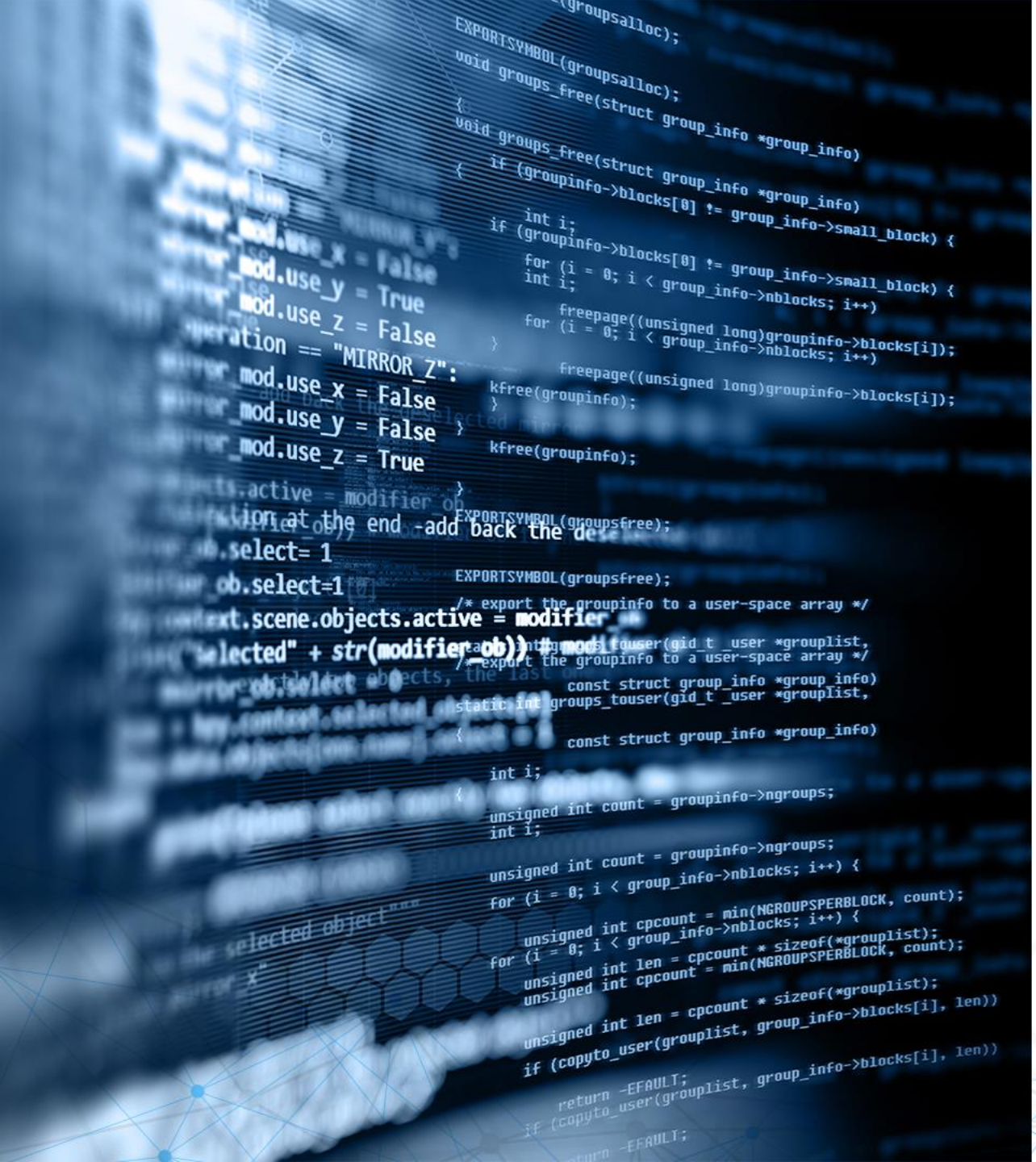
- Startup happens very often and is highly critical!

WHY IS AUTOMOTIVE DIFFERENT?

LIFETIME AND COST

technica engineering
Member of KPIT Group

- Automotive needs to design for a long lifetime
  - Parts need to be available e.g., 10 years after end of production.
  - Electronics need to last longer than in IT.
  - E.g., flash wears over time, so we cannot just write to flash all the time.
- Environmental
  - ECUs need to work in for example -40°C to +125°C (-40 F to 257 F)
    - Higher temperatures zone exist.
- Cost is also very critical as so many ECUs are needed.



#2 AUTOMOTIVE REQUIREMENTS

MKA SPECIFIC

WHAT DOES THIS MEAN FOR MKA?

STARTUP PERFORMANCE OF “AUTOMOTIVE MKA”

technica engineering
Member of KPIT Group

- A typical Automotive Industry target for starting MACsec with MKA: <30ms.
  - MKA does not achieve this by default (8s or less guaranteed).

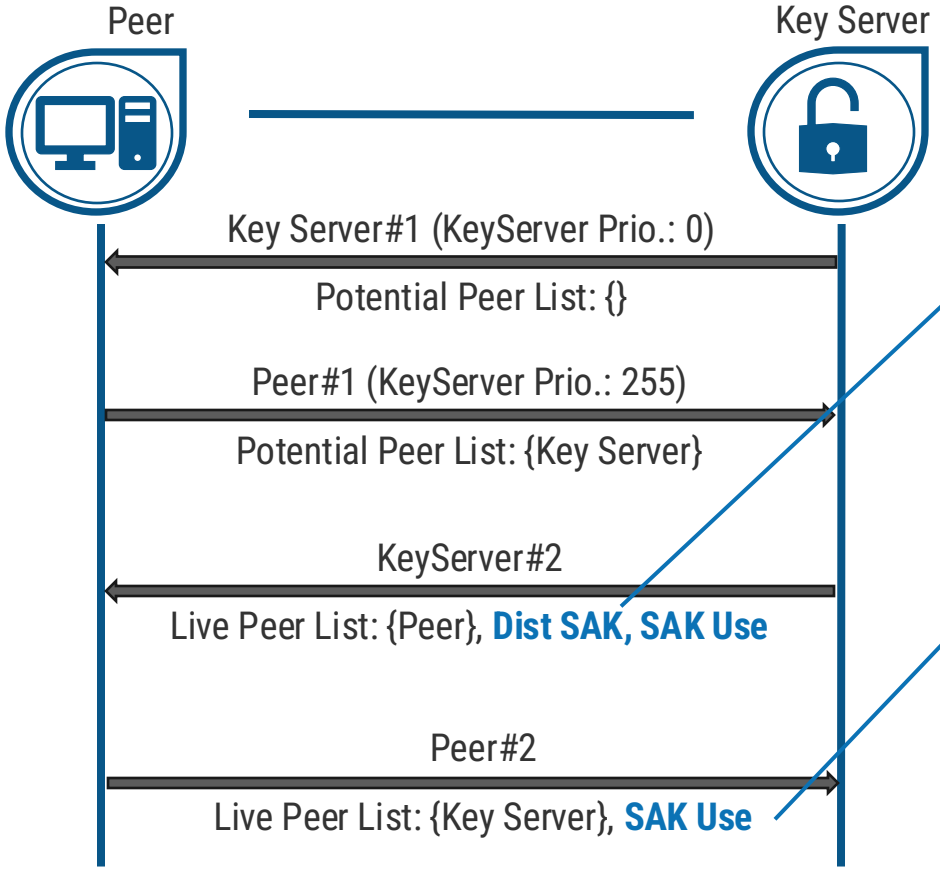
- As MKA makes sense for Automotive MACsec too:
  - Hard-coding Key Server priority and optimizing timings.
  - This allows for less than 10ms startup while being compatible to MKA (*).
  - However, this only works for Switch Ethernet (2 stations).

- Along came 10BASE-T1S Shared Medium
  - And startup timing for e.g., 7 stations is a problem again.

(*) measured as link-up to last SAK Use (RX=1, TX=1). Both implementations need to be optimized to achieve fast startup.

WHAT DOES THIS MEAN FOR MKA?

RECAP: MKA EXAMPLE WITH ONLY 2 STATIONS




```
Distributed SAK parameter set
   Parameter set type: Distributed SAK (4)
   01.. .... = Distributed AN: 1
   ..00 .... = Confidentiality Offset: No confidentiality (0)
   .... 0000 0010 0100 = Parameter set body length: 36
   Key Number: 00000001
   MACsec Cipher Suite: GCM-AES-XPN-128 (0x0080c20001000003)
   AES Key Wrap of SAK: f0636a29710eaf847cea17a960e60c98cbe78b043ca44b61
```

```
MACsec SAK Use parameter set
   Parameter set type: MACsec SAK Use (3)
   00.. .... = Latest Key AN: 0
   ..0. .... = Latest Key tx: False
   ...0 .... = Latest Key rx: False
   .... 01.. = Old Key AN: 1
   .... ..1. = Old Key tx: True
   .... ...1 = Old Key rx: True
   0... .... = Plain tx: False
   .0.. .... = Plain rx: False
   ...0 .... = Delay protect: False
   .... 0000 0010 1000 = Parameter set body length: 40
   Latest Key: Key Server Member Identifier: 00000000000000000000000000
   Latest Key: Key Number: 00000000
   Latest Key: Lowest Acceptable PN: 00000001
   Old Key: Key Server Member Identifier: cccb1f0eee52ba6468a7df3e
   Old Key: Key Number: 00000001
   Old Key: Lowest Acceptable PN: 00000001
```

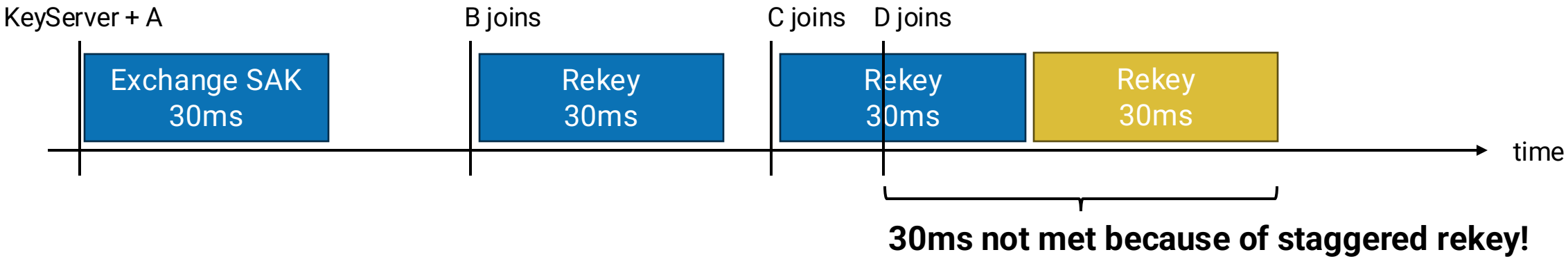
Allows also to rekey without break communication.

WHAT DOES THIS MEAN FOR MKA?

RECAP: MKA RULES FOR STATIONS JOINING

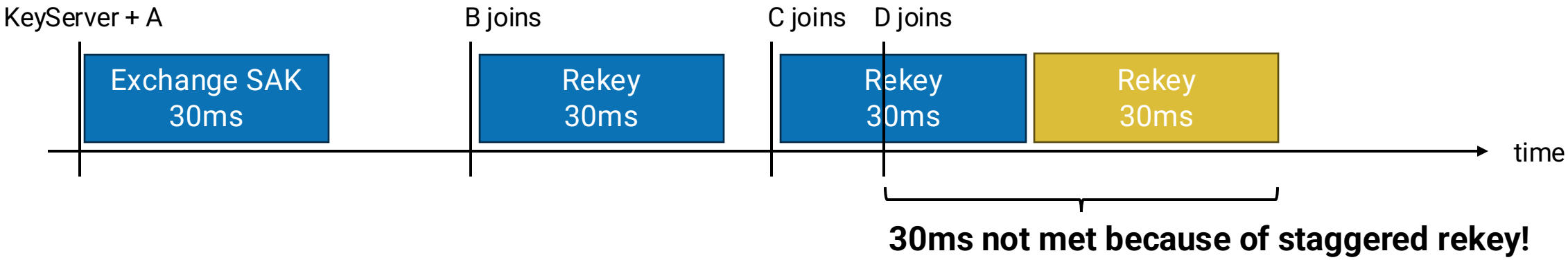
- MKA needs to avoid reuse of key + salt + PN/XPN for security reasons.
- Also, reused PN/XPN might be detected as replay and not accept.
- MKA (see 802.1X-2020, 9.8):
  - Distribute new SAK on member joining.
  - Optional on member being removed.

- What can go wrong, if we can rekey in 30ms?



WHAT DOES THIS MEAN FOR MKA?

RECAP: MKA RULES FOR STATIONS JOINING (2)



- You could break the rekey in progress, but this might drop connectivity or make C's join late!
- Plus: ECUs are faster on startup but when MACsec is running, they have higher application load and MKA performance is reduced. Minimizing their work would help.
- Can we avoid Rekeying everyone, when someone joins?

#3 AUTOMOTIVE VS. MKA

APPROACHES

APPROACHES INVESTIGATED.

APPROACH 1: “DO NOT REKEY ON JOIN”.

- On join: Key Server just redistributes SAK with same KN.
- On leave: Rekey.

- Does not work for XPN due to SSCI change. With 10Mbit/s acceptable!?
- How to ensure leave is detected before 6s timeout???
- With undervoltage situation, multiple stations fall out and come back.
  - It is right now not reliable to know, if a station used a SAK before going out.
  - You could have just lost a SAK Use.
  - We need to rekey on every station rejoining as we do not know what they used last.
  - This can lead to a staggered restart, which is the same as Rekey on Join.

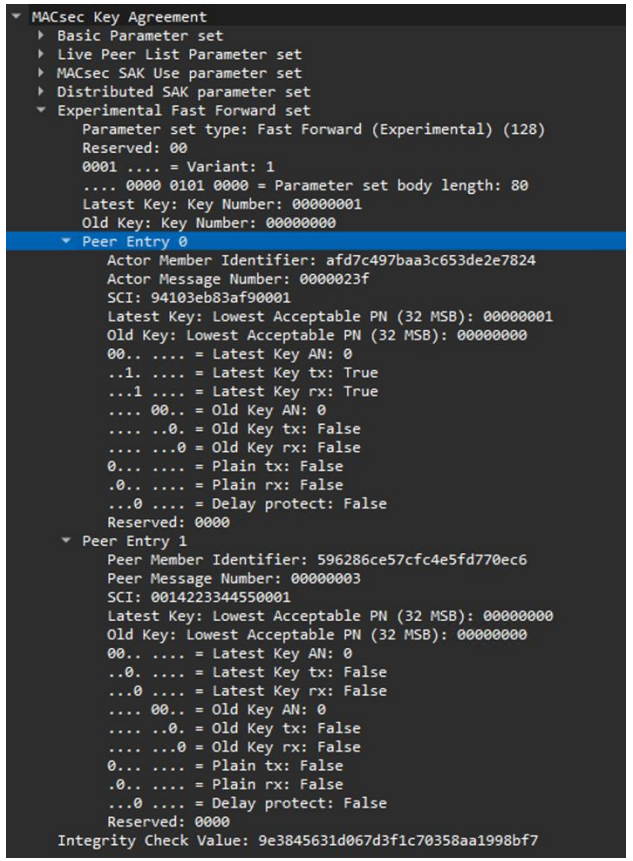
- Overall: Degrades into the “Rekey on Join” worst case and does not help.

APPROACHES INVESTIGATED.

APPROACH 2: “KEY SERVER HOLDS STATE AND FAST FORWARDS”.

- Key Server collects and holds state of all stations (SAK Use).
- If a station comes back, Key Server sends state (like SAK Use content) out with key.
  - Key Server adds a margin to PN/XPN.
- This pushes stations XPN/PN forward
- Returning station needs to check all SAK Use of other ECUs to set up RX PN/XPNs.

- **Con: Incompatible MKA change.**



Example for illustration only

APPROACHES INVESTIGATED.

APPROACH 3: “SSCI BUMPING”

- Idea: Make SSCI changes on join/leave compatible.
  - Key Server adds new station to the peer list without changing other SSCIs.
  - Key Server does not free SSCIs, when station is removed, but marks them invalid.
  - When station rejoins, Key Server gives out new SSCI.

- Con: XPN only solution means higher cost. Better than no solution.

- Con: Not quite compatible to MKA:
  - SSCI list not ordered anymore. Is this a problem?
  - To be defined in MKA: How to mark SSCIs as invalid, so that they are ignored (KAY).

APPROACHES INVESTIGATED.

SUMMARY.

- Many approaches investigated (only showed 3 examples).
- No working solution that is fully MKA compatible was identified.
- Open questions:
  - How can we solve this?
  - Do we need to update MKA?

#4 AUTOMOTIVE VS. MKA

CONTACT

Technica Engineering GmbH
Leopoldstraße 236
80807 Munich
Germany

DR. LARS VÖLKER
Technical Fellow
lars.voelker@technica-engineering.de
+49 175 11 40 982