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European XFEL

Securing Light Source SCADA Systems

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European XFEL GmbH

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Overview

- The security of SCADA systems is an increasing concern as they interconnect a significant number of COTS computers via IP networks; support *de facto* standards like USB.
- What happens once attackers have been granted access to / broke into the Control Network?
  - Can they do everything?
  - Can they easily escalate their privileges?
- “We trust whoever has access to the Control Network”
  - Would you let your personal laptop unlocked 24/7 in a control room? If no, why should the control system be less protected than your laptop?
- We suggest to secure the SCADA system beyond the general IT infrastructure security
  - Device servers would authenticate and authorize users for every issued message.

The European X-ray Free Electron Laser

- The most brilliant X-ray light source: $5x10^{33}$ photons s^{-1} $mm^{-2}mrad^{-2}$ per 0.1% bandwidth
- 4.5 MHz pulse rate in burst mode, maximum electron energy of 17.5 GeV, 0.05 nm minimum wavelength
- 1.4 billion euro facility
- Unique pieces of technology: Adaptive Gain Integrating Pixel Detector, Large Pixel Detector, DEPSET Sensor with Signal Compression
- 15 TB of data per beam day

LPD detector in the FXE instrument hutch

The security **onion**

```
# Dictionary attack on weak passwords
# Trojan horses, viruses via e-mails, USB
  sticks or software downloads
# Keyloggers ...
```

Any random compromised account often suffices.

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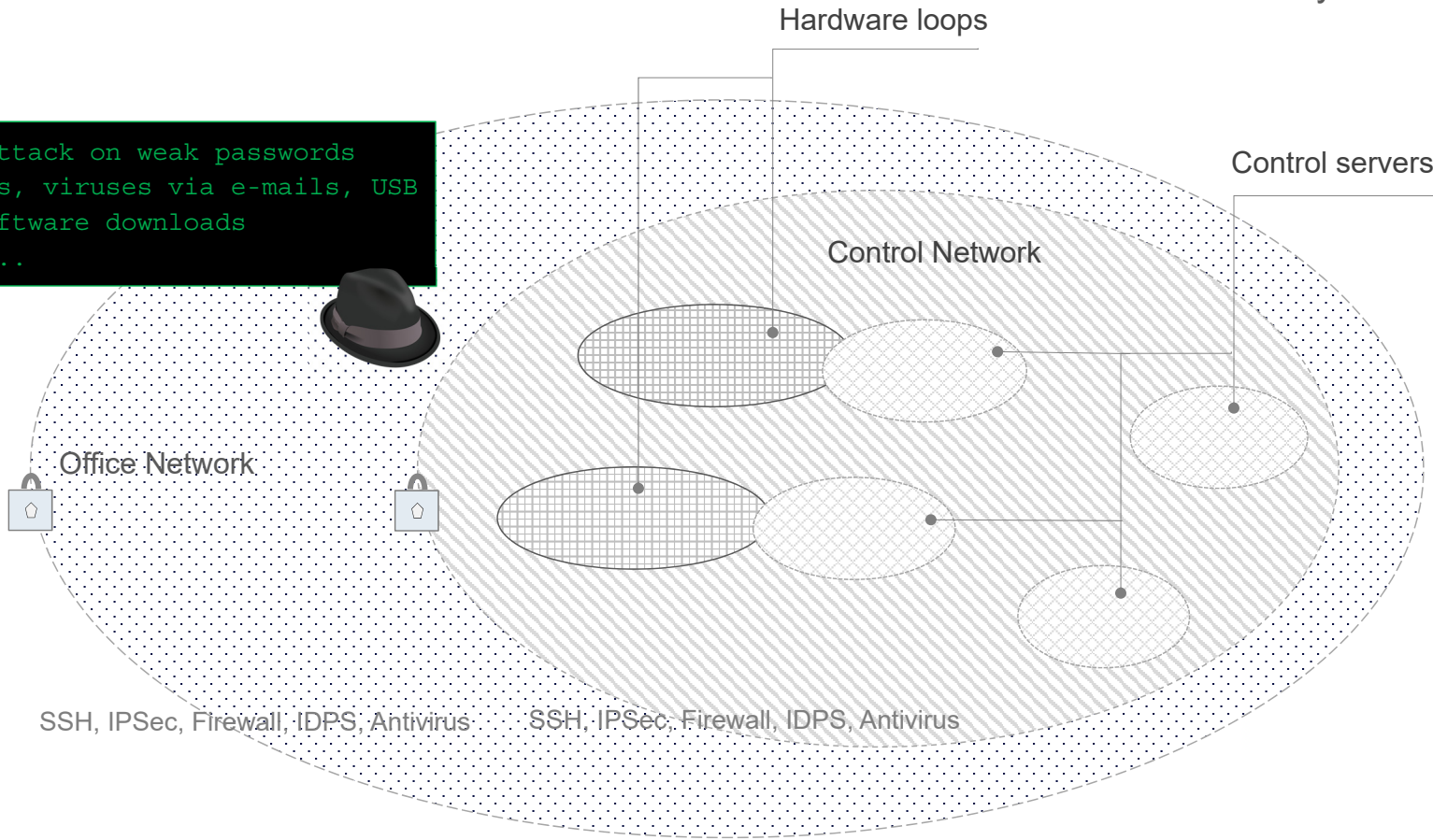

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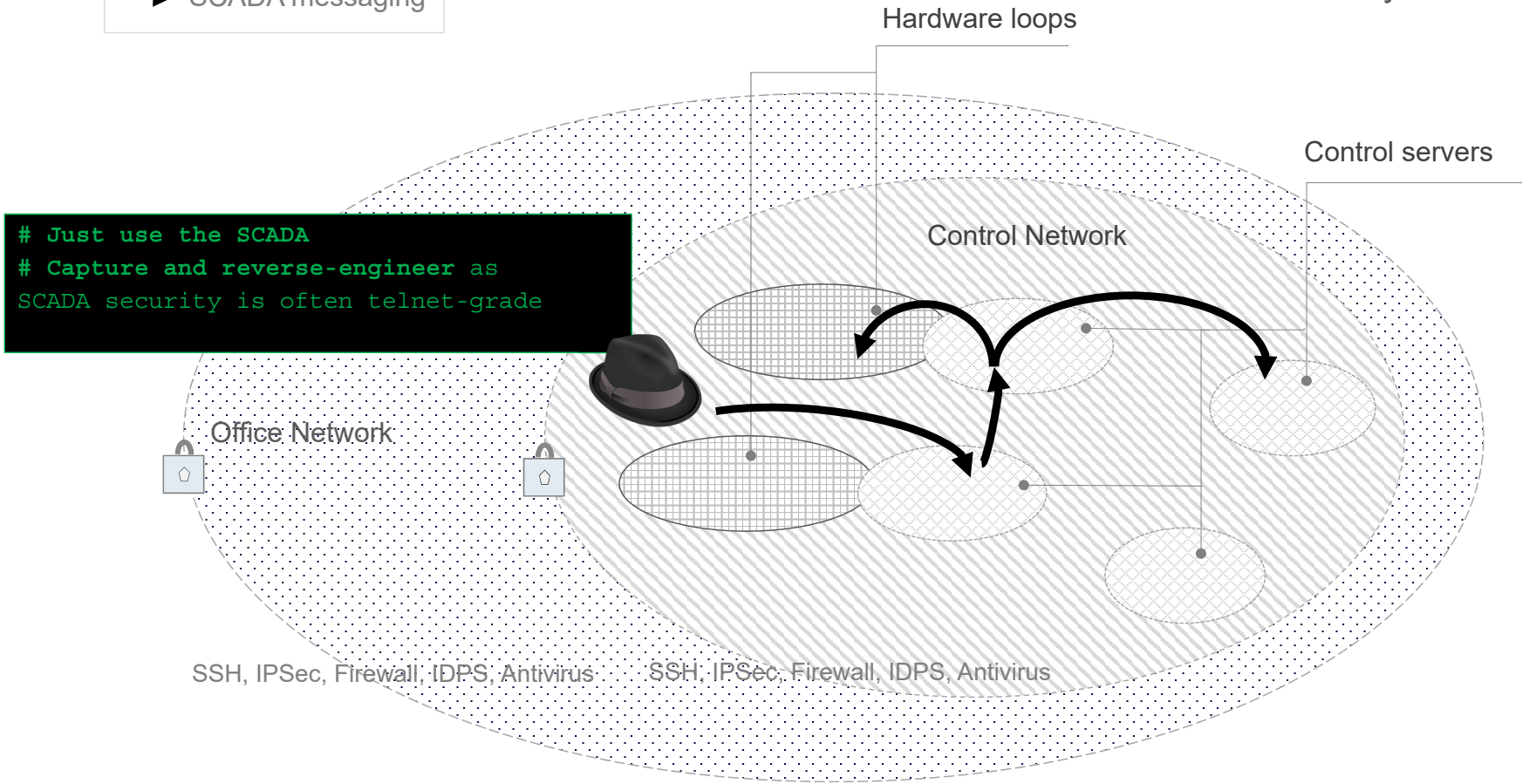
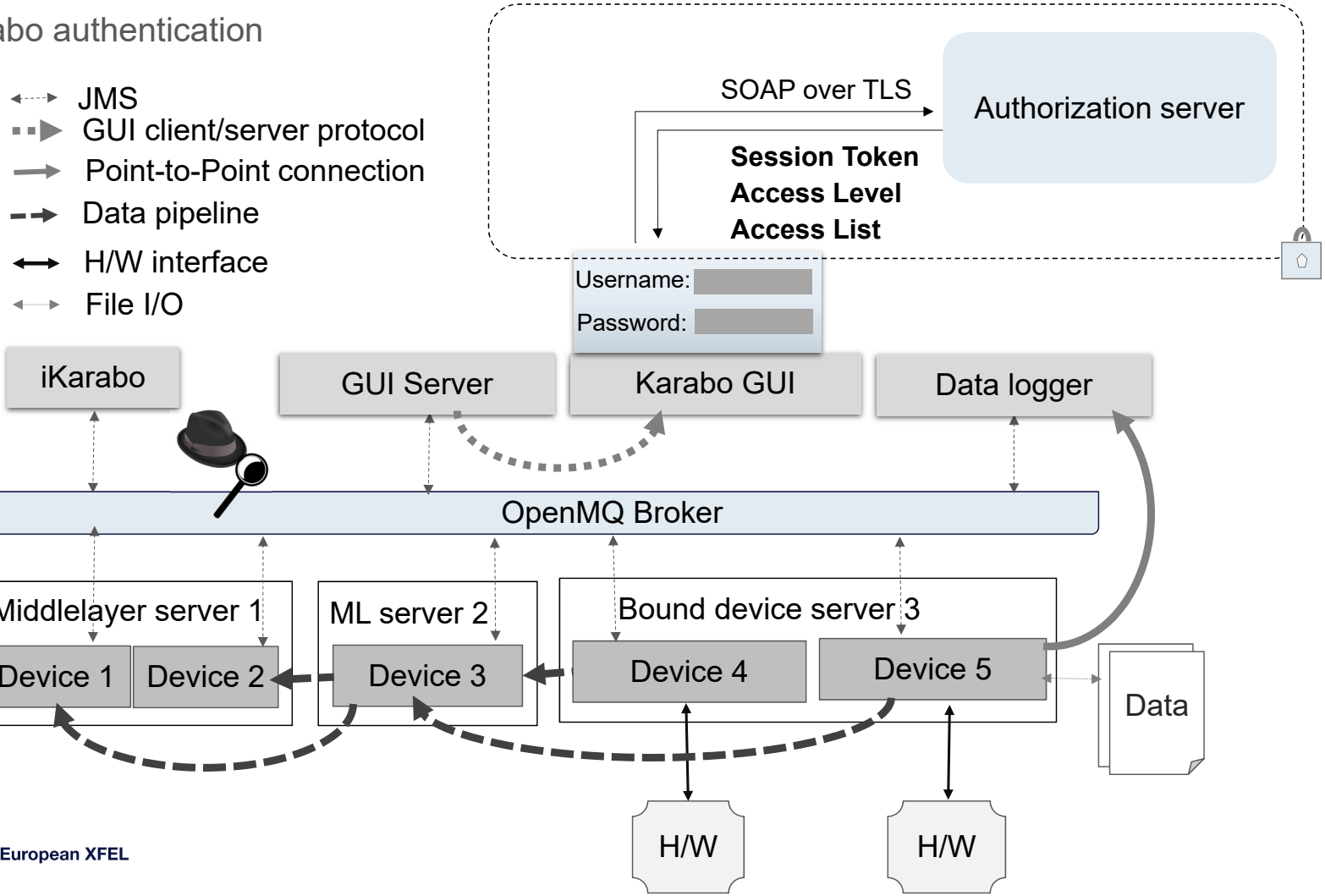
The security **onion**

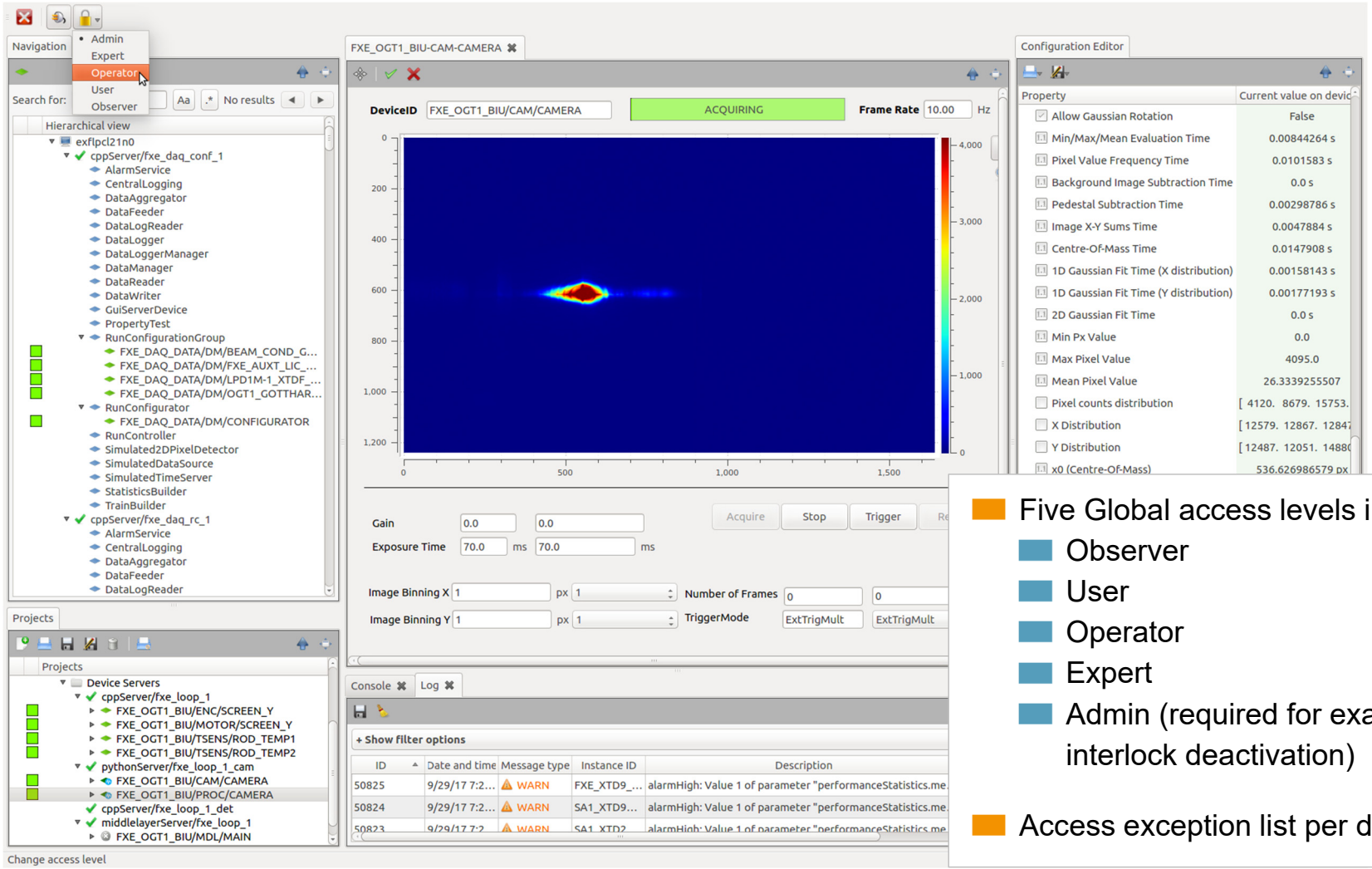
SCADA messaging



Example: **Stuxnet**(2010) attacking PLCs.

Basic Karabo authentication





- Five Global access levels in Karabo:
  - Observer
  - User
  - Operator
  - Expert
  - Admin (required for example for interlock deactivation)
- Access exception list per device.

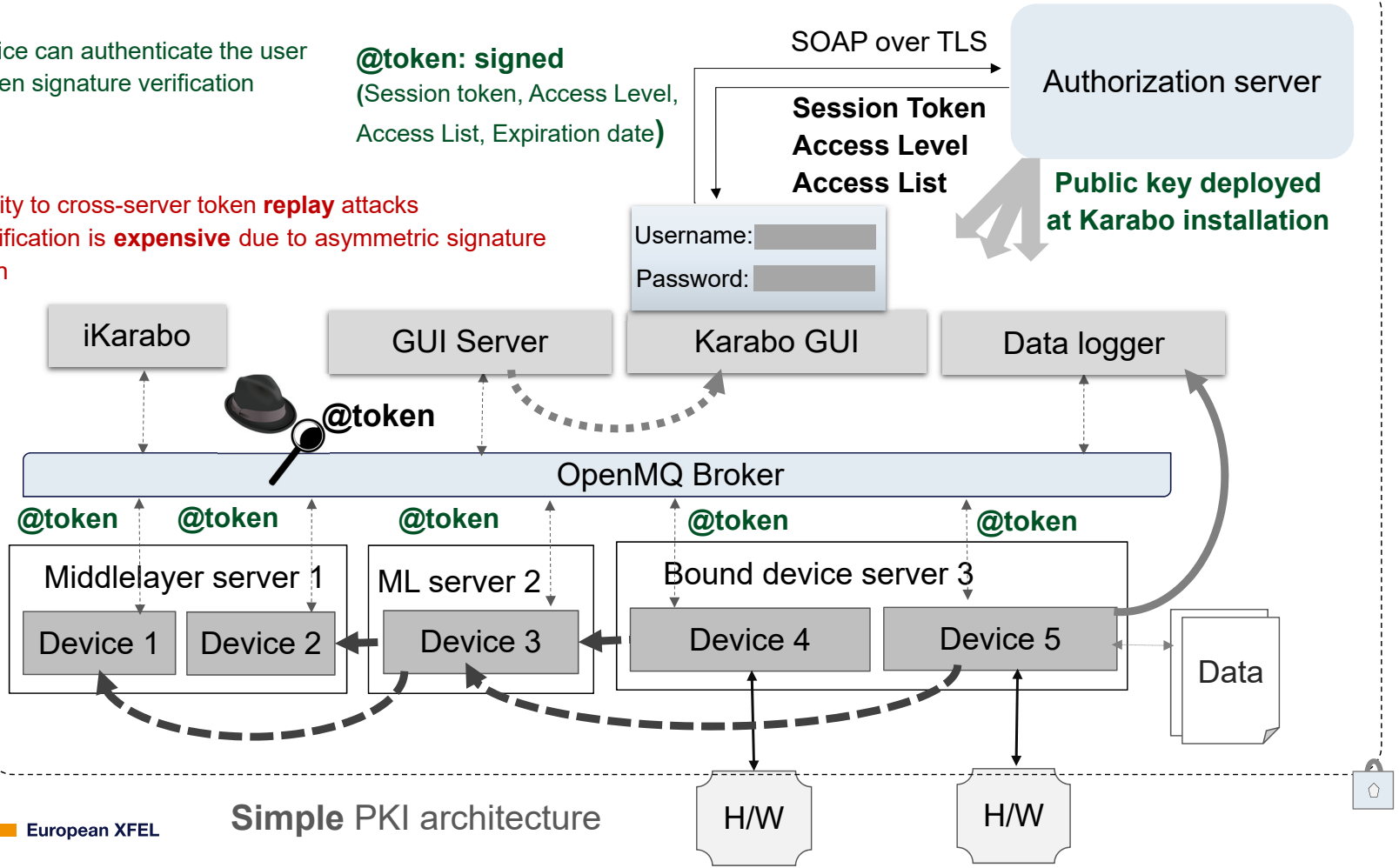
Benefits

- Every device can authenticate the user
- Offline token signature verification

Drawbacks

- Vulnerability to cross-server token **replay** attacks
- Token verification is **expensive** due to asymmetric signature verification

@token: signed
(Session token, Access Level, Access List, Expiration date)



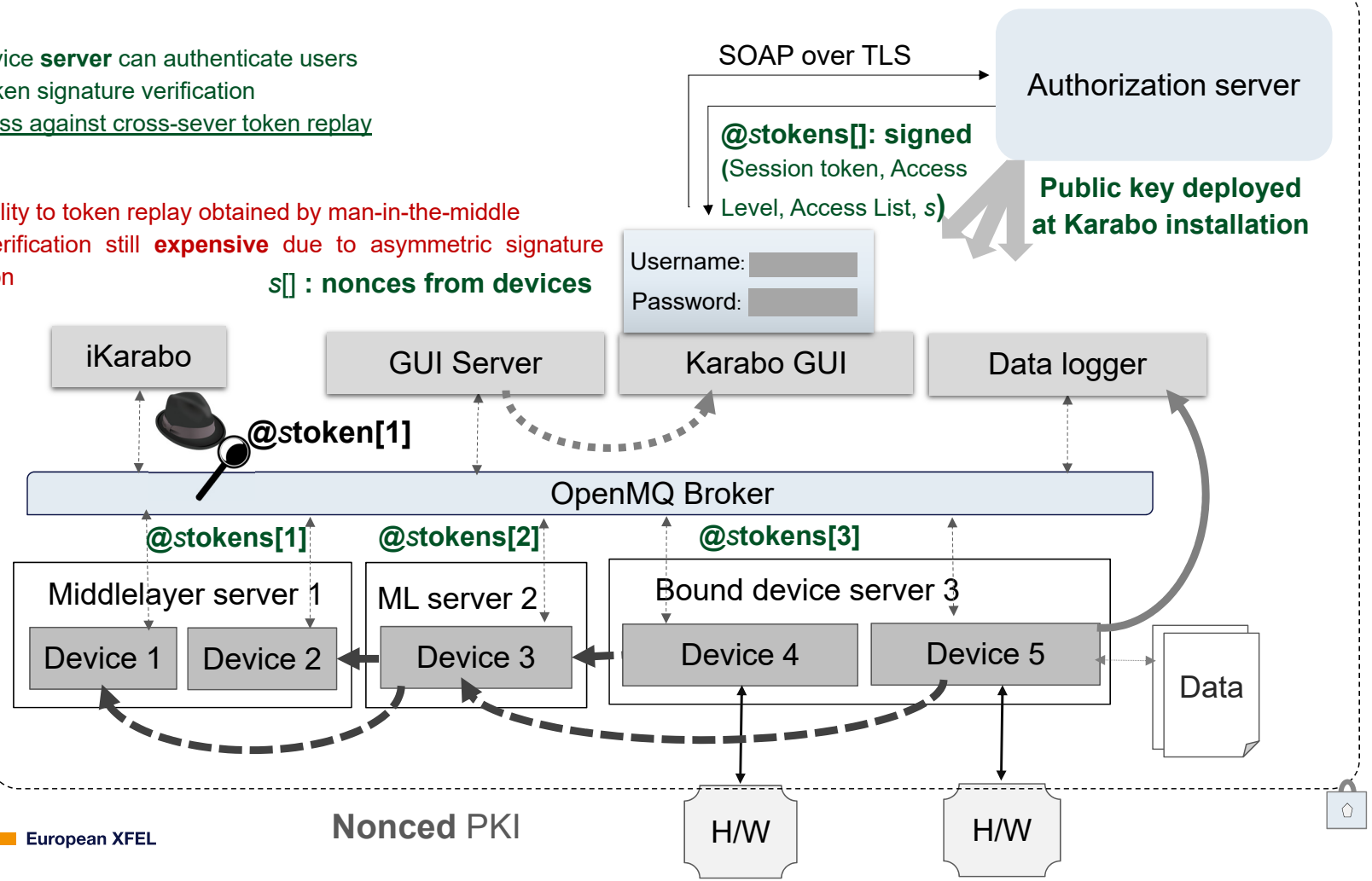
Simple PKI architecture

Benefits

- Every device **server** can authenticate users
- Offline token signature verification
- Robustness against cross-sever token replay

Drawbacks

- Vulnerability to token replay obtained by man-in-the-middle
- Token verification still **expensive** due to asymmetric signature verification



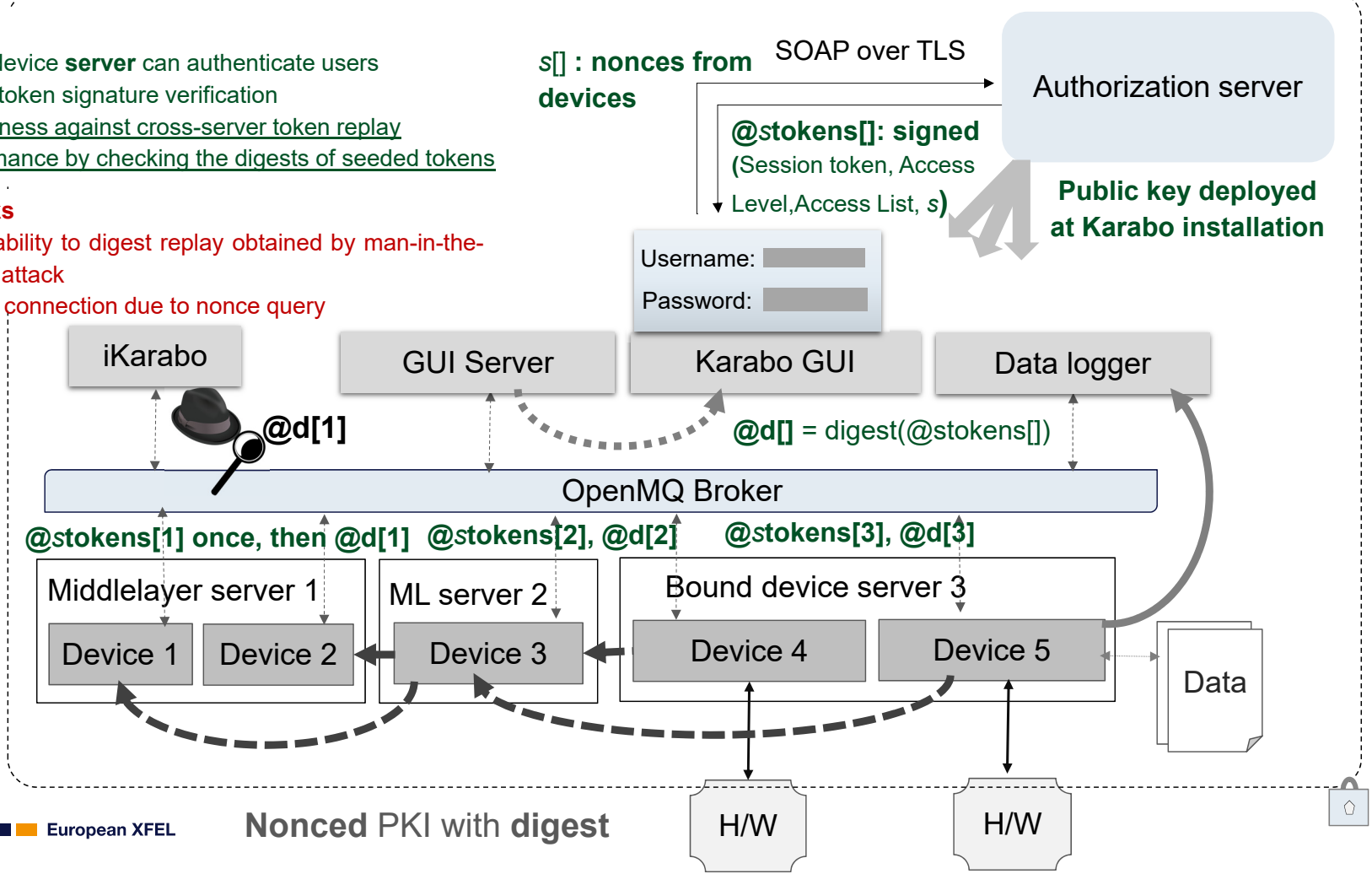
Nonced PKI

Benefits

- Every device **server** can authenticate users
- Offline token signature verification
- Robustness against cross-server token replay
- Performance by checking the digests of seeded tokens

Drawbacks

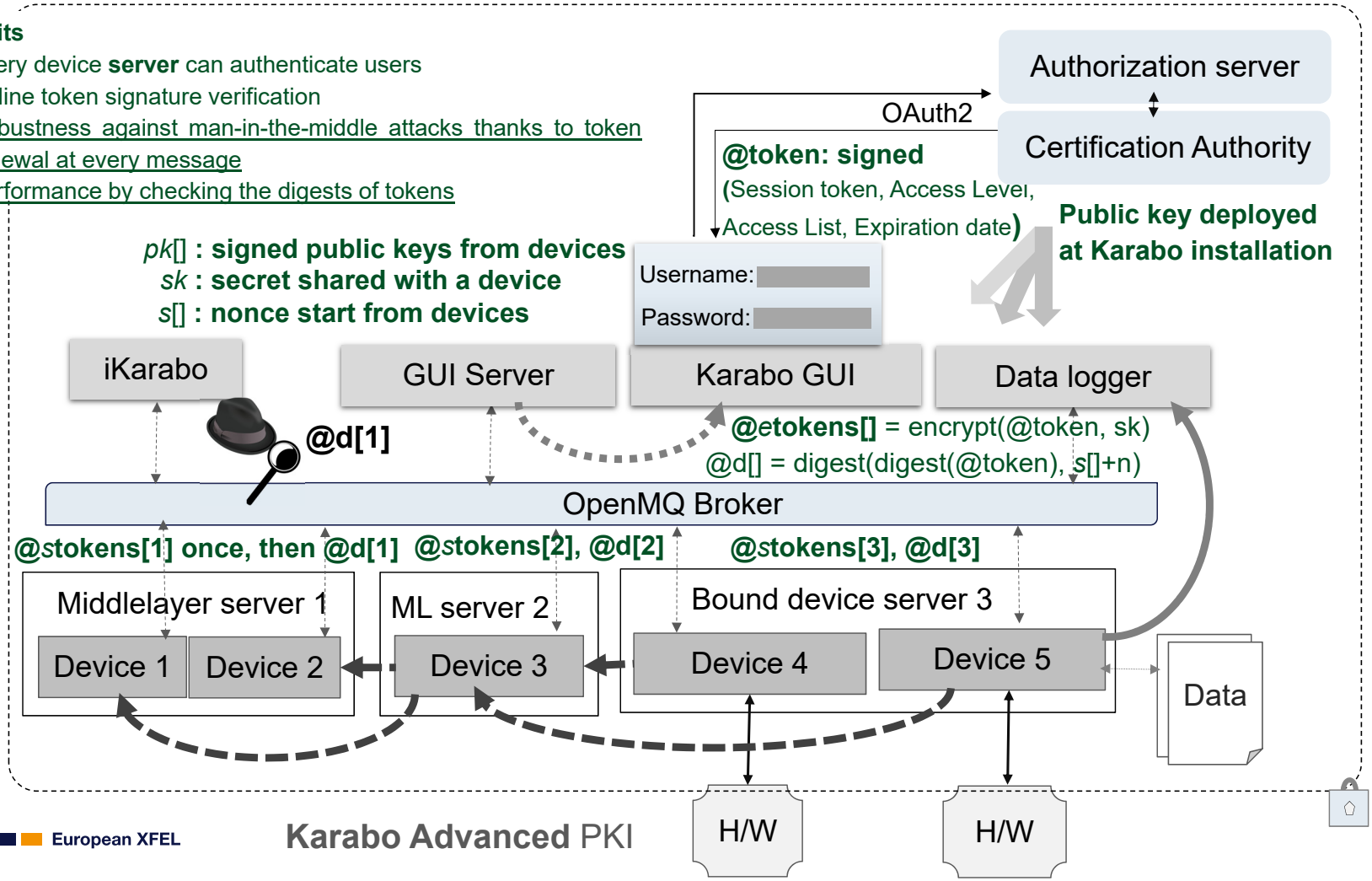
- Vulnerability to digest replay obtained by man-in-the-middle attack
- Slower connection due to nonce query



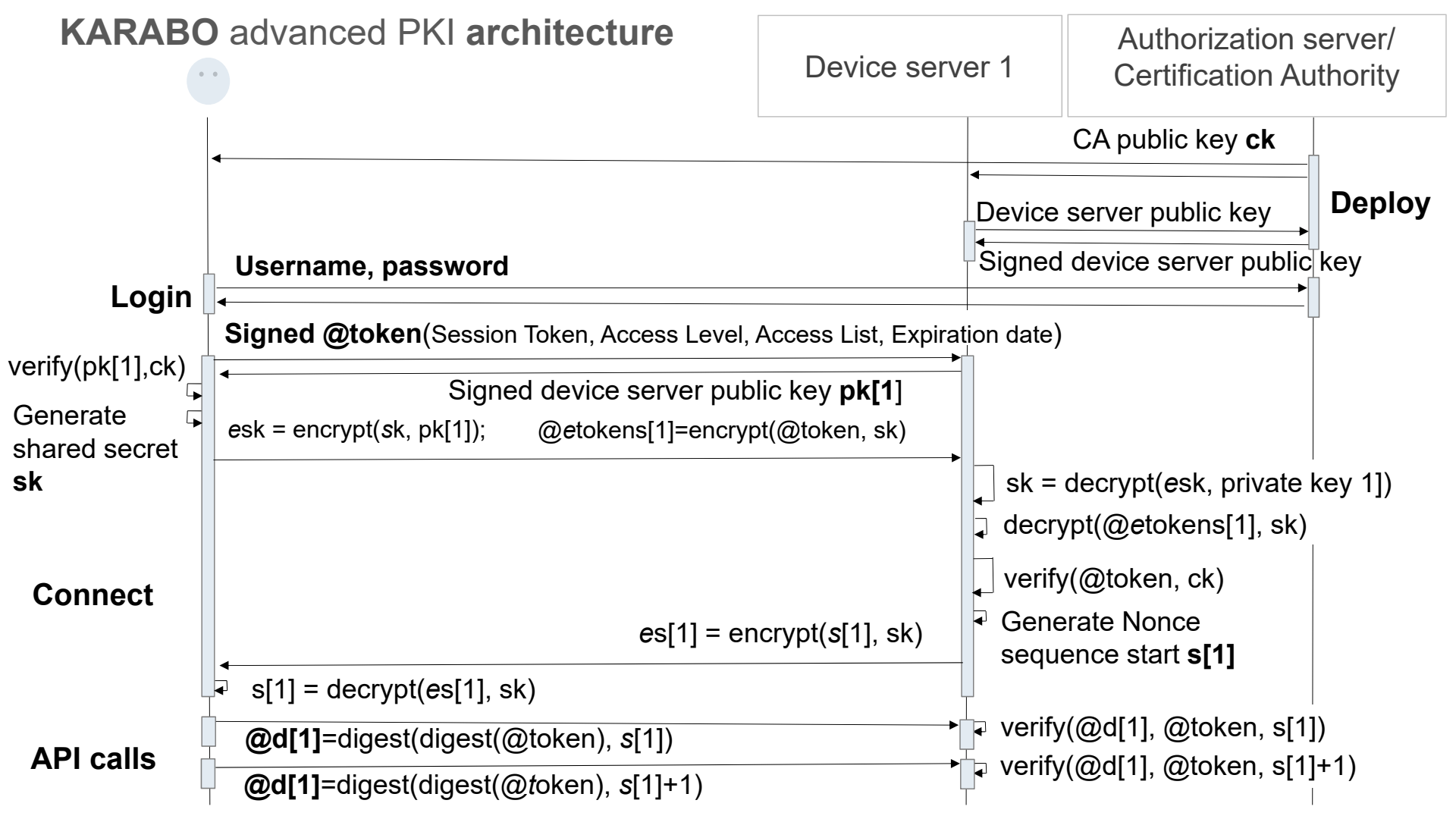
Nonced PKI with **digest**

Benefits

- Every device **server** can authenticate users
- Offline token signature verification
- Robustness against man-in-the-middle attacks thanks to token renewal at every message
- Performance by checking the digests of tokens



KARABO advanced PKI **architecture**



Conclusion

- We aim to protect the SCADA system **beyond general IT security**
- This prevents attackers from issuing valid SCADA messages or **escalading** their privileges
- Our Public-Key Infrastructure proposal for Karabo:
  - User shall access Karabo using a **token signed** by a Certification Authority
  - Device servers have their **public keys signed** by this same Certification Authority
  - Users communicate their session token only to certified device servers, encrypted with the device server public key.
  - The session token is only known to the CA, the user and the certified device servers
  - The nonce start is only known to the user and to a device server, encrypted by a **shared secret**
  - A **nonced digest** of the session token is sent within every API call, preserving performance.