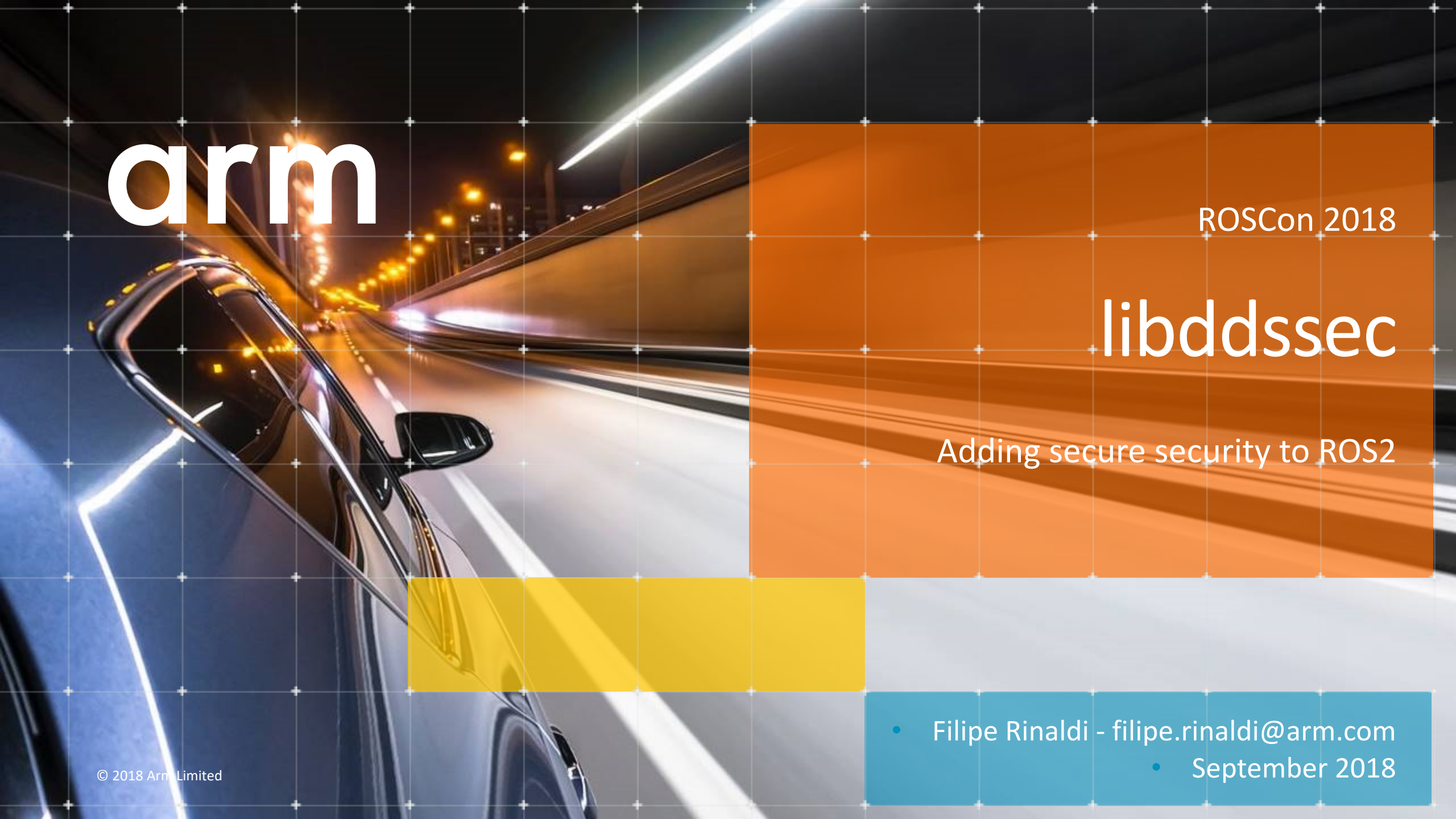

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ROSCon 2018

libddssec

Adding secure security to ROS2

- Filipe Rinaldi - filipe.rinaldi@arm.com

- September 2018

Introduction

About us:

Members of the Arm Open Source Software group. Part of a new team (a revamp of the Robotics team) with focus on the automotive area:

- Filipe Rinaldi (myself)
- Florian Depraz (present at ROSCon)
- Louis Mayencourt (present at ROSCon)
- Kurtis Charnock

Todays presentation:

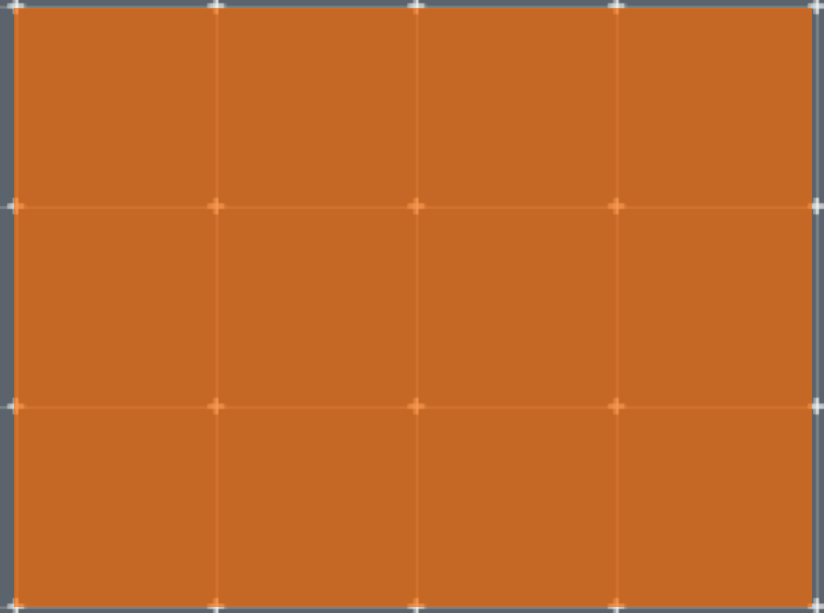
Overview of a new project called **libddssec:** A library that implements the security portion of a DDS implementation using Arm TrustZone (Cortex-A profile) [1].

Agenda:

- Key concepts
  - DDS Nodes
  - DDS Security
  - Arm TrustZone
- The libddssec project
  - Overview
  - The current work
  - Main challenges
  - Future work
- Why securing DDS/ROS2?
- References

Key Concepts

DDS



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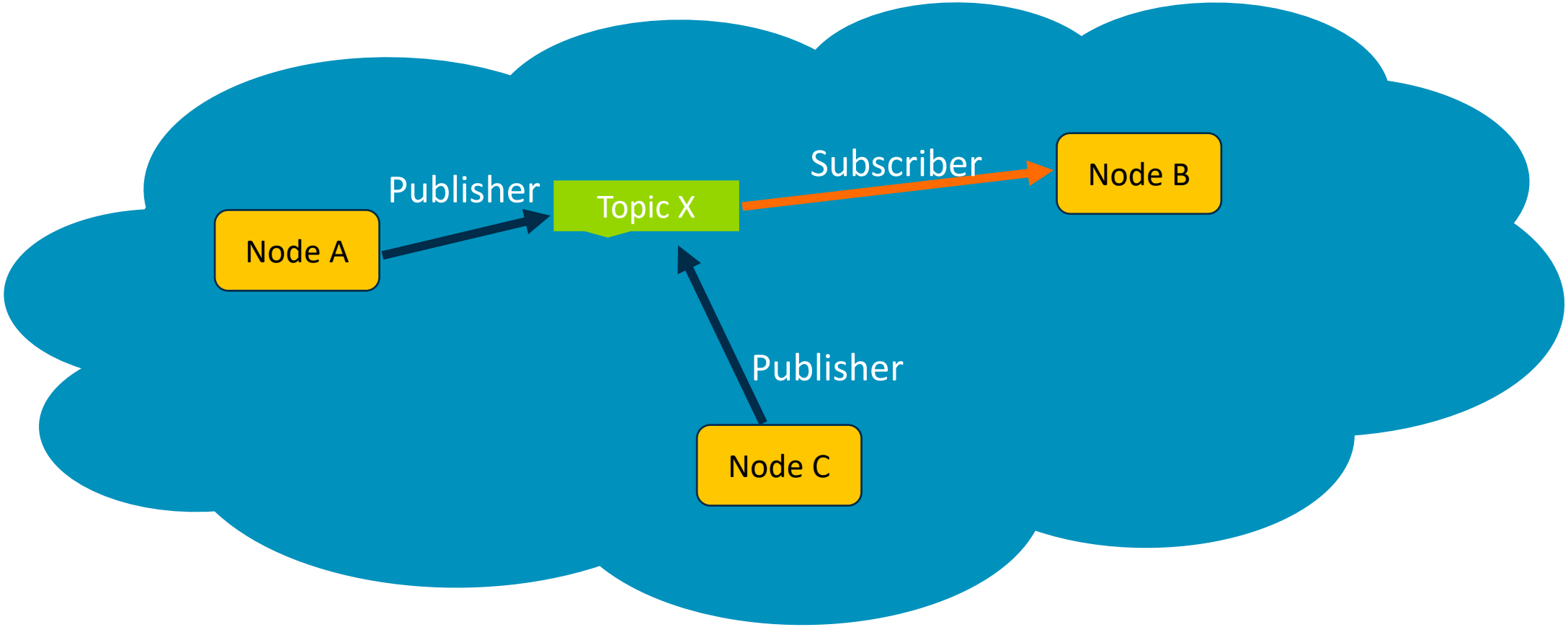
DDS: Nodes



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DDS: Specs (cont.)

There is a collection of specifications [2] around the DDS split into different groups: Core, Extensions, Gateways and API).

This presentation focus on:

- DDSI-RTPS protocol v2.2 [core]: low-level interoperability wire protocol
- DDS v1.4 [core]: Data centric Push/Sub model
- DDS-Security v1.1 [extension]: Security model and plugin interface

DDS: Security Model

The DDS security model defines the **users of the system**, the **objects** that are being secured and the **operations** that are to be restricted.

- Securing DDS means providing:
  - **Confidentiality** of the data samples
  - **Integrity** of the data samples and the messages that contain them
  - **Authentication** of DDS writers and readers
  - **Authorization** of DDS writers and readers
  - **Message/Data origin** authentication
  - **Non-repudiation** of data

DDS: Security - Threat Model

Specification details four categories of threats:

- Unauthorized subscription
- Unauthorized publication
- Tampering and replay
- Unauthorized access to data

DDS Security: Implementation

The DDS Security specification defines **plugins** to implement

- Authentication
  - Certificate management
- Cryptography
  - Crypto operations
- Access control
  - Policy enforcement

DDS Security: Implementation (cont.)

- Asymmetric key cryptography used mainly for discovery, authentication and shared-secret establishment phase.
- The use of cyphers, HMAC, or digital signatures is selectable on a per stream (Topic) basis.

Key Concepts

What is Arm TrustZone?

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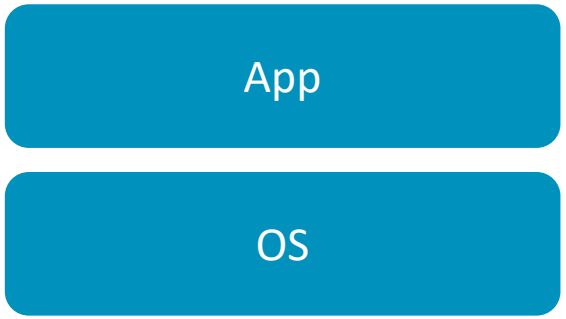
What is Arm TrustZone?

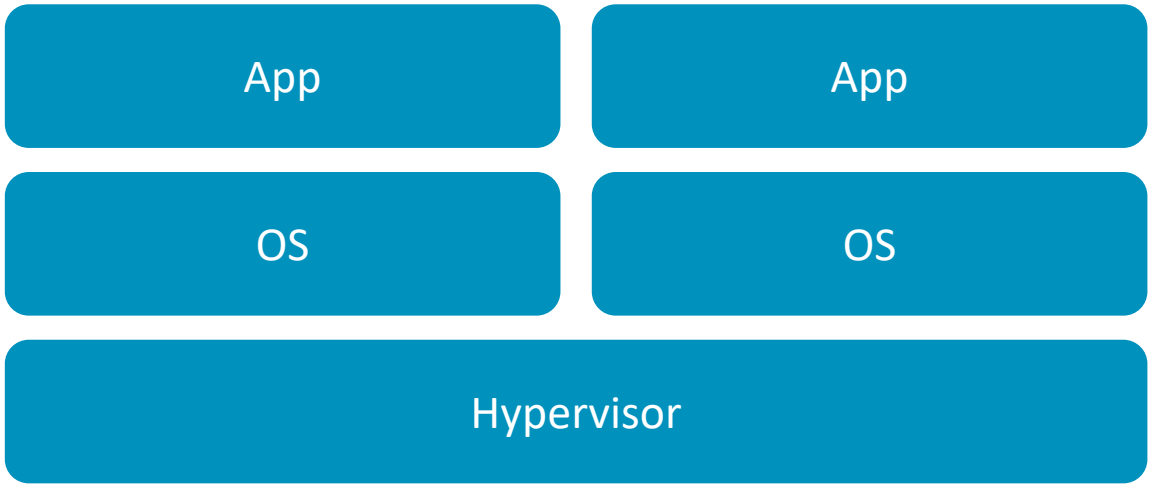
- Provides a second virtual world allowing a different software stack to co-exist
- Physical address space is partitioned between these two worlds
- Orthogonal to the Exception/Privilege Levels

What is TrustZone? (cont.)

- It is all about who you **trust**



What is TrustZone? (cont.)



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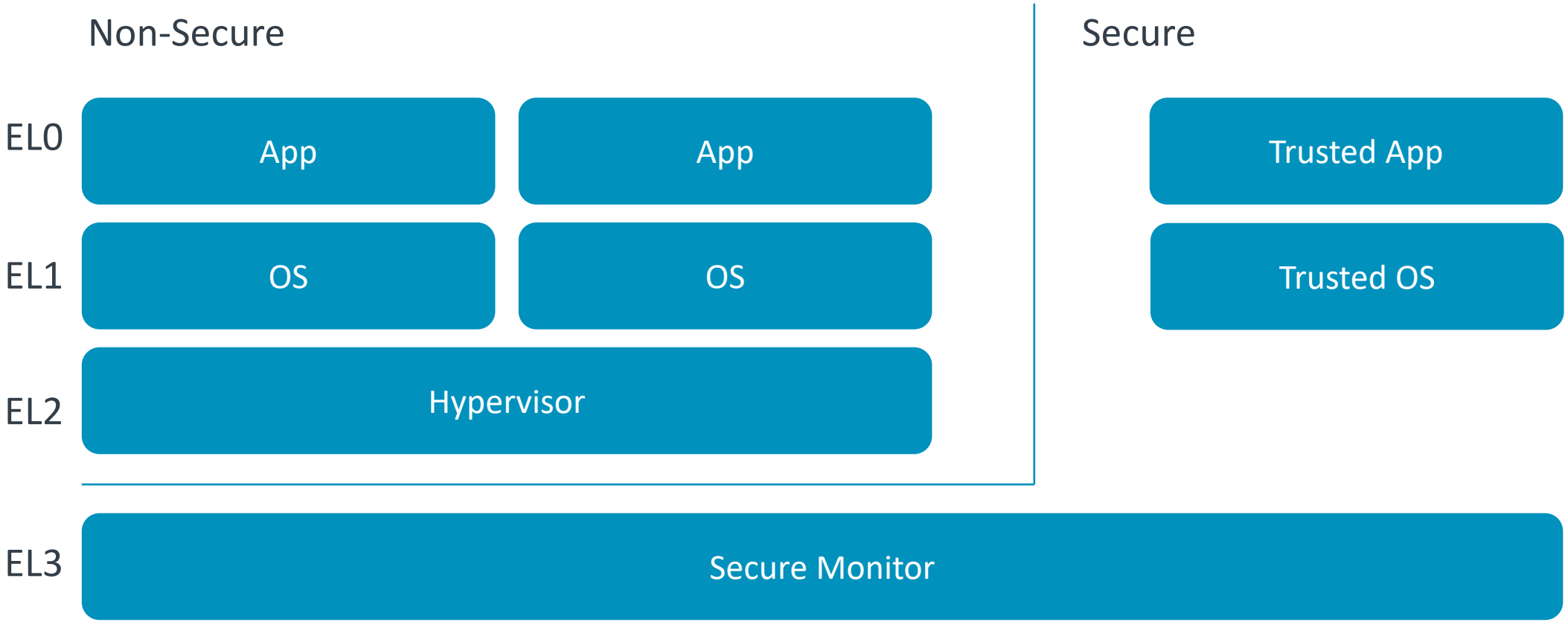
What is TrustZone? (cont.)



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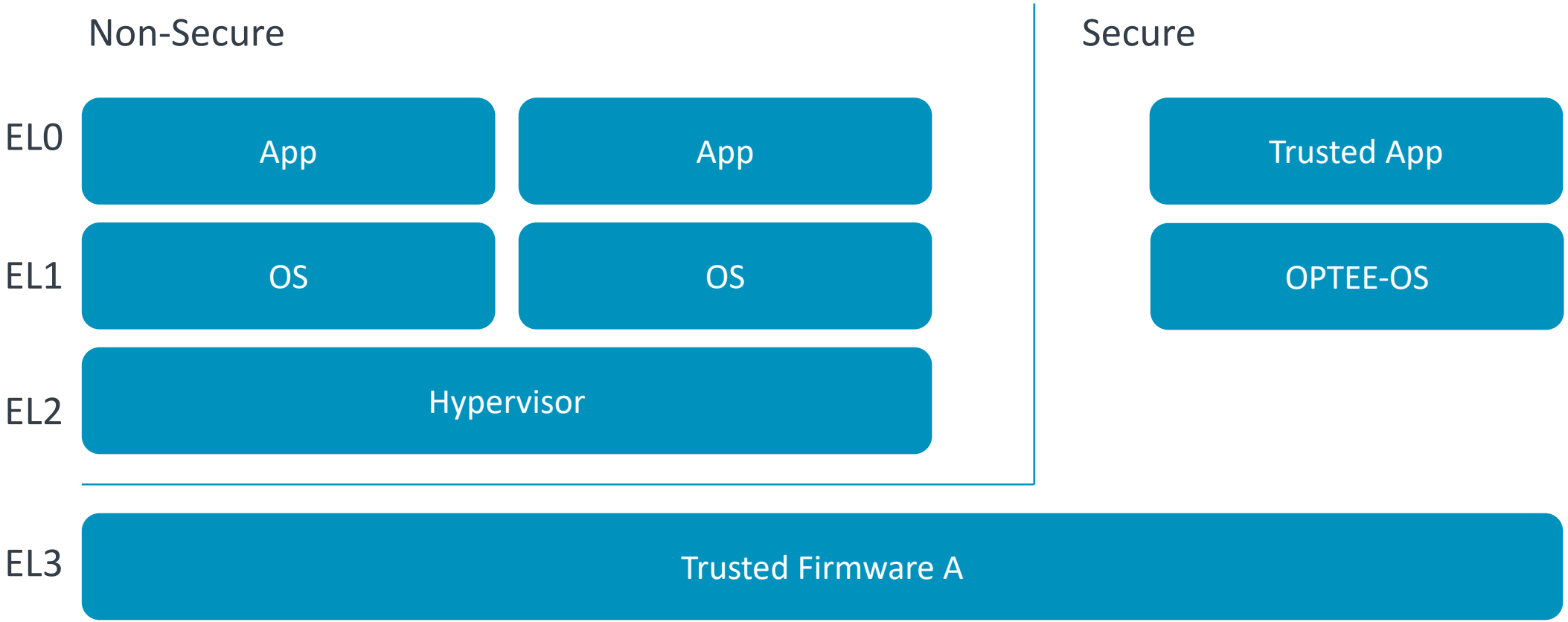
What is TrustZone? (cont.)



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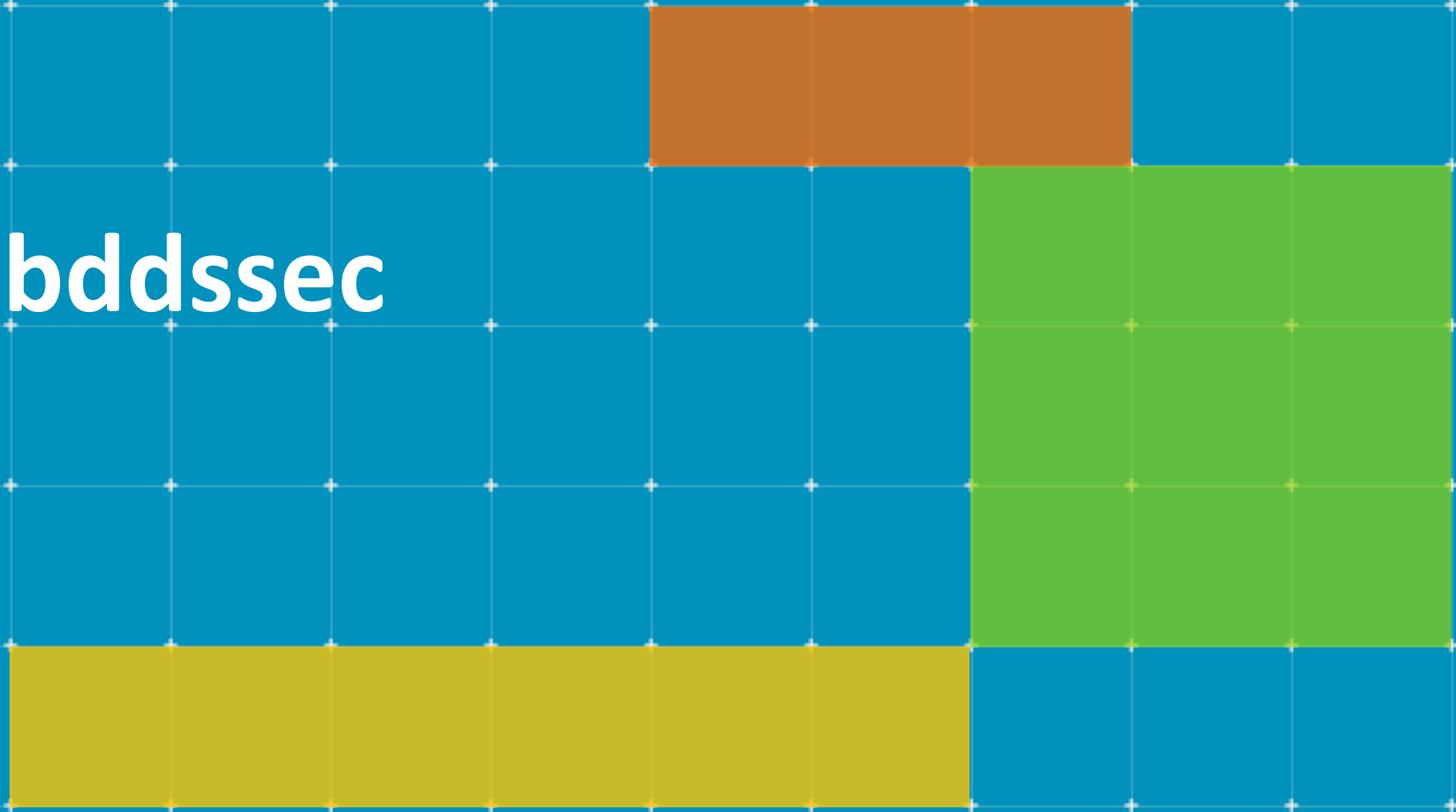
The libddssec



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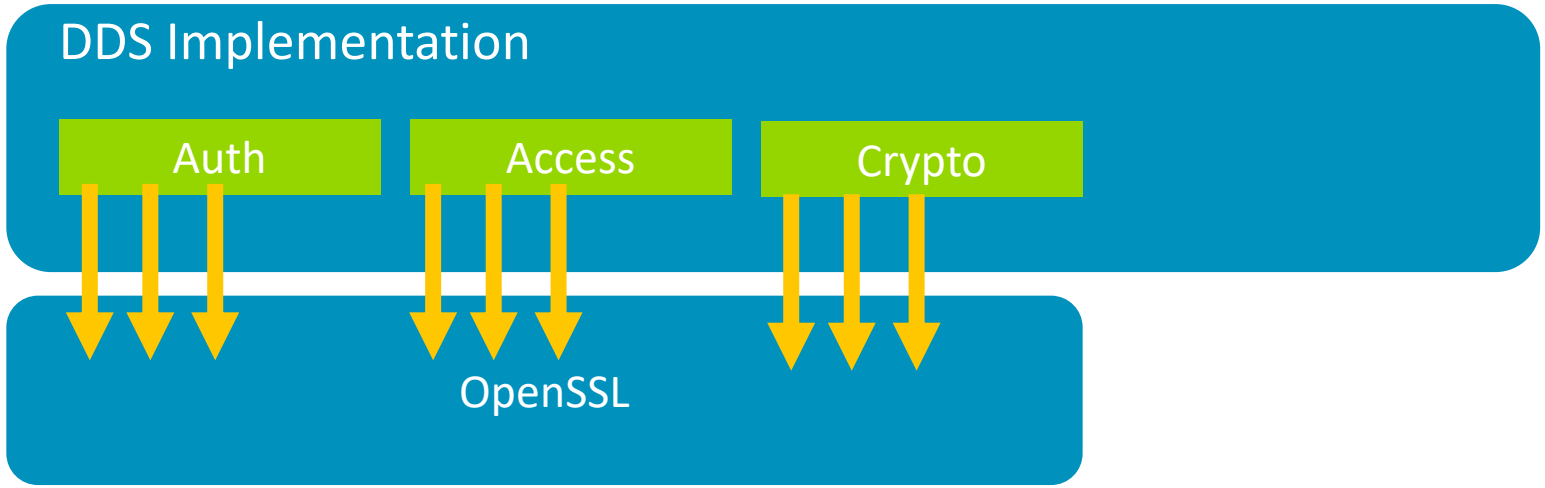
The libddssec: Goals

- Move all security assets into the Trusted Execution Environment (TEE)
  - Certificates
  - Key generation
  - Security operations
- Limit attacks
  - E.g. No key leakage
- Provide a reference implementation on how to take advantage of the TrustZone IP to secure DDS (using OPTEE).

The libddssec: Overview

The DDS implementations we came across use OpenSSL for the security support:



- Certificates in filesystem
- Operations in non-secure world

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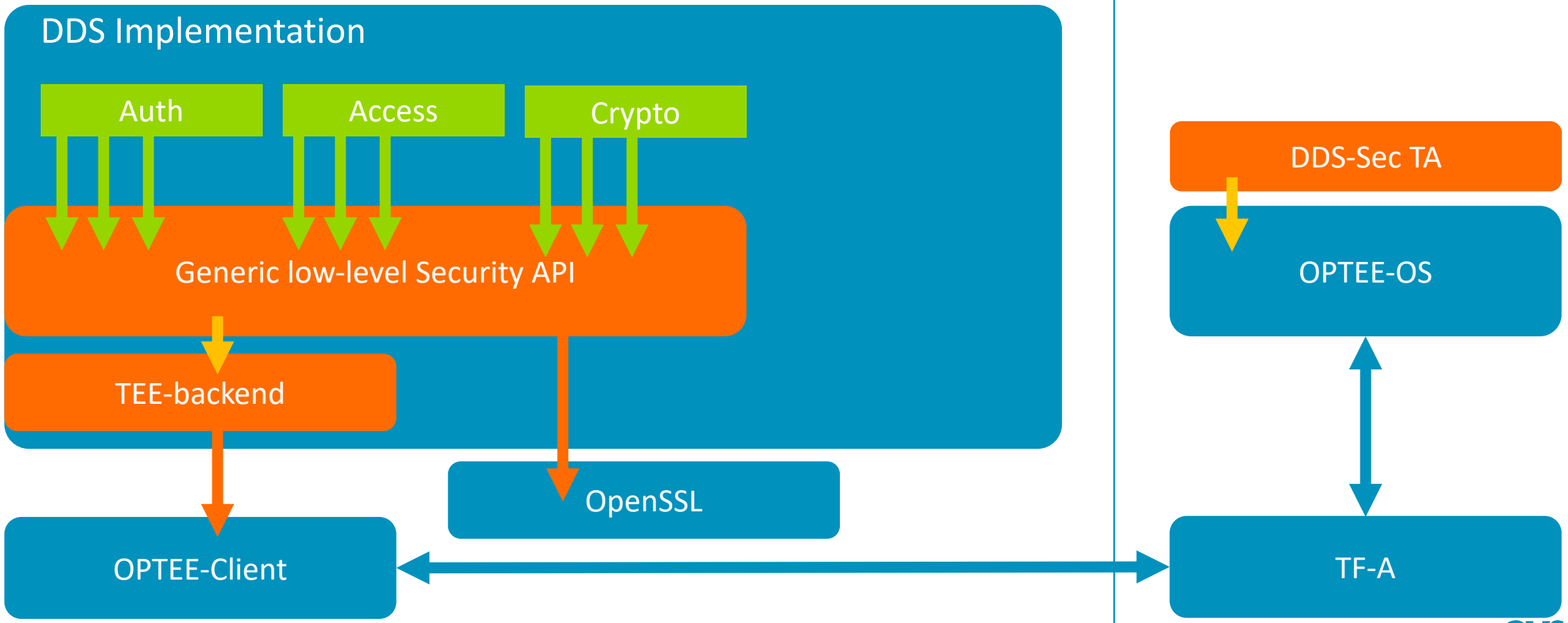
The libddssec: Overview (cont.)

Move security operations into a TEE



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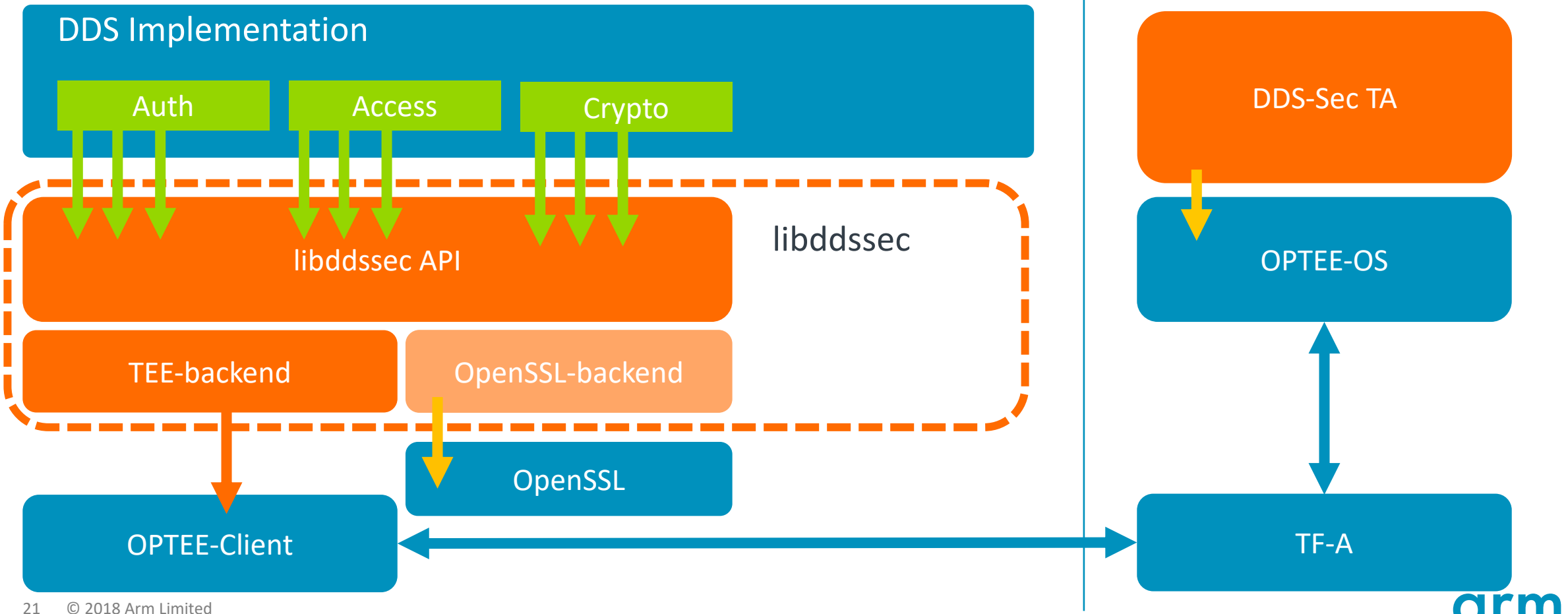
The libddssec: Overview (cont.)

Isolate code into its own project



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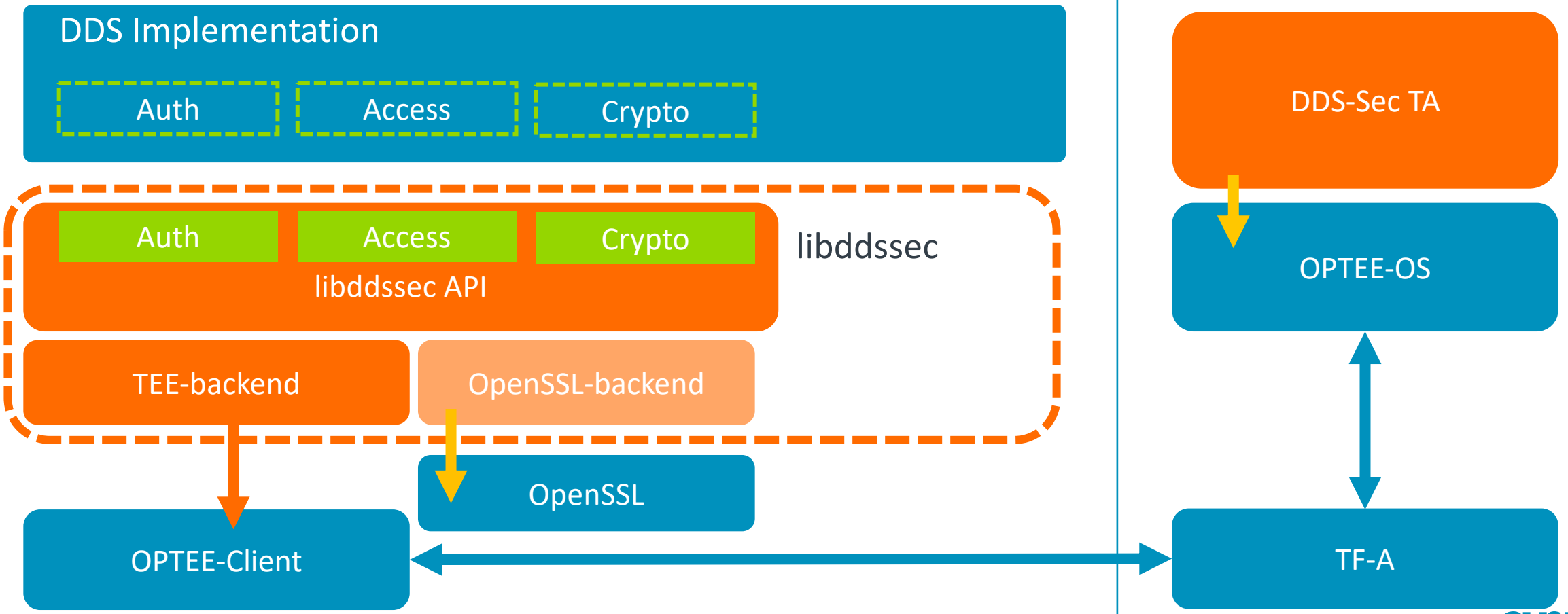
The libddssec: Overview (cont.)

Non-secure world

Secure world

Under discussion: Implement plugins in the library



The libddssec: Current work

- Moving code from the prototype into the standalone library:
  - Reviewing prototype API whilst moving code into the new library
  - Adding unit tests instead of relying only on Fast-RTPS's tests
- Threat model
  - Ensure ~~prototype~~ design is sound
  - Ensure key deployment is safe
  - Ensure Non-secure interface is safe (or at least limit attacks)
- Investigating the new x.509 support in OPTEE 3.2
  - Current base code still uses OpenSSL for some of the operations, including handling of certificates

The libddssec: Main challenges

- Latency:
  - One of the main trade-offs when using TEE will be the extra latency
  - Apex.ai recently released a benchmark tool to measure latency in DDS implementations that can be useful on this area.
- Vulnerabilities in the non-secure world could allow the secure assets to be **used** by potential attackers
- Key and certificate deployment

The libddssec: Future work

Further areas that can be explored:

- Key and certificate deployment
  - Ideally using hardware ID to derive keys
  - As far as we are aware, OPTEE (or GlobalPlatforms) has no API for deriving keys using hardware ID (yet)
- Evaluate the possibility of running “DDS Trusted Applications”
  - In other words, move a whole DDS application into the TEE
  - This means having a DDS layer in the TEE other sorts of complications
- ARMv8-M Support (microcontrollers)
  - Retarget OPTEE and Trusted application to use Trusted-Firmware-M
  - Both using MBedTLS

The libddssec

- Under development and soon to be available in Github under the **ARM-Software** umbrella
- License: BSD (provisional)
- Language: C, C++
- Development using standard-*ish* ArmPlatforms [4] stack:
  - Base AEMv8-A Base Platform FVP
  - Linaro's kernel-latest
  - OpenEmbedded
  - OPTEE (currently manually enabled)

Why are we doing this?

- DDS being adopted in mission critical applications
  - These usually have associated security requirements as well
- Increased adoption on the automotive area:
  - Autosar consortium [5] is adopting **DDS** in its specifications (Adaptive)
  - Baidu's Apollo [3] uses ROS1 and is moving to another solution based on **DDS**
  - Autoware [6] currently ROS1 but planning to add support for **ROS2**
- We are aware of other automotive frameworks based on ROS2 project.

Thank You
Danke
Merci
谢谢
ありがとう
Gracias
Kiitos
감사합니다
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References

[1] https://www.arm.com/why-arm/technologies/trustzone-for-cortex-a

[2] http://portals.omg.org/dds/omg-dds-standard

[3] http://apollo.auto/

[4] https://community.arm.com/dev-platforms/w/docs

[5] https://www.autosar.org/

[6] https://autoware.ai/

[7] https://github.com/ApexAI/performance_test