Linaro Connect 2018

LibDDSSec

Securing DDS with OPTEE

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Introduction

Myself:

- Principal Software Engineer at Arm
- Tech lead of the Safety Critical Machines team (a revamp of the Robotics team) with focus on the automotive area

Todays presentation:

Overview of a new project called **libDDSSec:** A library that implements the security portion of a DDS implementation using a TEE based solution.

Agenda:

- Key concepts
  - What is DDS
  - DDS Security
  - The ROS Project
- The libDDSSec project
  - Overview
  - The current work
  - Main challenges
  - Future work
- Why securing DDS
- References

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Key Concepts

What is DDS?

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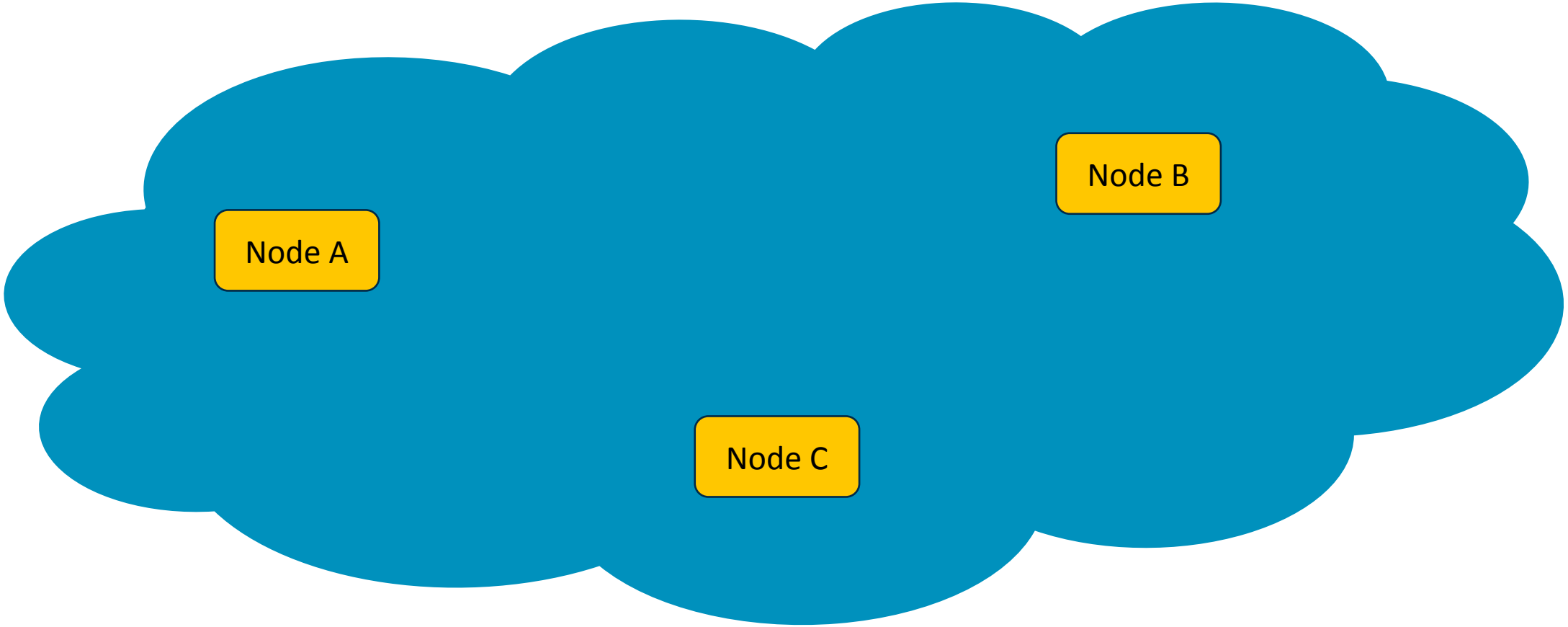
What is DDS?

DDS stands for **Data Distribution Service** [1] and it refers to a standard. There are many implementations of the standard specifications (both commercial and open source).

Data-centric publish-subscribe model for distributed application communication and integration. Its purpose is to enable efficient and robust delivery of the right information to the right place at the right time.

- Network middleware to simplify networking programming
- Data is exchanged between nodes via **topics**
- Nodes can **publish** data on a specific topic as well as receive data when they **subscribe** to a topic

What is DDS? (cont.)



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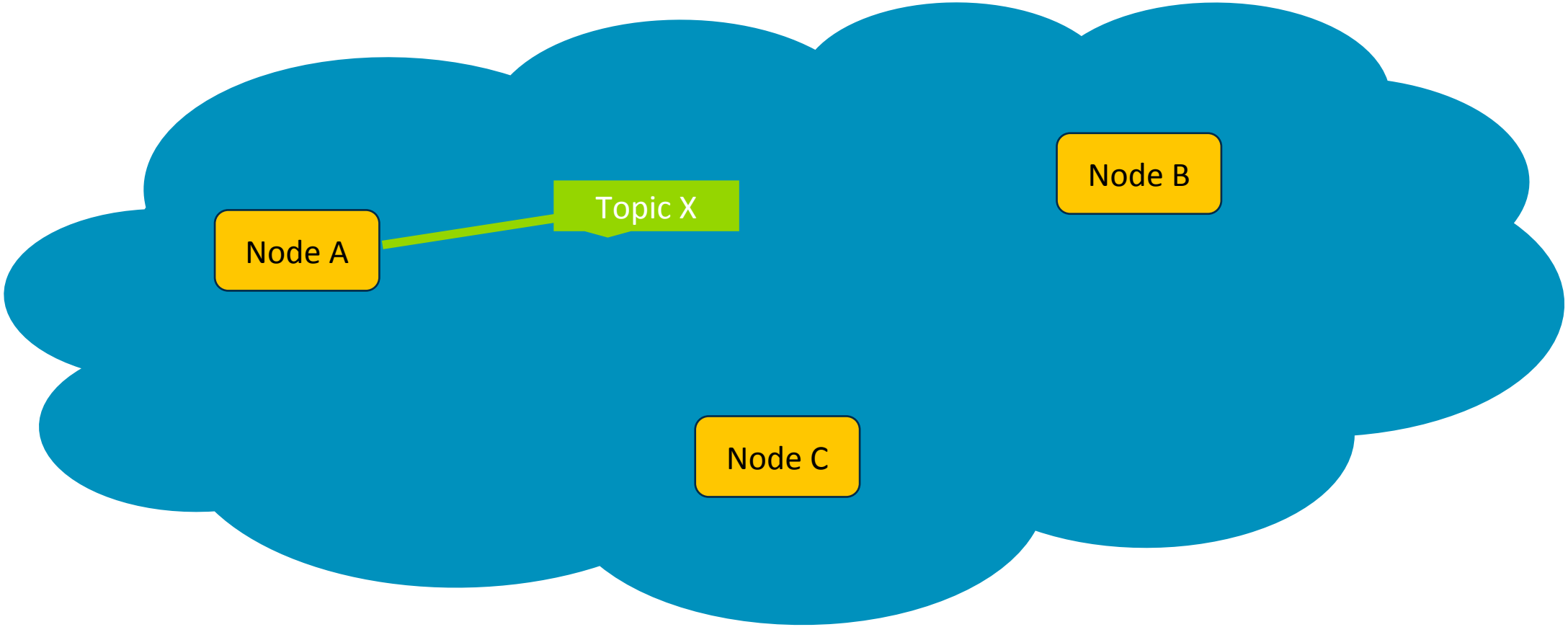

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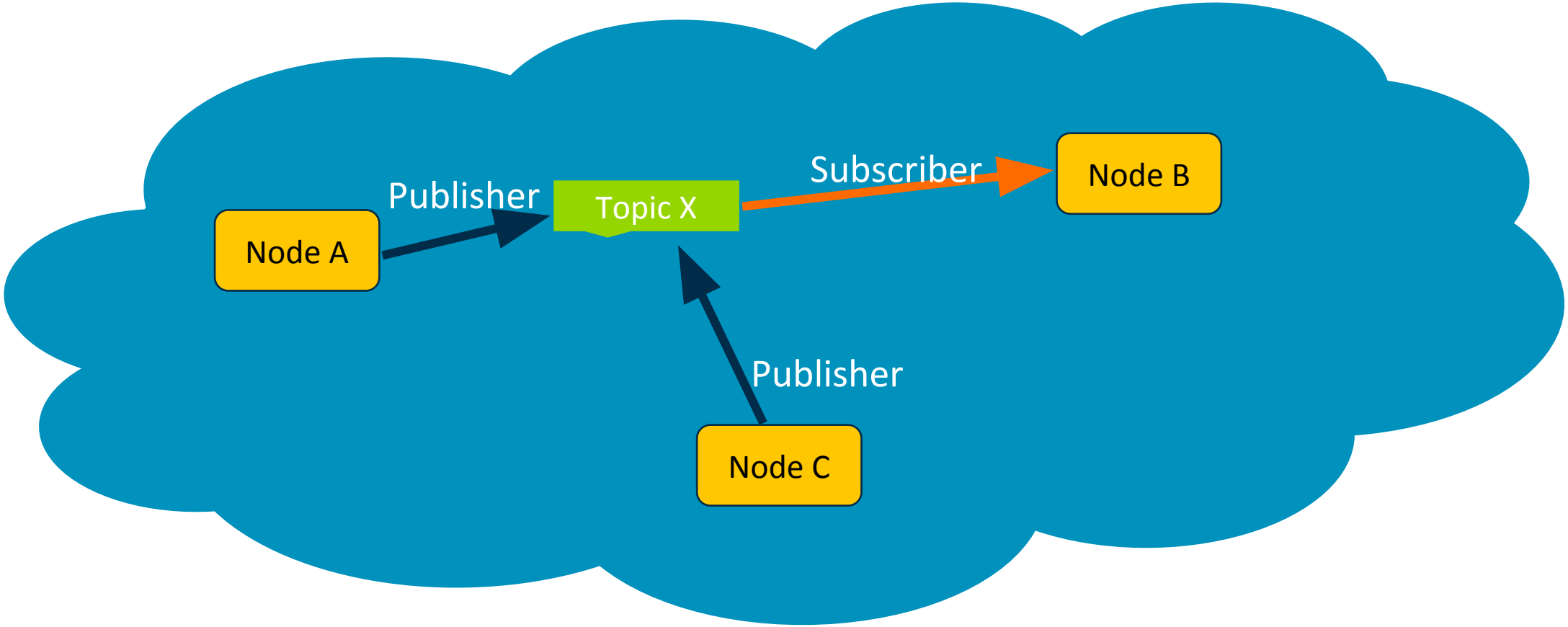

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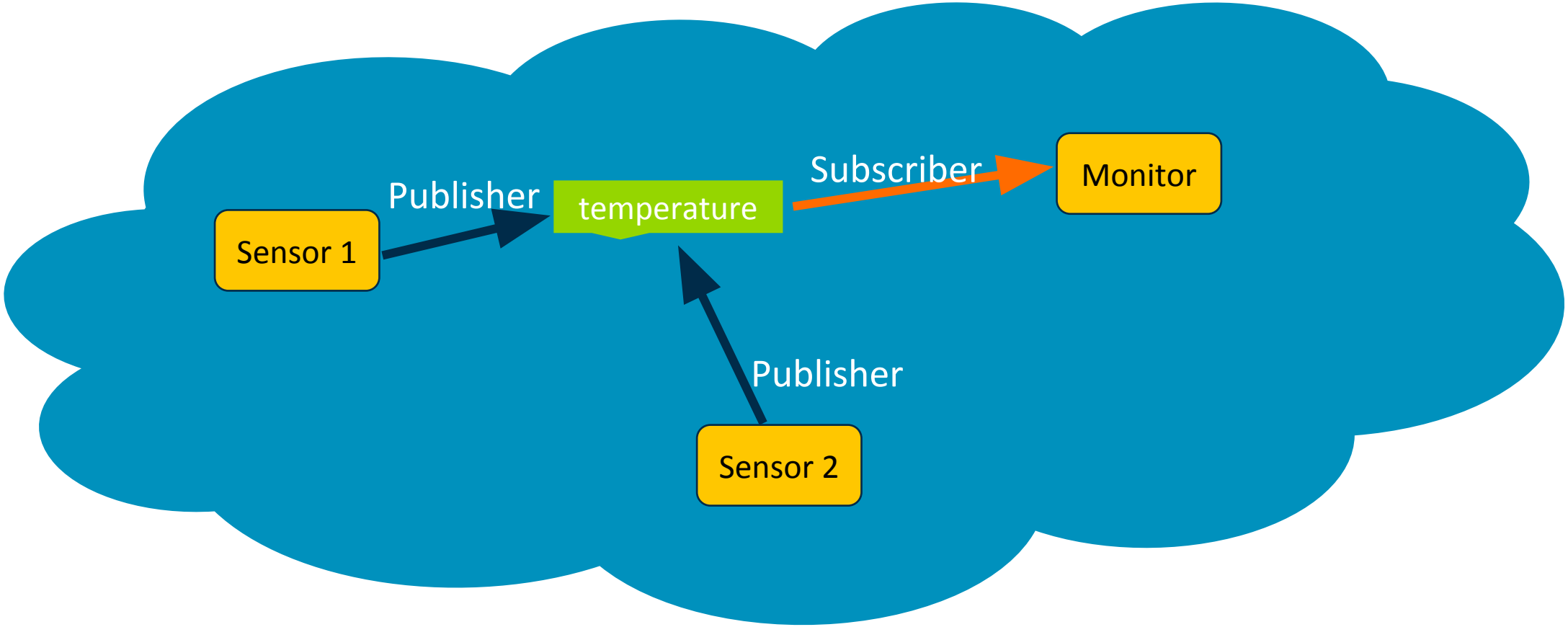

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What is DDS? (cont.)

There is a collection of specifications 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

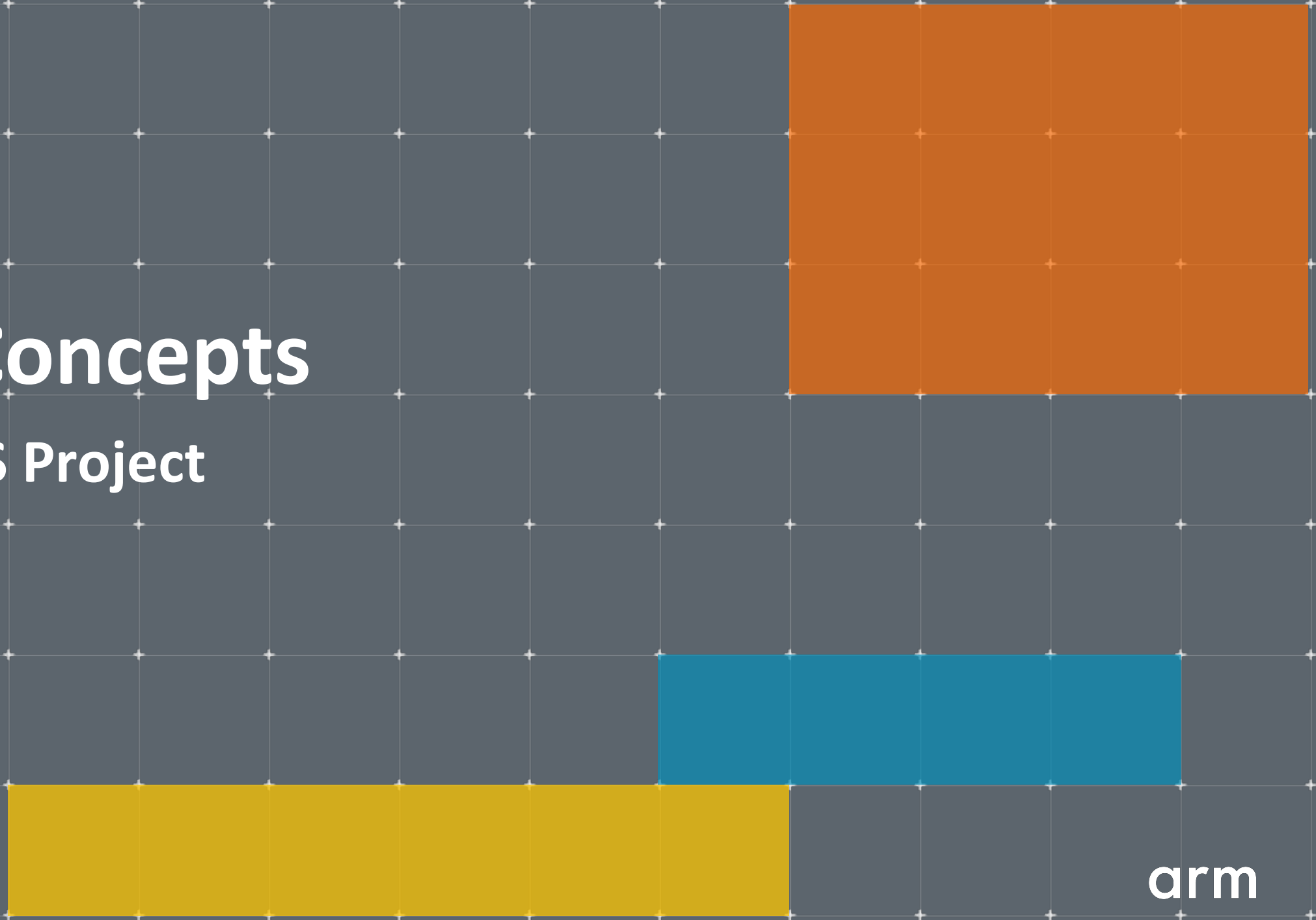
- Authentication
  - Certificate management
- Cryptography
  - Crypto operations
- Access control
  - Policy enforcement

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

The ROS Project



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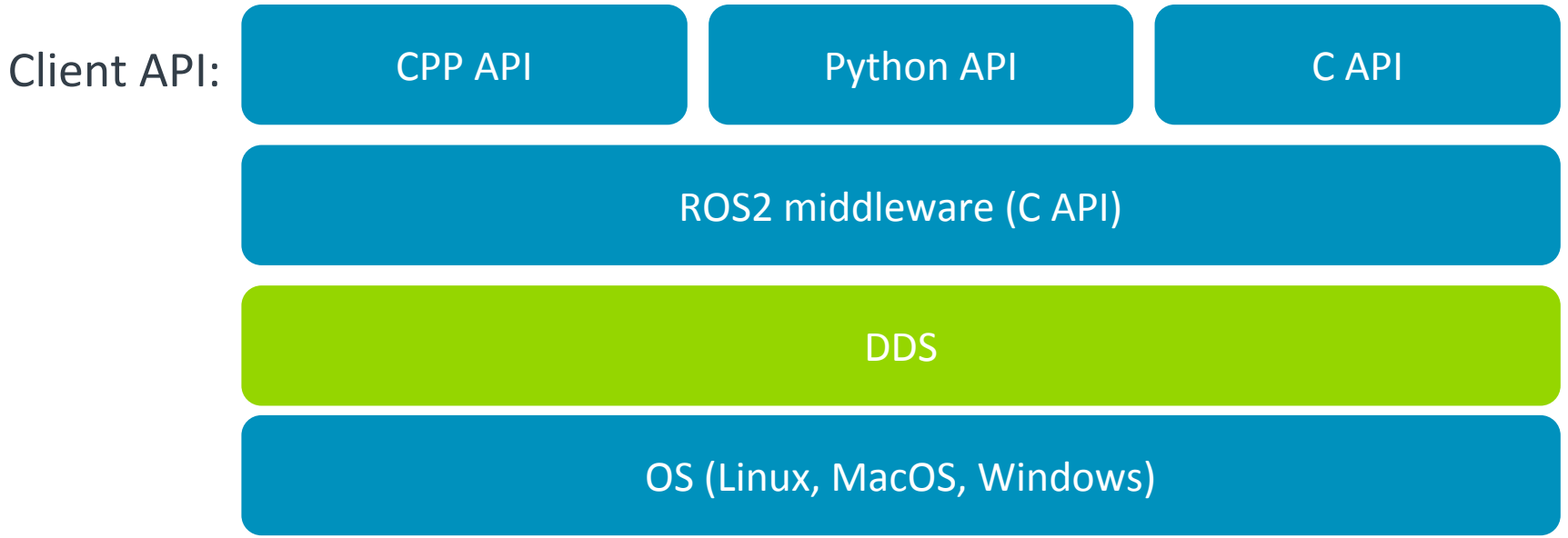
The ROS Project

The **R**obotic **O**perating **S**ystem [2] is a framework (libraries and tools) to develop robot applications.

ROS2 adopted DDS as its communication layer: Bundled by default with the open source DDS library called Fast-RTPS by eProsima but can be integrated with other DDS implementations (e.g. RTI Connext).



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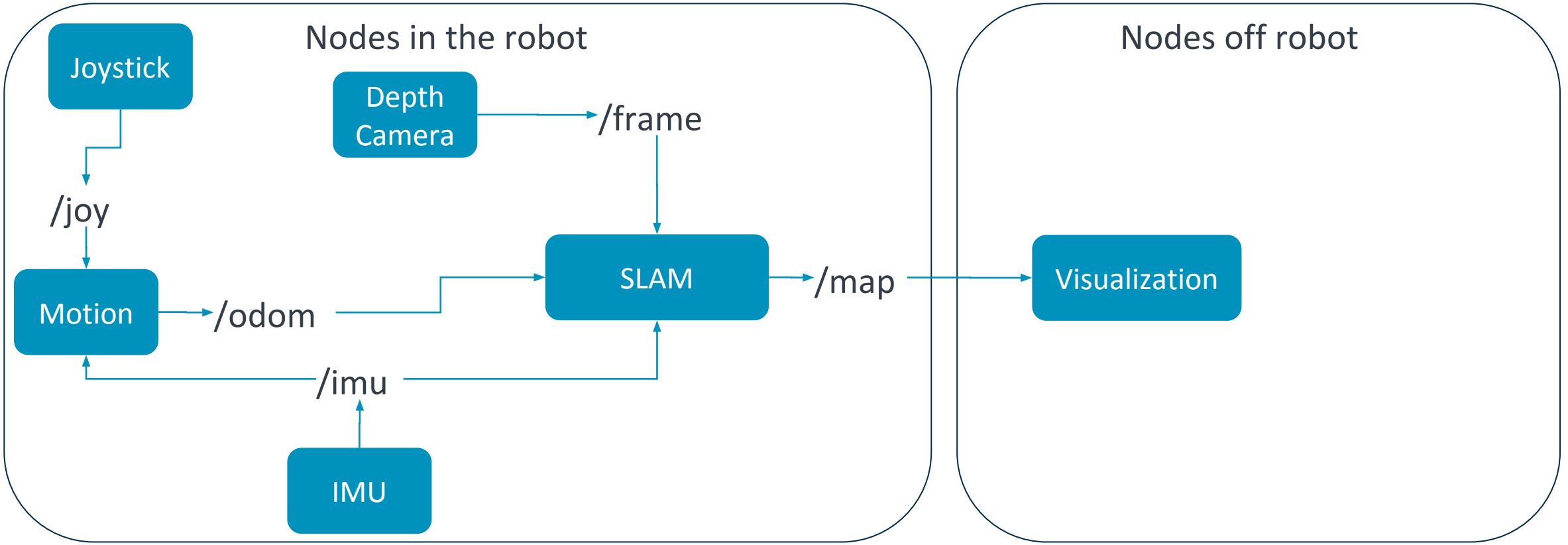
The ROS Project

ROS comes with a plethora of **packages** that can be interfaced with each other to build a robot.



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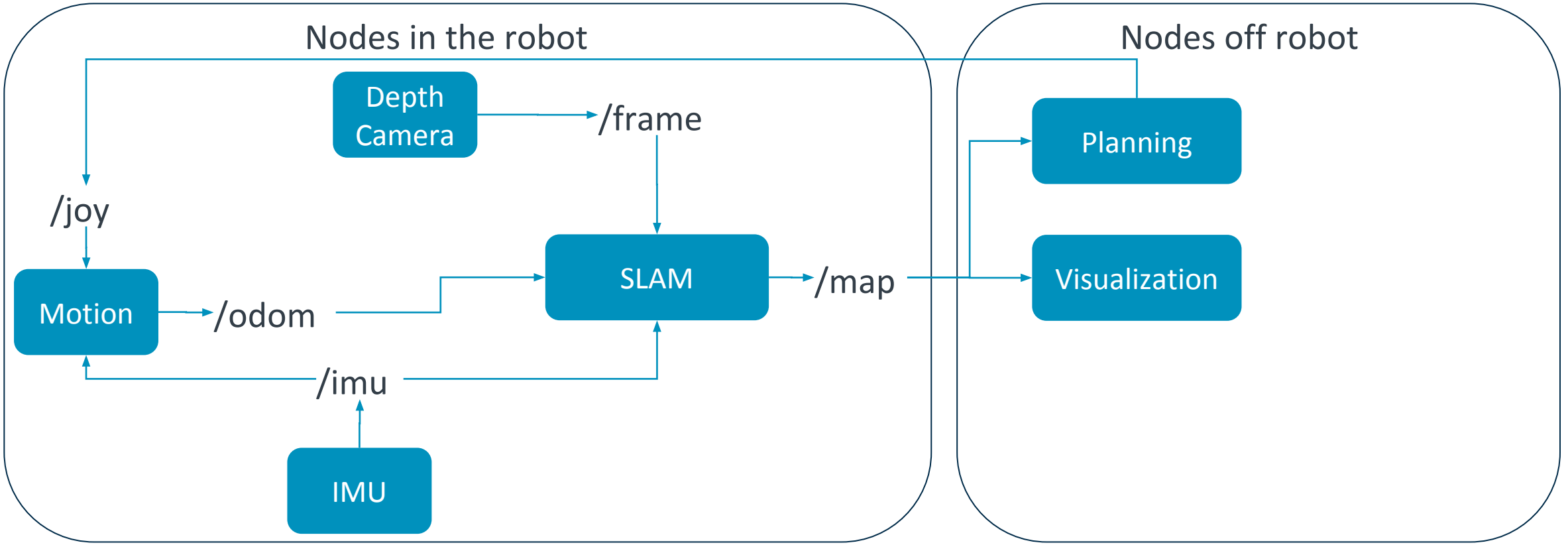

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The LibDDSSec

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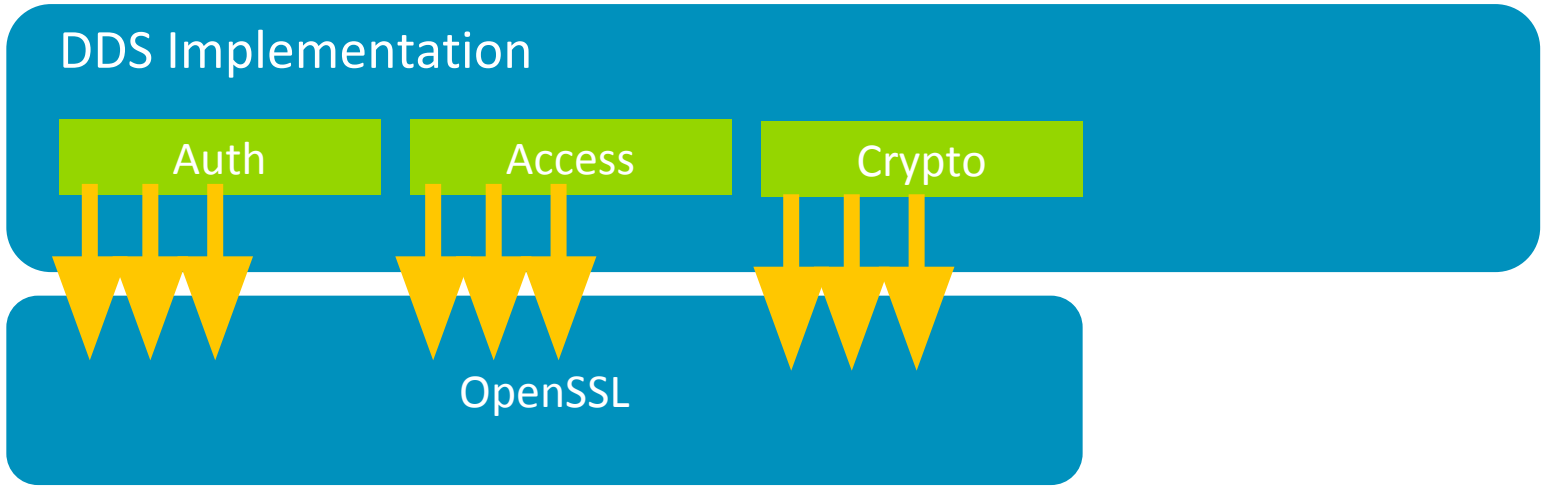
The LibDDSSec: Goals

- Move all security assets into the 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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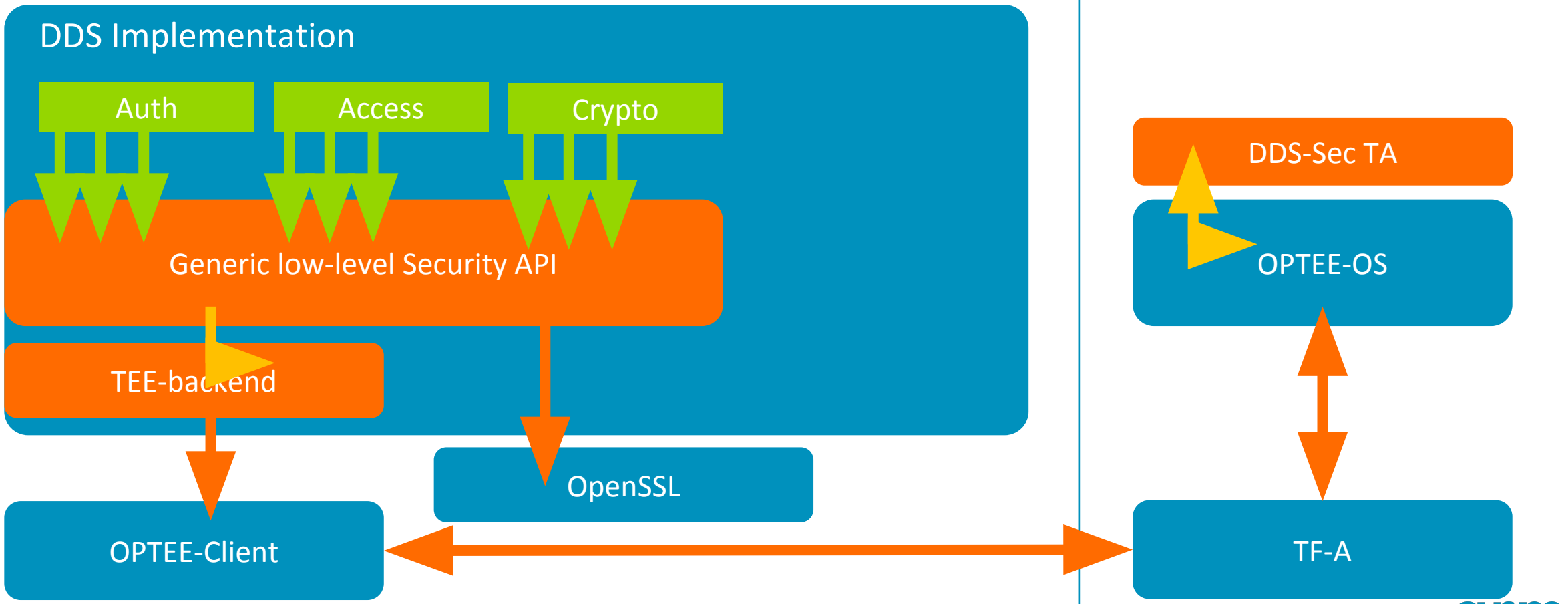
The LibDDSSec: Overview (cont.)

Move security operations into a TEE



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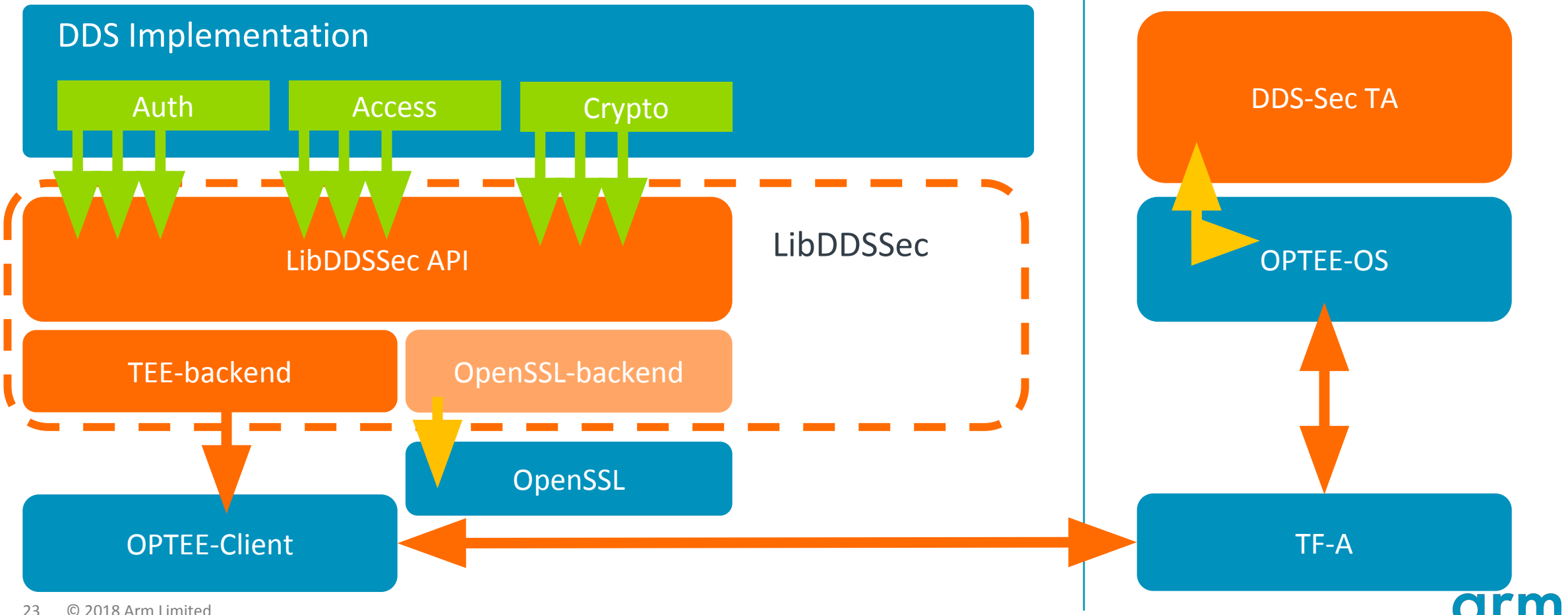
The LibDDSSec: Overview (cont.)

Isolate code into its own project



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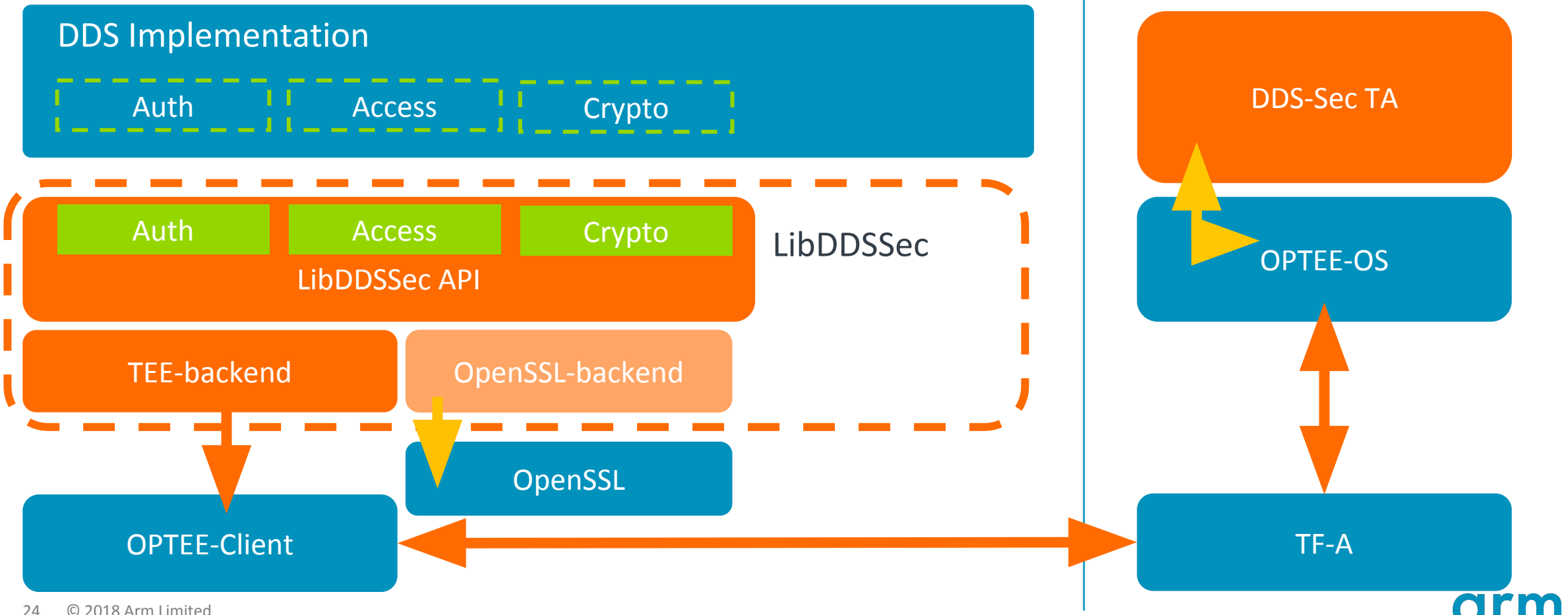
The LibDDSSec: Overview (cont.)

Under discussion: Implement plugins in the library



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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
  - Adding more
- 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

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
धन्यवाद
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References

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

[2] http://www.ros.org/

[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

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