Your systems.
Working as one.

Using DDS with TSN and Adaptive AUTOSAR

Bob Leigh, Director of Market Development, Autonomous Vehicles
Reinier Torenbeek, Systems Architect

Agenda

- Intro to Data Distribution Service (DDS)
- Use Cases for DDS in Automotive
- AUTOSAR and other platforms
- DDS and TSN

Intro to DDS

DDS and the Industrial Internet of Things

Deployed in 1000s of Systems

INDUSTRIES

Energy, Industrial Control, Transportation, Healthcare, Defense

Industrial IoT Systems

- Reliability: Severe consequences if offline for 5ms (or 5 min)
- Real-time: measure in ms or µs
- Interface scale: 10+ applications/teams
- Dataflow complexity: data has many destinations
- Architecture: Next generation IIoT

3+ Yes?

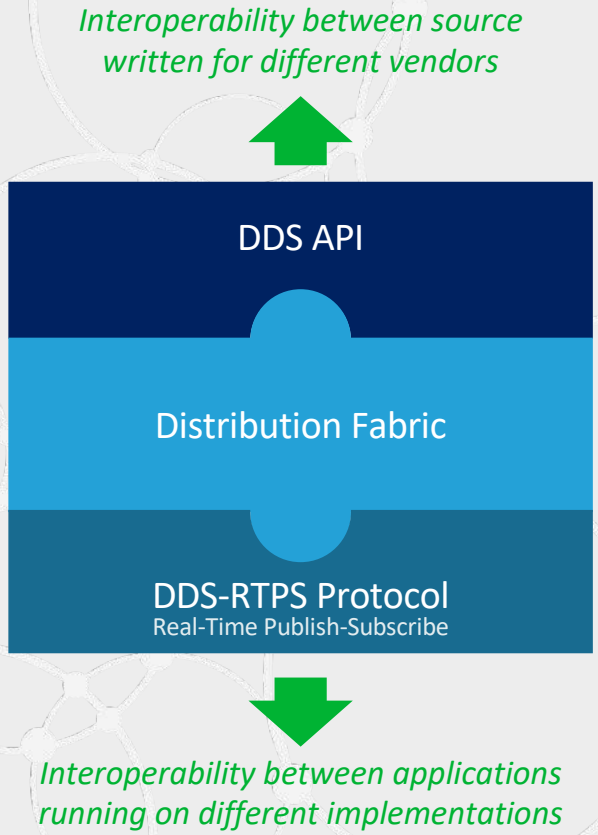
DDS

RTI Connext DDS in Autonomous Vehicles

- Commercial systems
  - 7+ Passenger vehicles
  - 8+ EV startups
  - 5+ Software platforms
  - 7+ Trucks, mining vehicles, forklifts
  - 2 Flying taxi services
  - 2 Hyperloop & other
  - 2+ Autonomous ships
  - 2+ Underwater robots
- Many defense systems (land, sea, air)
- Many research programs (companies, universities, etc.)

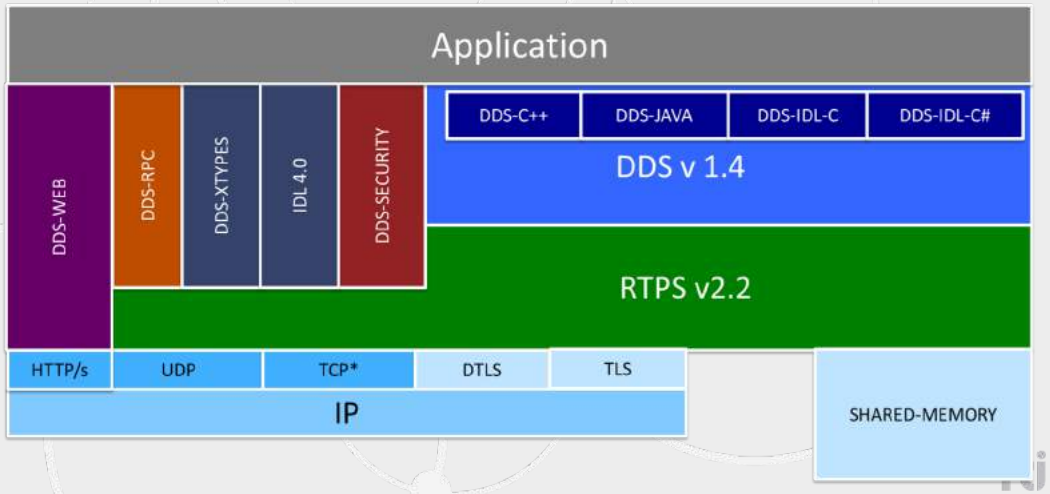
The DDS Standard

- DDS is the Proven Data Connectivity Standard for the IoT
- OMG: world's largest systems software standards org
  - UML, DDS, Industrial Internet Consortium
- DDS: open and cross-vendor
  - Open Standard and Open Source
  - 12+ implementations

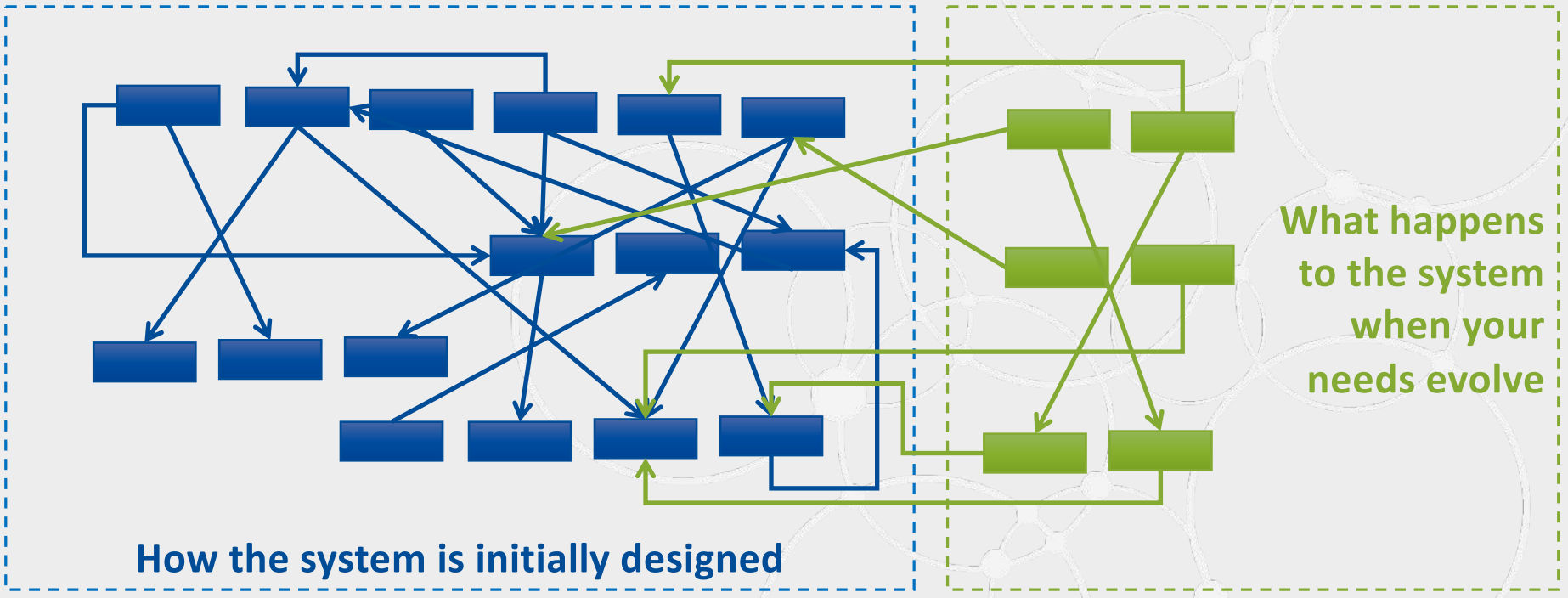


DDS Wire Protocol (RTPS)

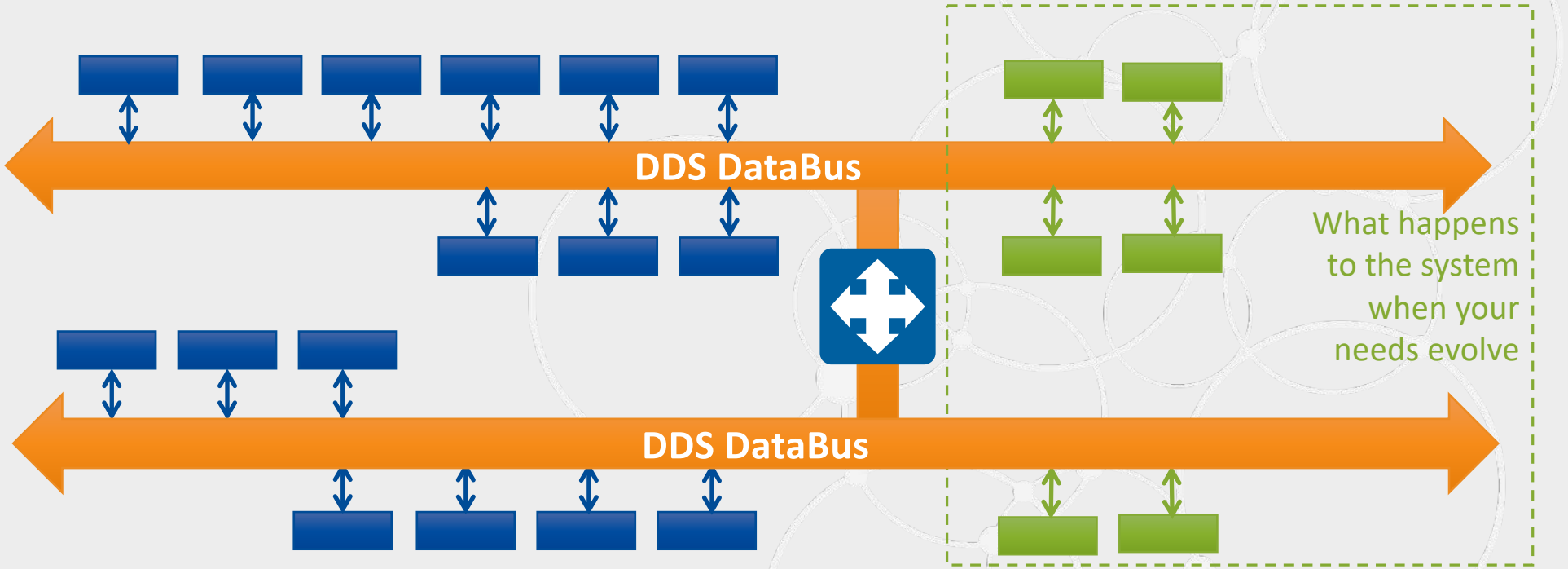
- Peer to peer
- Transport-independent QoS-aware and Reliable Communication
  - Including multicast, for 1-many reliable communication
- Any data size over any transport.
- Automatic Discovery and Presence Plug and Play
- Decoupled
  - Start applications in any order
- Support for Redundancy
  - Multiple data sources
  - Multiple network paths
- High performance native “wire” speeds



What most systems of systems look like



DDS Creates This…



Use Cases

How to Deal with the Data?

Source	Type	Size	Frequency	Volume (approx.)
8 Cameras	2D high-res. video stream	8x 1-4 Mpixel/frame x 30 frames/s x 12-24bit/pixel	30 Hz	2.5-20 Gbit/s
4 Lidar sensors	3D point cloud	4x 300k-3M 3D points /s * 24bit/point	5	30-300 Mbit/s
5 Radar sensors	Object/target list	bytes to kbyte	Hz	~10 kB/s
16 Ultrasonic sensors	Object/target list	by	10 Hz	~10 kB/s
1 GPS	Data mess	A couple of bytes	20-200 Hz	~10 kB/s
Control commands	ge	A couple of bytes	50-250 Hz	~10 kB/s
Status/error handling	Data/string message	Whatever needed	Whenever needed	Whatever needed

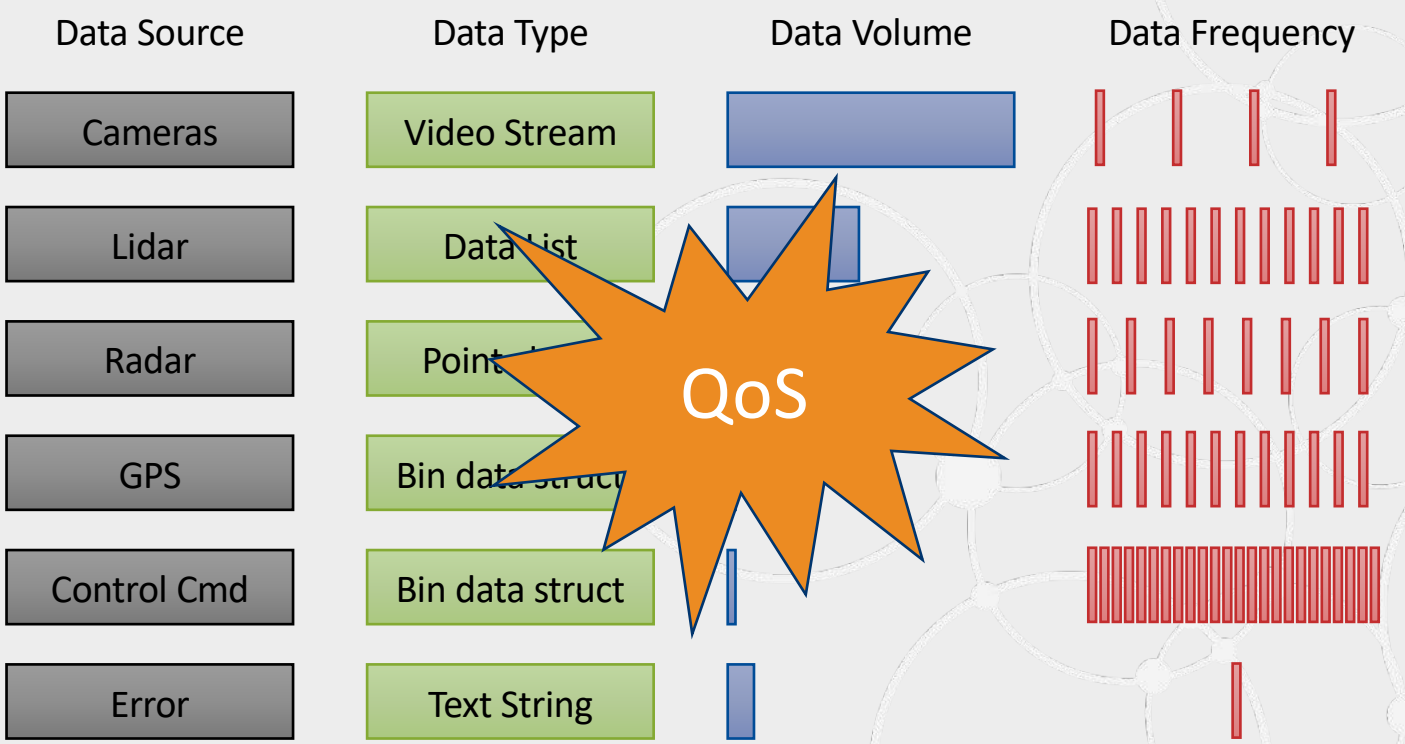
Autonomous Systems Need Massive Data Flow

12 Gb/s or 1.5 GB/s or 90 GB/min or 5 TB/h or 100 TB/d

Approximately and assuming 20h of operation per day

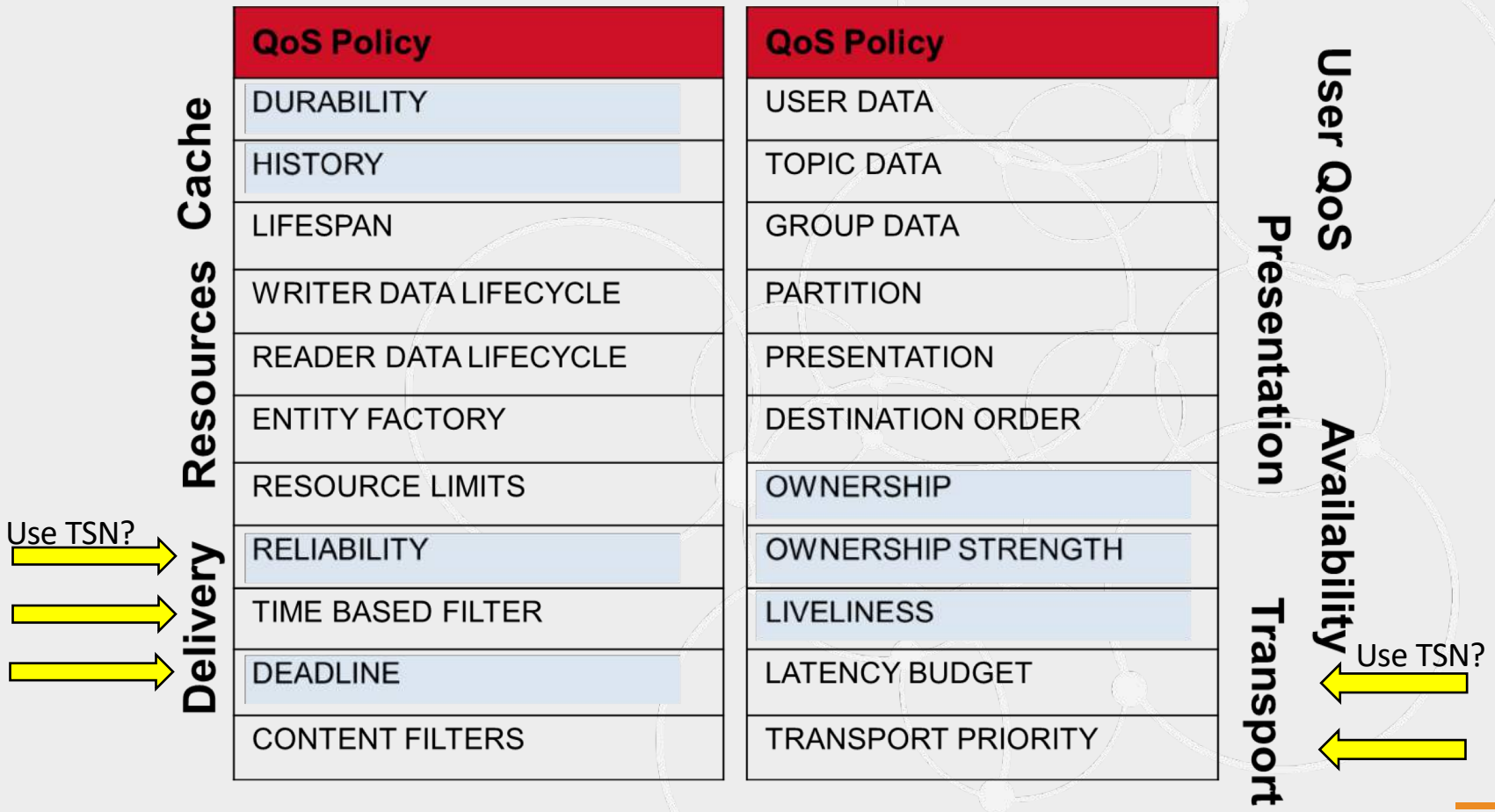
5G data rate: 100Mbps (cell edge) to 10Gbps (theoretical)

Dataflow Challenge

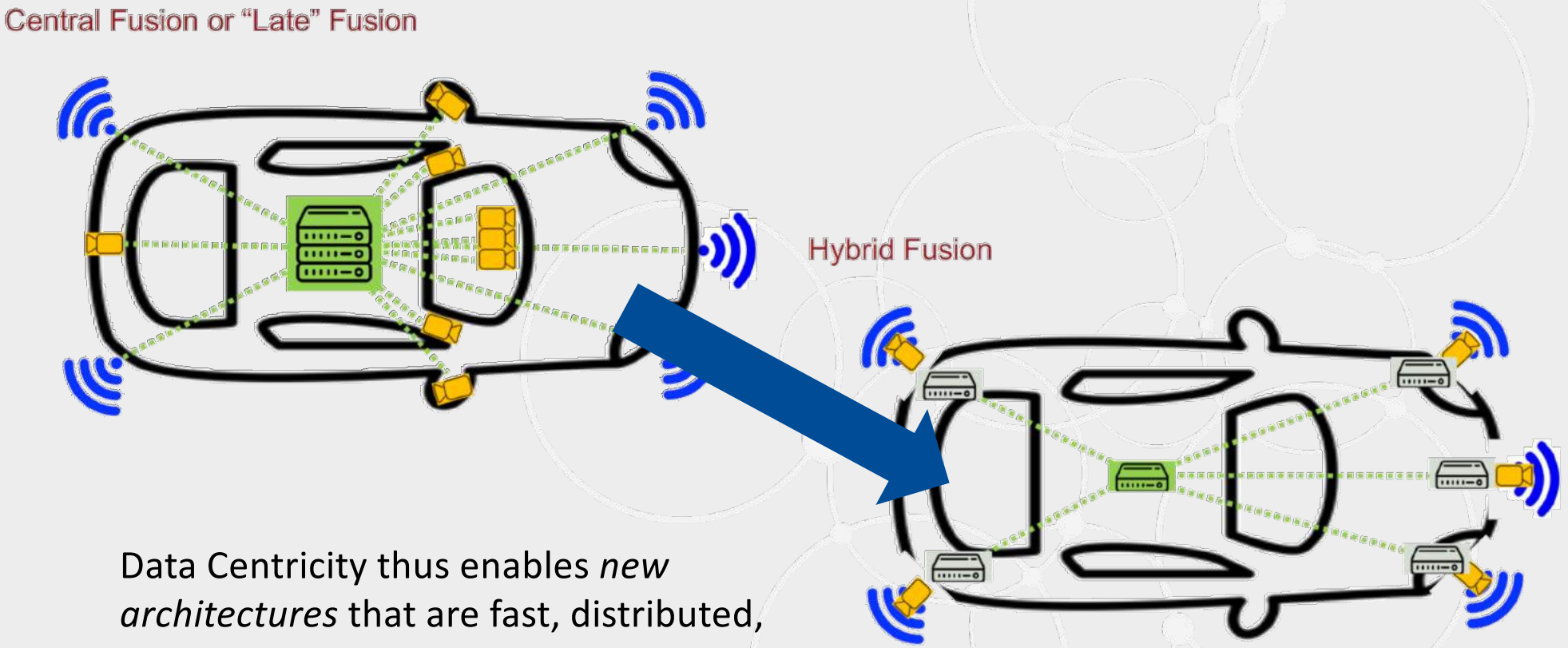


- Carbots need many different dataflows
  - Volume
  - Frequency
  - Latency
  - Reliability
  - Destination
- A single databus that can handle all greatly simplifies the system

Quality of Service Capabilities

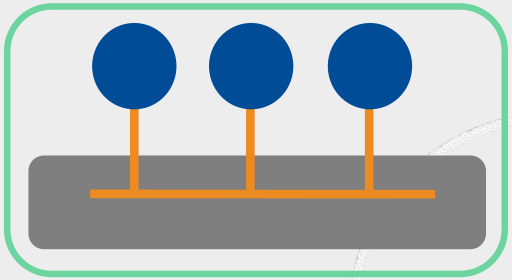


Distributed Architectures for Higher Autonomy



Data Centricity thus enables *new architectures* that are fast, distributed, and reliable.

Connected & Secure



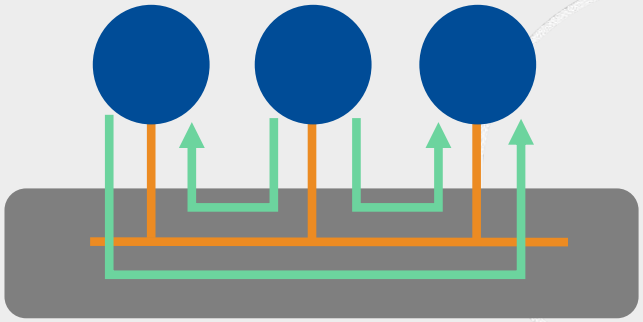
Traditional Method

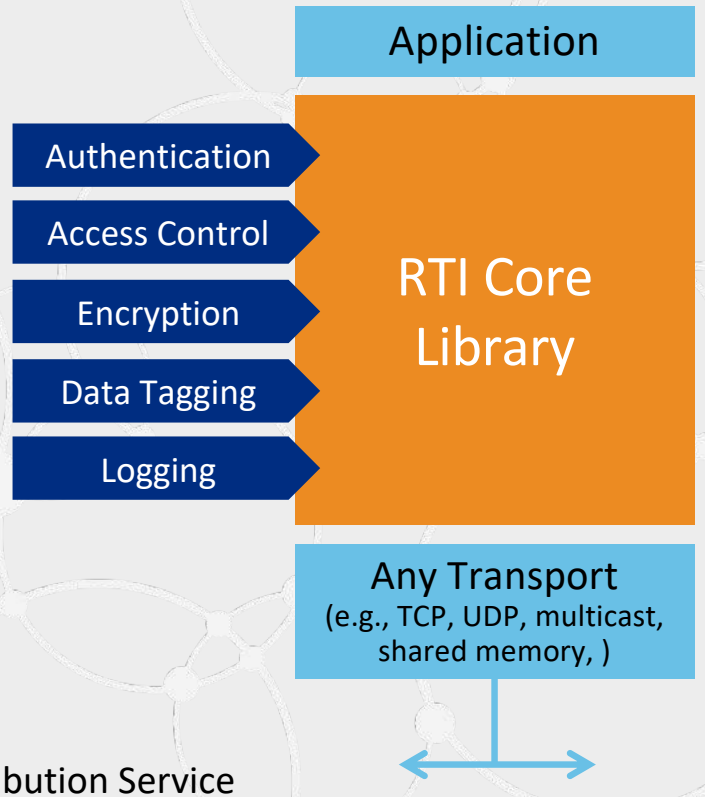
- Secure the System
- Secure the Host
- Secure the Network

Security does not need to be black and white

Fine-Grained, DDS Security

Data Flow Security, by Topic

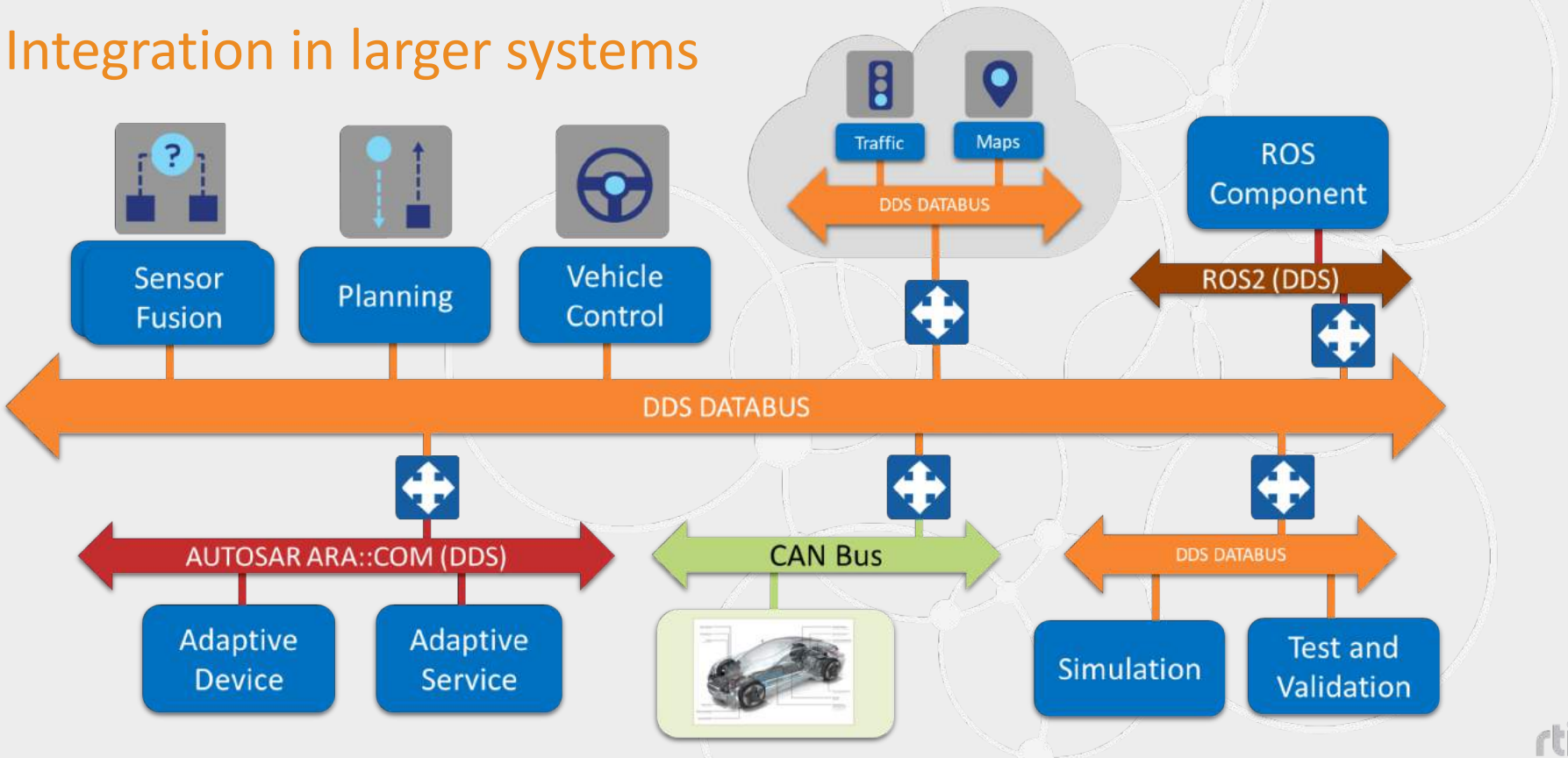




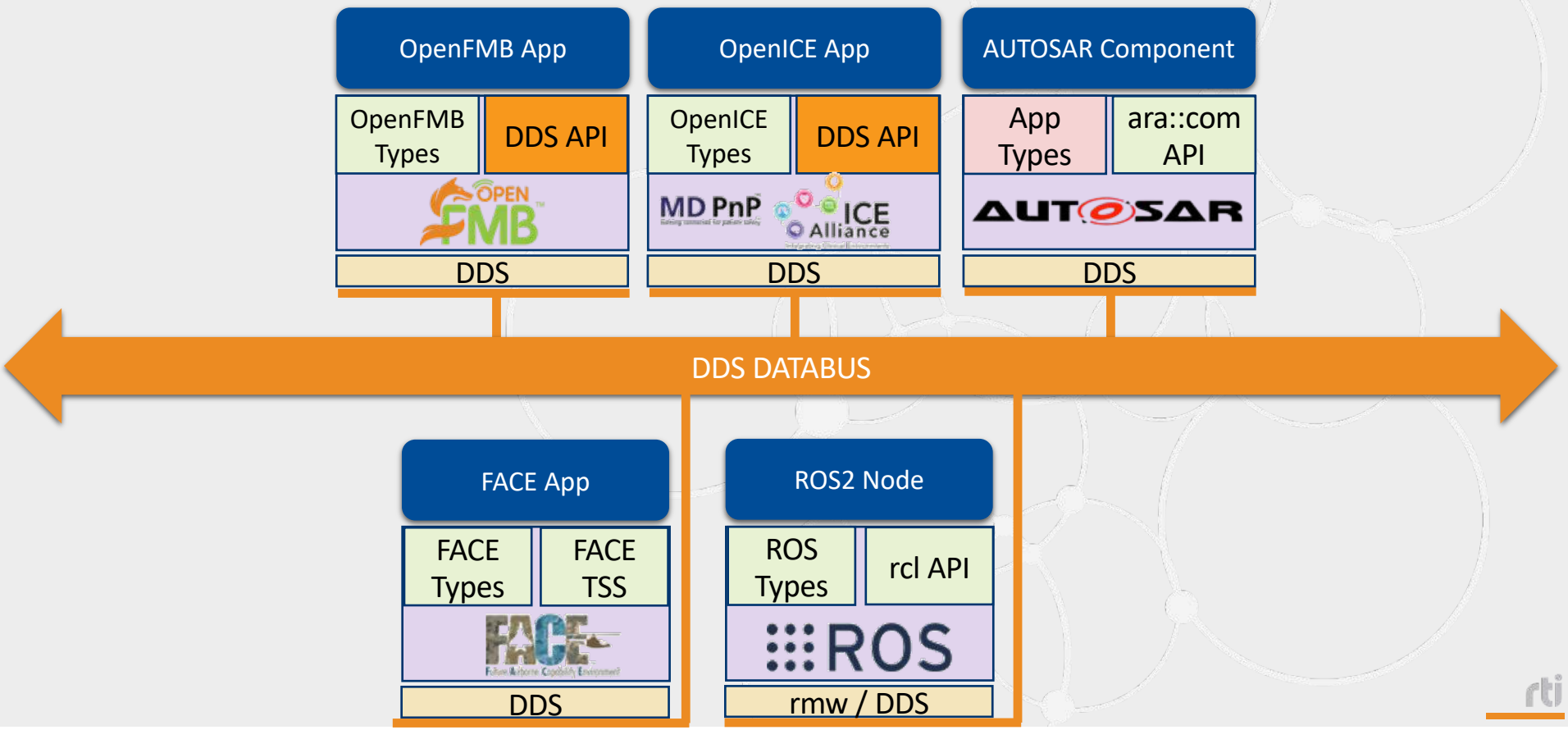
DDS = Data Distribution Service

DDS Across Platforms, Industries, and Networks

- Integration in larger systems



Connext DDS as Core Connectivity Framework



Adaptive AUTOSAR and DDS

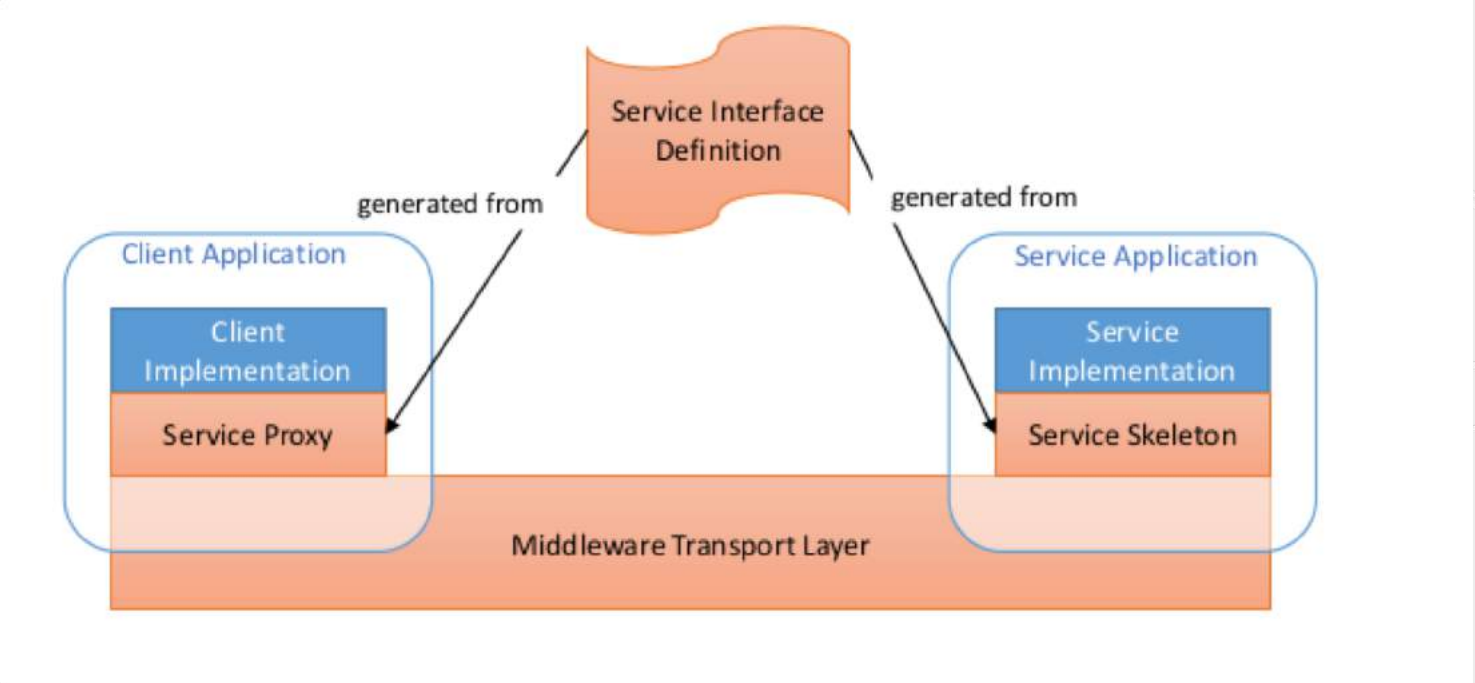
What is AUTOSAR?

- **AUTOSAR** (**AUT**omotive **O**pen **S**ystem **AR**chitecture) is a worldwide development partnership of vehicle manufacturers, suppliers, service providers and companies from the automotive electronics, semiconductor and software industry.
- > 270 partners including
  - Core Partners: BMW, Bosch, Continental, Daimler, Ford, GM, PSA, Toyota, and VW.
  - RTI joined as a Development Partner in 2017

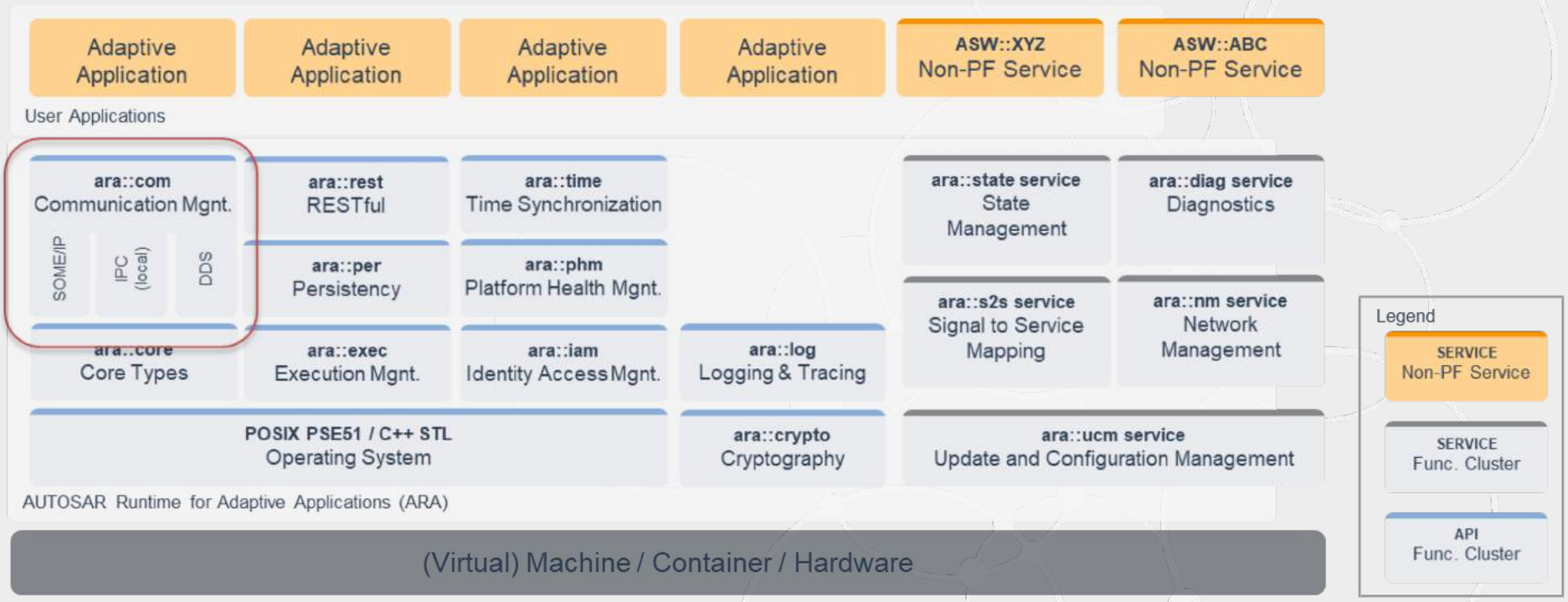
Overview

- ara::com is the Communication Management API for the AUTOSAR Adaptive Platform.
  - EXP_AraComAPI.pdf provides an overview of the API.
  - SWS_CommunicationManagement.pdf provides the formal spec.
- Developed in 2014 in the context of Adaptive AUTOSAR FT-CM
  - Aims to be communication framework independent
  - Was initially built around SOME/IP and follows most of its principles
  - Based on a proxy/skeleton SOA architecture
  - Especially tailored for Modern C++ (C++11 in External APIs, C++14 in Internal APIs)

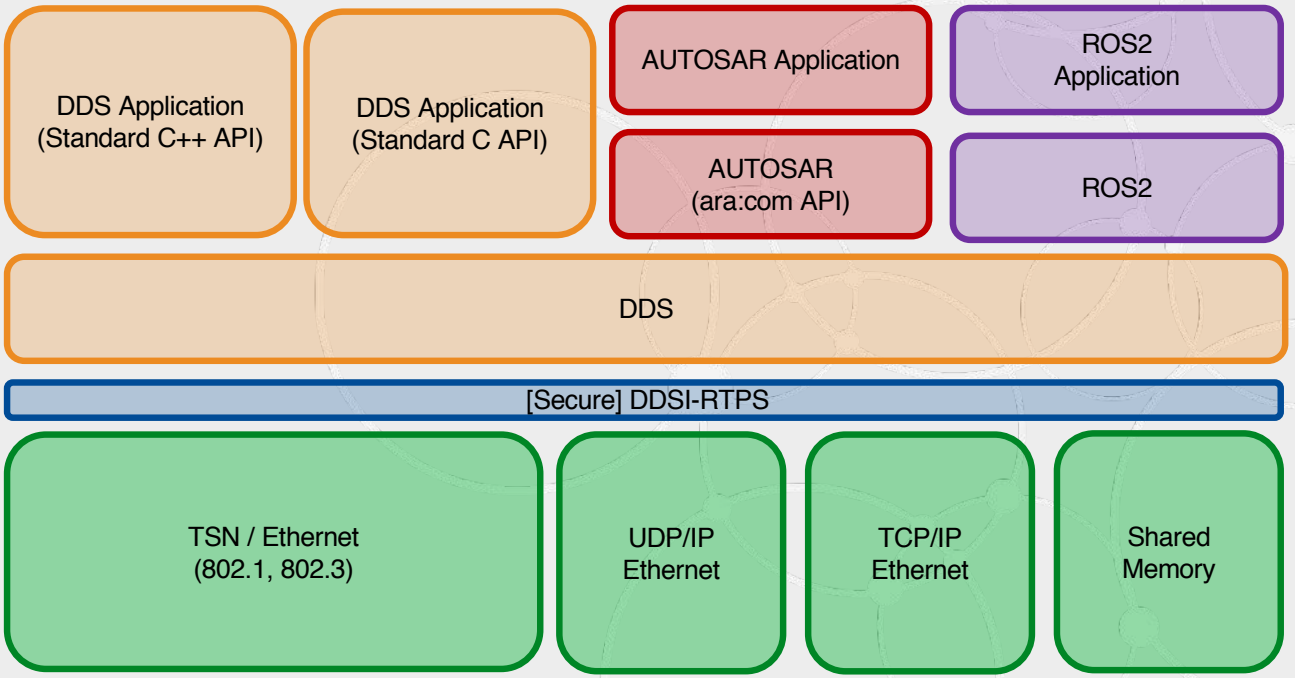
Architecture



Adaptive AUTOSAR



Network Stack




The Network is the Car
AUTONOMY
PERFORMANCE
SECURITY
SAFETY
DDS can simplify wide deployment and use of TSN, across systems and platforms

DDS TSN

How do the two fit together?

How do DDS and TSN fit together

- Intuitively, DDS and TSN are a good fit
  - Fundamentally both are about predictable and fault tolerant one-to-many delivery with bound latencies
  - TSN could provide QoSes and mechanisms to DDS at a networking level
  - DDS could provide TSN mechanisms at higher level of abstraction

How do DDS and TSN fit together

- What does DDS provide to TSN?
  - Simplified usage by means of a higher level abstraction
    - TSN can be complicated to configure and use, compared to DDS
  - Best practices for real-time data distribution, which are designed into DDS
  - A standardized API for applications to use, in several languages
  - Adoption by industry frameworks that already have selected DDS (for example ROS2, AUTOSAR, …)

How do DDS and TSN fit together

- What does TSN provide to DDS?
  - Possibilities to truly implement certain DDS QoSes that live at the network level
  - The concept of TSN data flows that naturally match DDS data flows, allowing for intuitive integration of the two all the way down to the network level

Problem statement

- DDS-TSN seems to have three different integration points. Looking at it from the DDS perspective, these are:
  1. Design-time system definition to include TSN-related properties
  2. Run-time DDS implementation to leverage TSN network
  3. Deployment-time actions to instruct TSN-enabled equipment
- All three need to be addressed by the OMG DDS-TSN standardisation

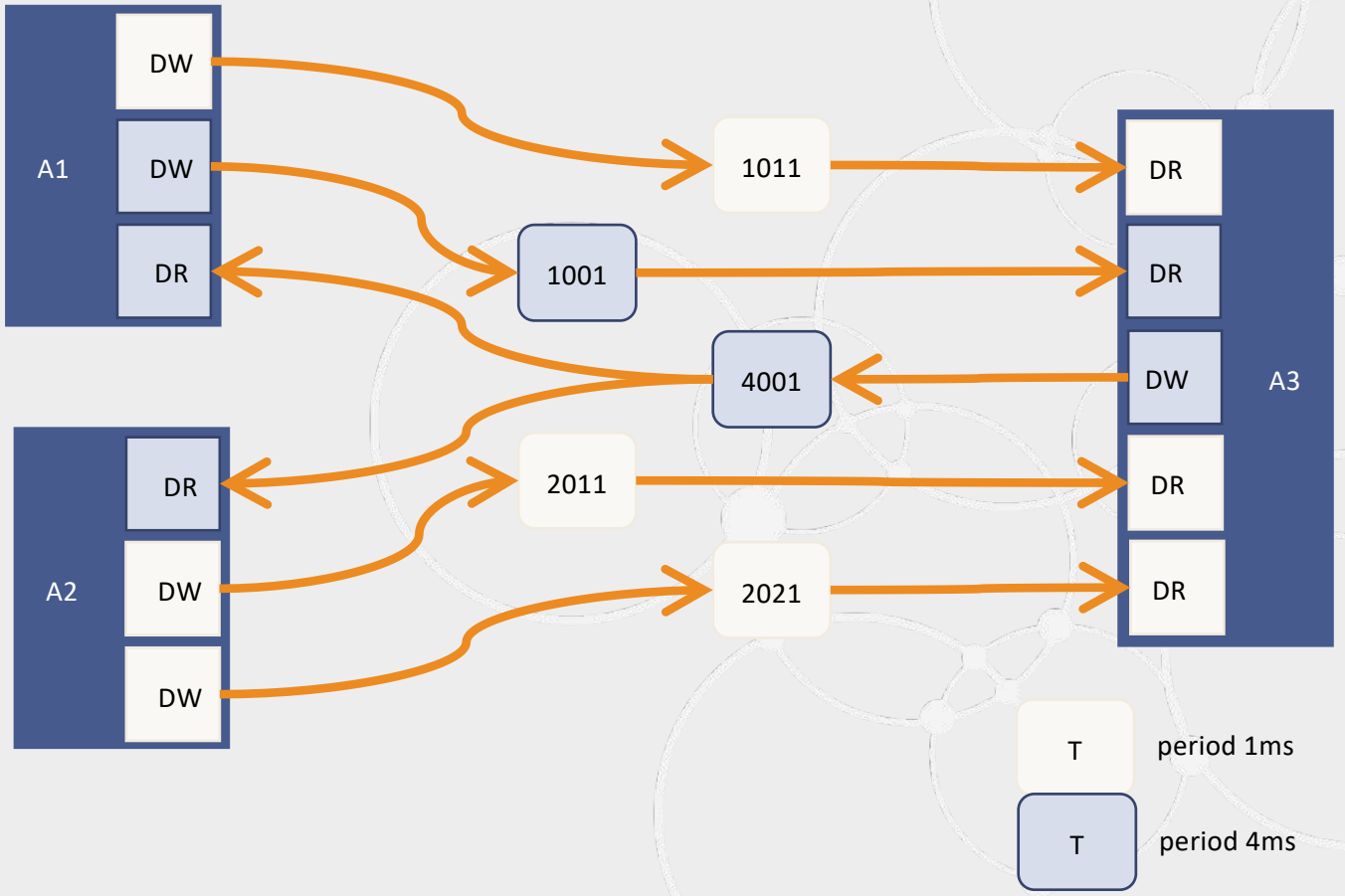
Design-time system definition

- In order to allow DDS-TSN integration, DDS design-time system definitions need to be extended, for example with:
  - DDS data flow properties such as “criticality” and “periodicity”
  - DDS endpoint location information, in combination with the underlying network topology

Run-time DDS implementation

- DDS implementations should know how to interact with the TSN network and do it in a standardized way
  - For certain use cases, using the Level-3 (UDP/IP) stack in the right way is good enough
  - For other uses cases, Level-2 (ETH) access is required and no standardized TSN APIs mechanisms seem to be available for that
  - Again, need to collaborate with TSN standardization body

DDS + TSN (Time Sensitive Networking)



OMG RFP

- **OBJECT MANAGEMENT GROUP ISSUES DDS-TSN REQUEST FOR PROPOSALS**
  ALLOWS DDS INFRASTRUCTURES BE DEPLOYED ON, AND LEVERAGE, TSN-ENABLED NETWORKS

- https://www.omg.org/news/releases/pr2018/10-08-18.htm

Thank you

Bob Leigh
Director of Market Development
bobl@rti.com

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