Service Oriented Architecture: Design and Implementation Using Automotive Linux BSP

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SECURE CONNECTIONS FOR A SMARTER WORLD

Agenda

- Introduction to Service Oriented Architecture Frameworks
- NXP’s infrastructure for SoA
- Applications & Use Cases

Introduction to Service Oriented Architecture Frameworks

Vehicle Architectures

Mega Trends: Safe and Secure Mobility

Autonomy

- Different sensor types
- Data fusion:
  Safe Processing with
  Integrated AI capabilities

- Fail operation
- Big Data

Electrification

- Power Efficiency
- Battery Management
- Electrification Levels
  Hybrid, full electric…

- Broad range of solution
- Need for standardization

Connectivity

- V2X, 5G, Digital Radio
- Diagnostics / Prognostic Health Management
- OTA Update Management
- Analytics (edge to cloud)

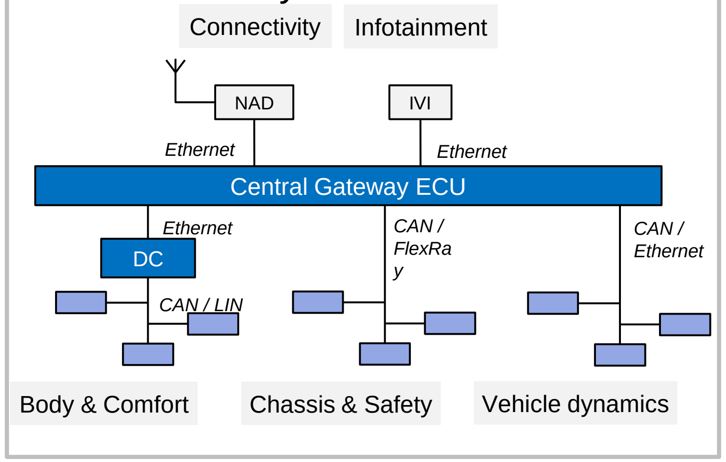
- Software-centric solutions
- System security

Major Changes in Network Topology and E2E Architectures

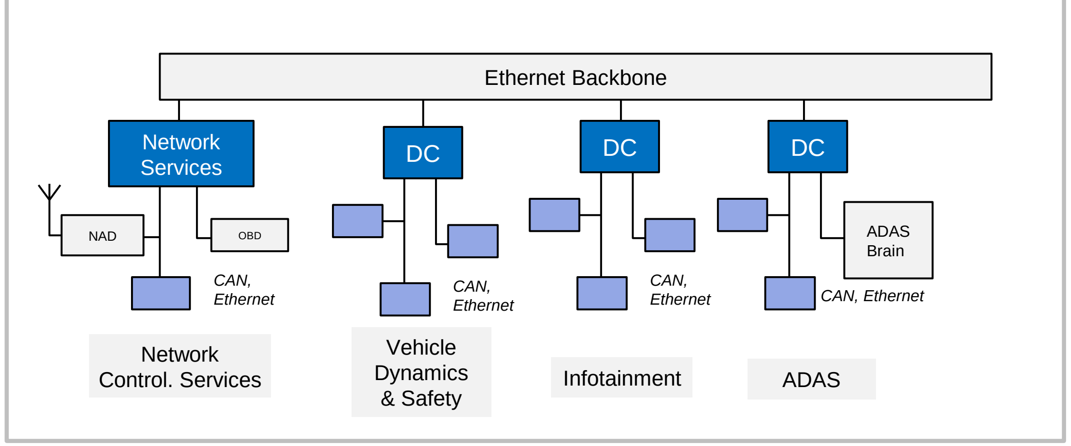
Vehicle Architectures

Different networking models across the 4 options

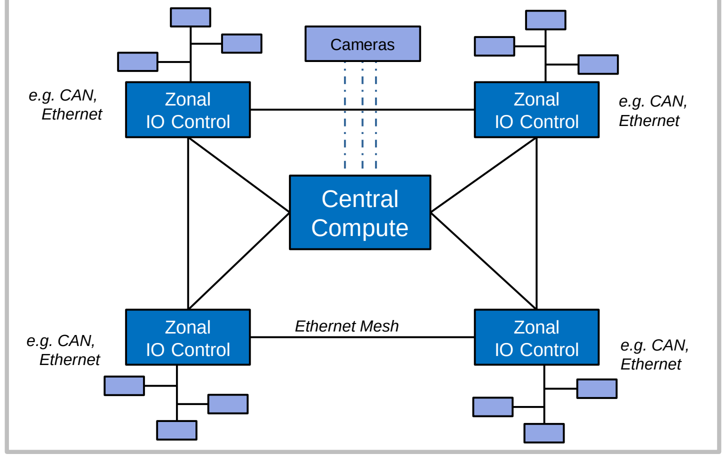
Central Gateway



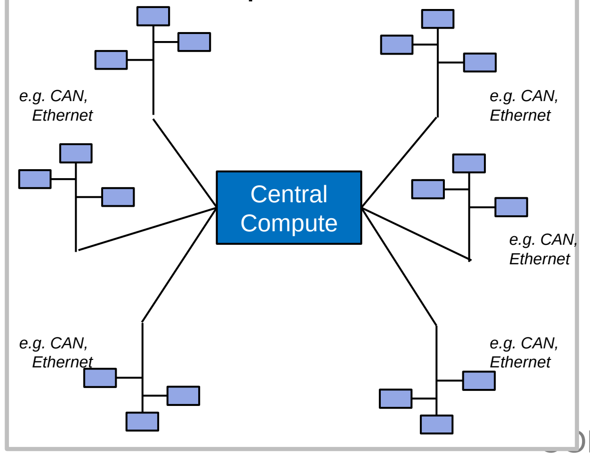
Domain Architecture



Zonal Architecture



Central Compute - Star



Vehicle Architectures

Mega Trends: Embedded Software become Software

Technology Trends

AUTONOMY
ELECTRIFICATION
CONNECTIVITY

E/E Implication

- **ECU Platform**
- **Topology**
- **Communication**

- **OSEK/VDX**
- **Signal Comm**
- **Static configuration**

→

- Rich Operating Systems (e.g. Linux)
- **Service Oriented Architecture**
- Dynamic configuration

Signal vs Service Oriented Communication Paradigms

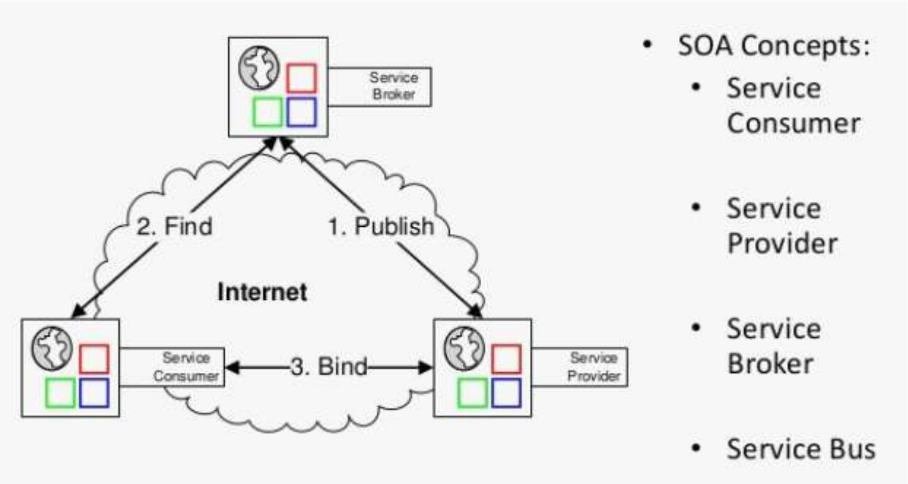
Background

With signal-oriented data transmission information is sent when the sender sees a need, such as when values are updated or changed, independent of whether these data are currently needed by a receiver in the network

Signal-oriented data transmission is used on classic bus systems (CAN, LIN, FlexRay)

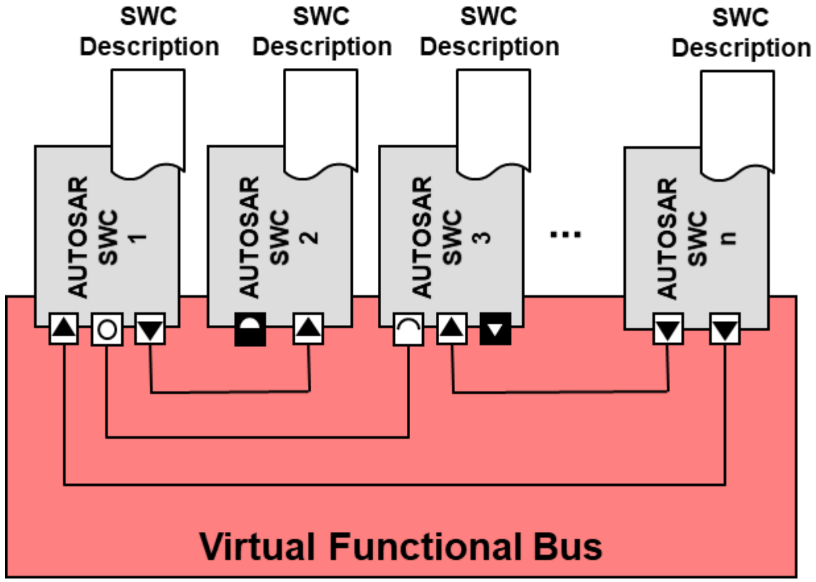
Service-oriented data transmission, a sender only sends data when at least one receiver in the network needs this data. The advantage of this procedure is that the network and all connected nodes are not loaded by unnecessary data.

Service-oriented data transmission is mainly using Ethernet bus

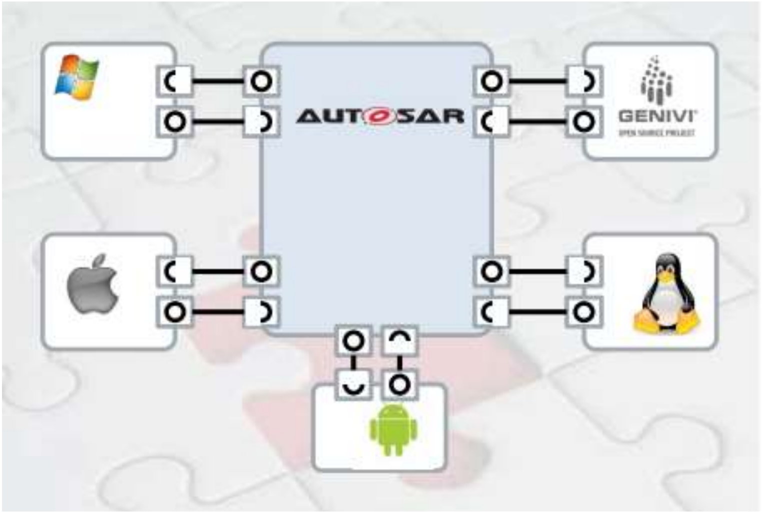


Service-oriented Architecture – SoA

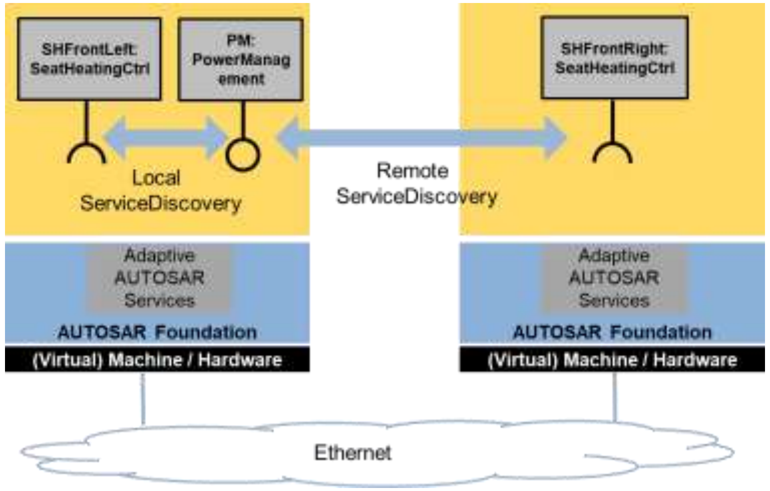
All about Middleware



Source: AUTOSAR_GuidedTour.ppt



Source: ISITA_World_Summit_2015_FUERST_Simon__for_web_.pdf



Source: AUTOSAR_AdaptivePlatformFor_EXP_TechnicalOverview.pptx

Service-oriented Architecture (SoA)

Service-orientated Architecture (SoA) is a **way of designing software** where the participating components provide and consume services over a predefined protocol over a network

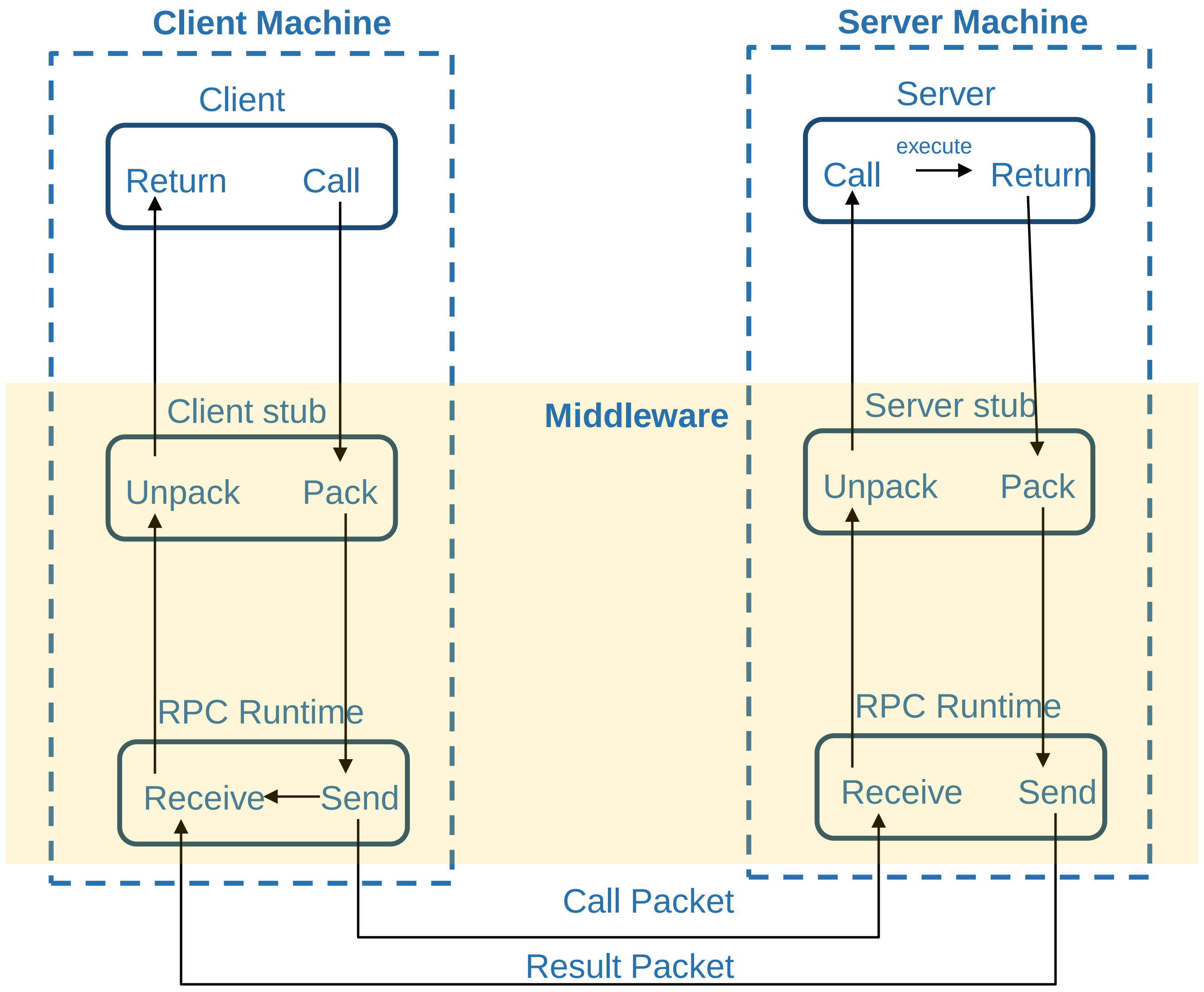
Functionality Separation	Functionality Distribution	Interoperability	Reusability
Units Services	Ownership domains	Interfaces Protocols	Combination Integration

A **service** is a discrete unit of functionality which can be remotely accessed and independently updated.

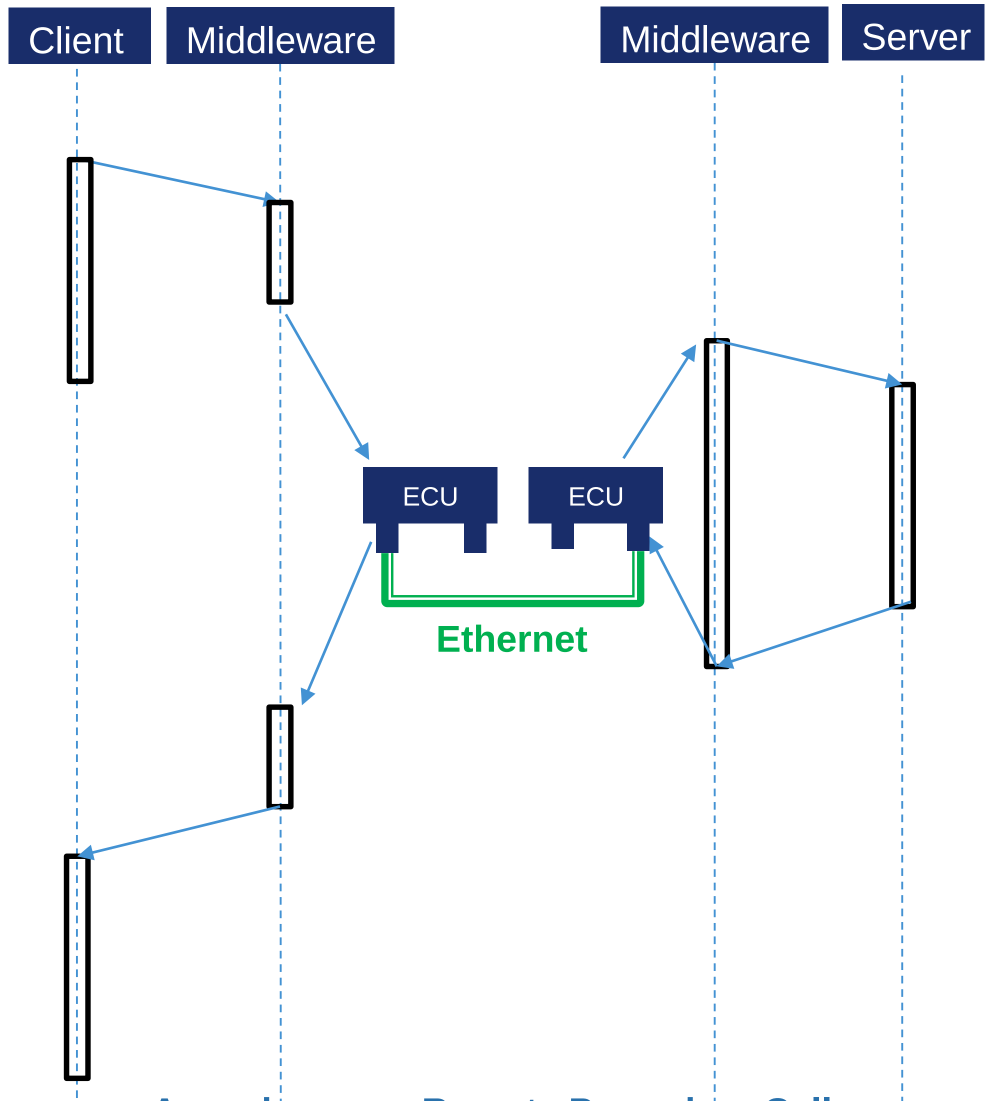
- Functional Unit
- Self Contained
- Black-box
- Stateless
- Reusable
- Standardized interfaces

Service-oriented Architecture (SoA)

Asynchronous Remote Procedure Calls



Implementation of RPC for SoA



Asynchronous Remote Procedure Calls

Service Oriented Middleware – SOME/IP

SOME/IP = **S**calable service-**O**riented **M**iddlewar**E** over **IP**

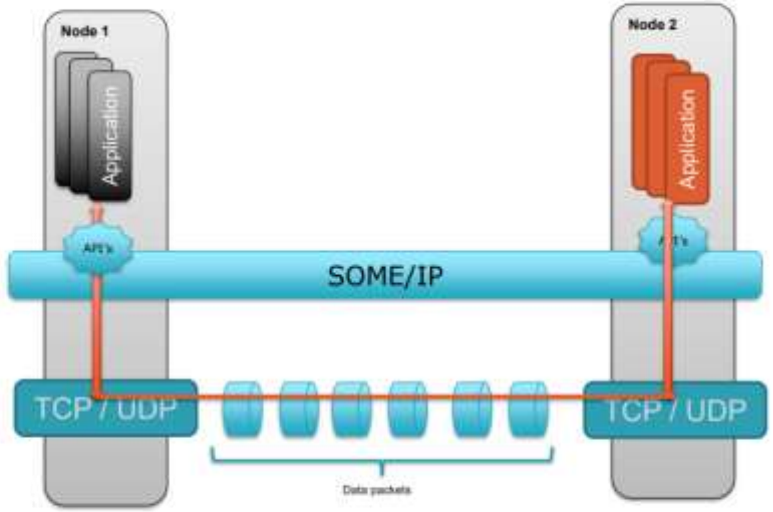
- SOME/IP provides service oriented communication over a network

- SOME/IP supports a wide range of middleware features:
  - Serialization
  - Remote Procedure Call (RPC)
  - Service Discovery (SD)
  - Publish/Subscribe (Pub/Sub)
  - Segmentation of UDP messages

- SOME/IP can be implemented on different operating systems

- SOME/IP is used for inter-ECU Client/Server Serialization

- SOME/IP allows applications to communicate.



Source: [SOME-IPIntro.pdf]

Service Oriented Middleware – SOME/IP

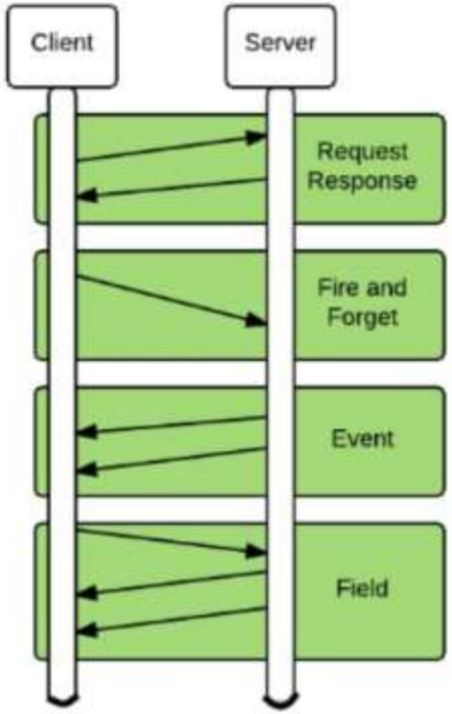
Services

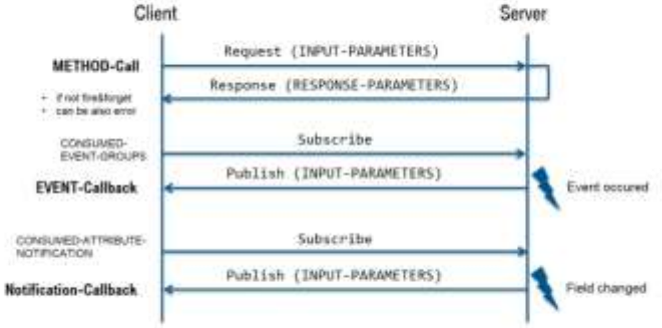
- **Request/Response** – a method call with Request and Response messages

- **Fire&Forget** – a method invocation with just a Request message (does not support answers and errors)

- **Event** – a Fire&Forget callback, that is sent out by the Server (e.g. cyclically or on change)
  – Sent from Server to Client (Similar to regular CAN messages)

- **Field** – represents a remote accessible property that includes Getter/Setter and/or Notification (similar to a property on MOST)





Service Oriented Middleware – SOME/IP

Service Discovery - SD

SOME/IP-SD is used to:

- Locate service instances.
- Detect if service instances are running.
- Implement the **Publish/Subscribe** handling

Image source:
realtimeapi.io/hub/publishsubscribe-pattern/

Service Oriented Middleware – SOME/IP

Pros and Cons[1]

Main Advantages:

- Coexistence with existing system
  > No functional Loss
- High Data Rate and Unicast
  > Increase data transfer amount
- Low Transportation Overhead
- Dynamic IP Addressing
  > Gain in maintainability and flexibility

Possible Issues:

- Computational Overhead due to complex architectures
- Increase Storage Requirements
- Single Point of Failure (e.g. Switch Malfunction)

Recommended usage:

- Suitable for driver assistance and Infotainment systems
- Still to complex for Hard Real-time system (e.g motor control)

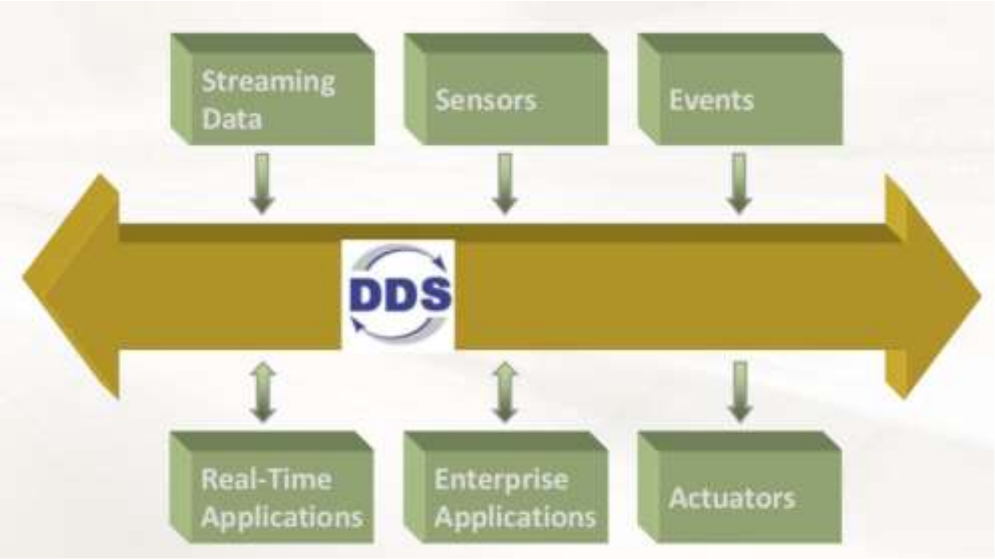
Several Open Source implementations (e.g. GENIVI vsomeip)

[1] https://www.slideshare.net/DaiYang/scalable-serviceoriented-middleware-over-ip

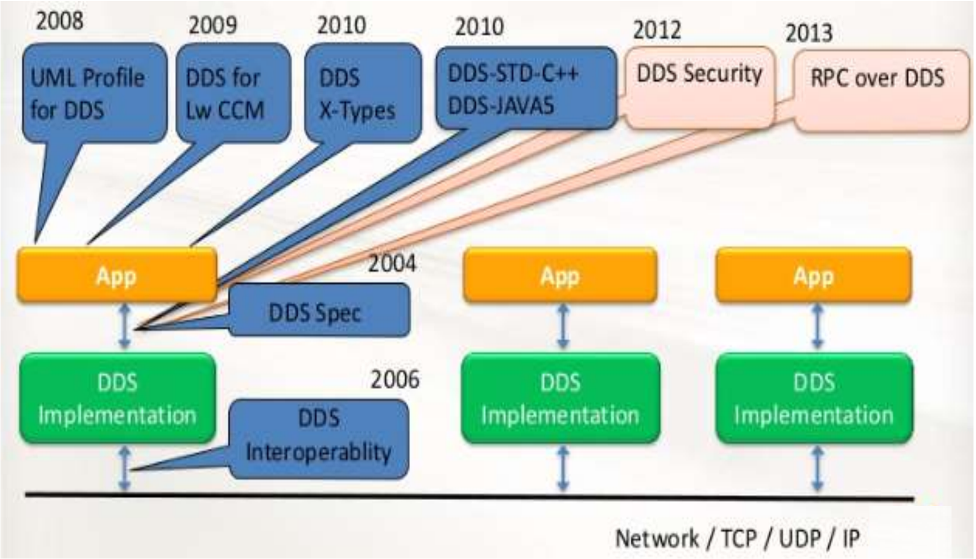
Service Oriented Middleware – DDS

DDS = Data Distribution Software

Standard-based Integration Infrastructure for Critical Applications



Family of specifications



Images source:
http://www.slideshare.net/SumantTambe/communication-patterns-using-datacentric-publishsubscribe
https://www.rti.com/deep-dive-into-the-dds-opc-ua-gateway-specification

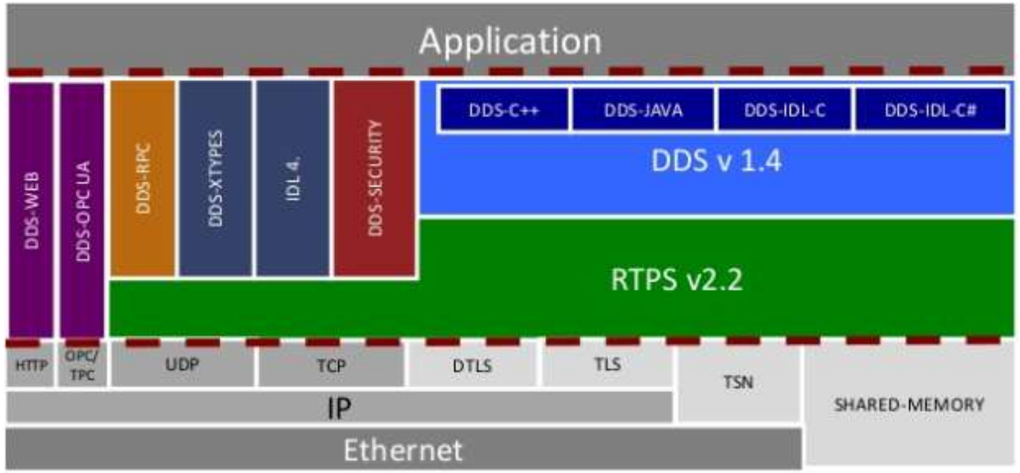
Service Oriented Middleware – DDS

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

Images source:
http://www.ieee802.org/1/files/public/docs2018/dg-leigh-autosar-dds-tsn-use-case-1218-v02.pdf

OMG: Object Management Group
RTPS: Real-Time Publish/Subscribe



DDS Wire Protocol (RTPS)

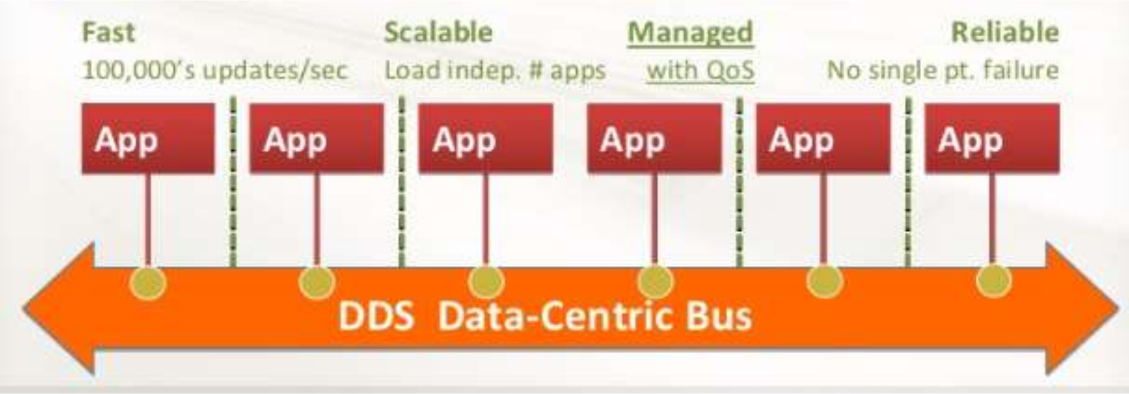
- Peer to peer
- Transport-independent QoS-aware and Reliable Communication
  – Including multicast, for 1-many reliable communication
- Any data size over any transport.
- Automatic Discovery and Presence Plug and Play
- Decoupled
  – Start applications in any order
- Support for Redundancy
  – Multiple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

Service Oriented Middleware – DDS

Communication pattern based on Data-centric Publish/Subscribe

Provides a “**Global Data Space**” that is accessible to all interested applications.

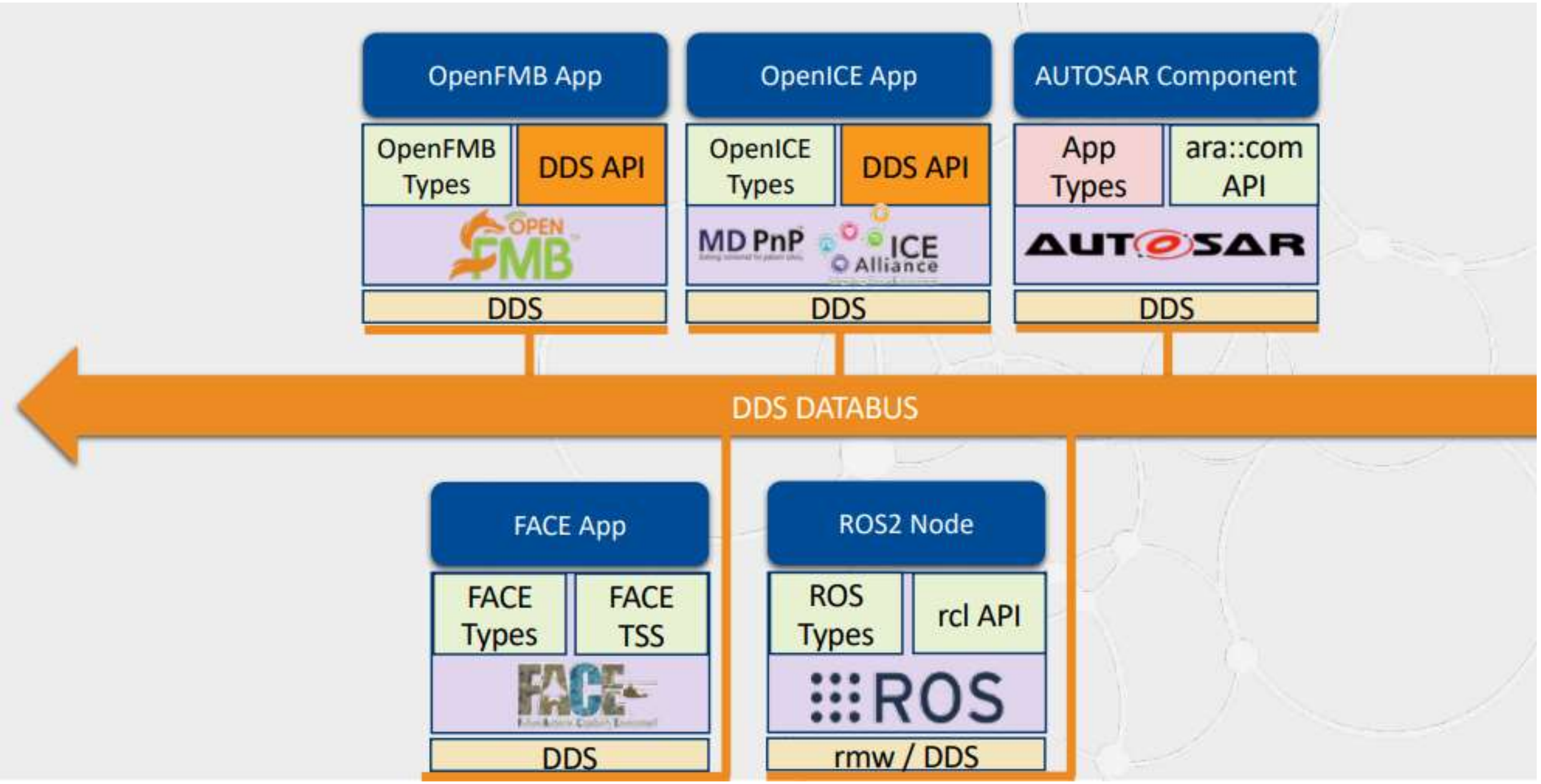
- Data objects addressed by **Domain, Topic** and **Key**
- Subscriptions are **decoupled** from Publications
- Contracts established by means of **QoS**
- Automatic **discovery** and **configuration**



Images source: http://www.slideshare.net/SumantTambe/communication-patterns-using-datacentric-publishsubscribe

Service Oriented Middleware

DDS as Core Connectivity Framework

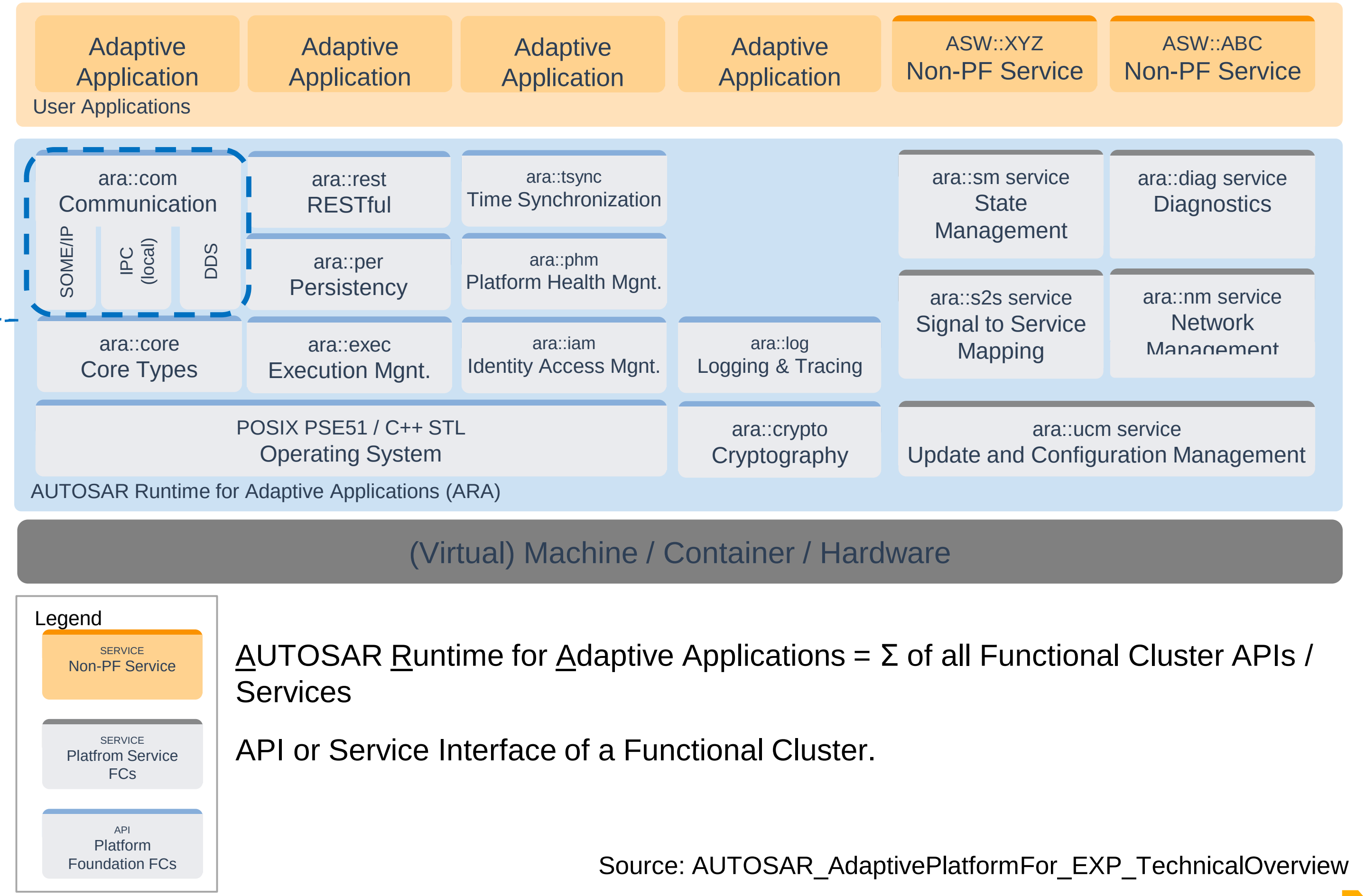


Images source: http://www.slideshare.net/SumantTambe/communication-patterns-using-datacentric-publishsubscribe

Adaptive AUTOSAR

as Service Oriented Communication Framework

- ara::com is the Communication Management API for the AUTOSAR Adaptive Platform.
- 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)



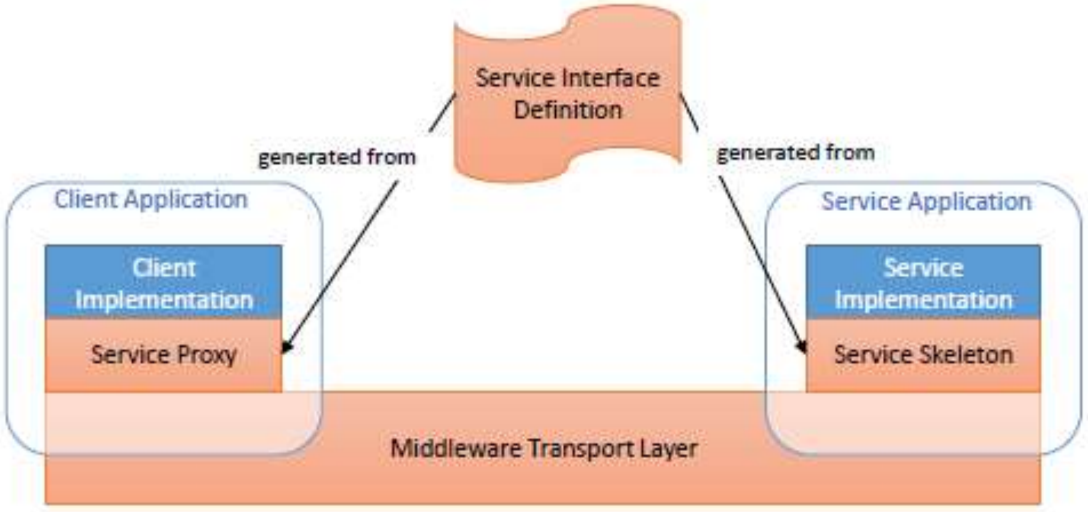
AUTOSAR Runtime for Adaptive Applications = Σ of all Functional Cluster APIs / Services

API or Service Interface of a Functional Cluster.

Source: AUTOSAR_AdaptivePlatformFor_EXP_TechnicalOverview

Service Oriented Middleware – Adaptive AUTOSAR

ARA::COM - Service-oriented Communication – Proxy/Skeleton Paradigm



Two code artifacts are generated from AUTOSAR ARXML service description.

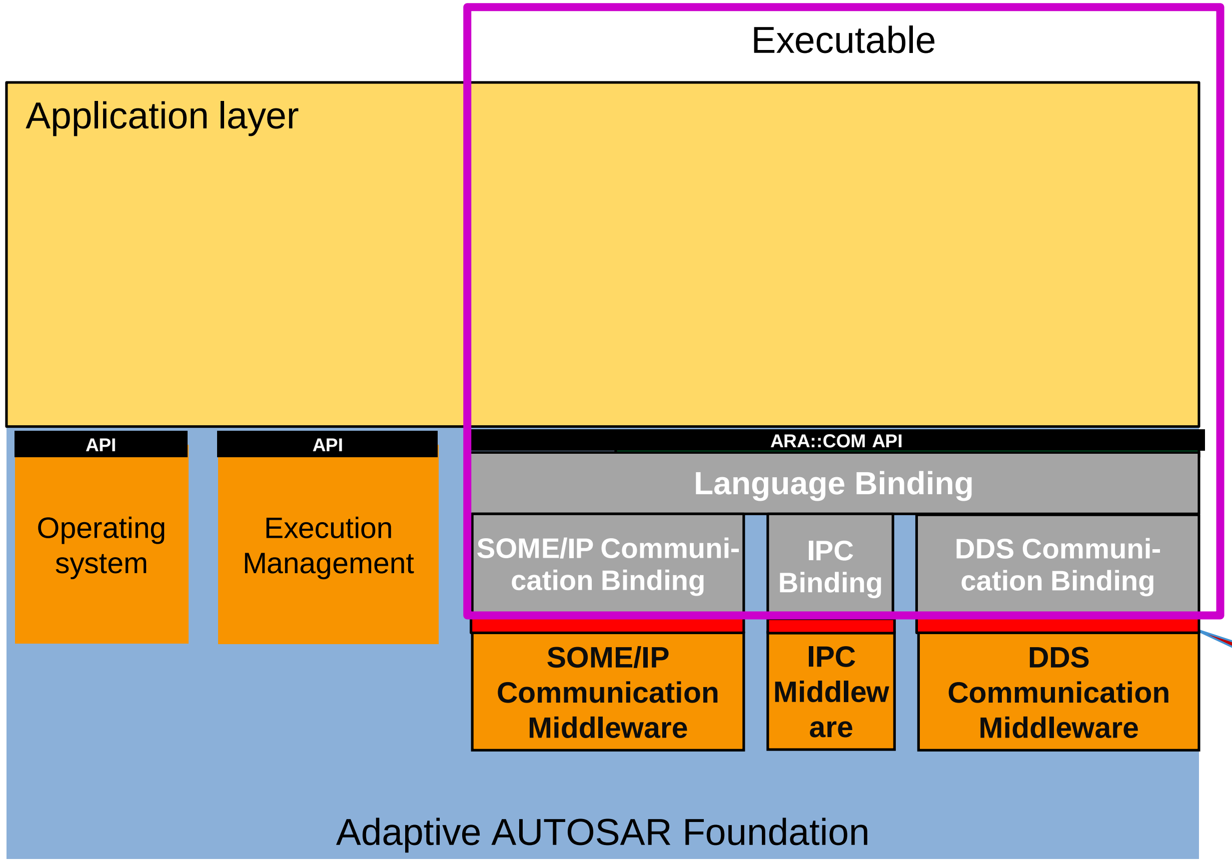
- Service Proxy: facade: an instance of a generated class, which provides methods for all functionalities the service provides.
- Service Skeleton: instance of a generated class which allows to connect the service implementation to the Communication Management transport layer

- Bindings can be implemented for REST, DDS or other Middleware Transport Layers that support publish / subscribe / event patterns
- SOMEIP is the default transport layer available on the shelf for ARA::COM
- Transport Layer is not necessary network, it can be shared memory or direct function calls if client and service are running the same ECU / address space

Source: AUTOSAR
AUTOSAR_AdaptivePlatformFor_EXP_TechnicalOverview

AUTOSAR Adaptive – Architectural Overview

ARA::COM – Language and Network Binding

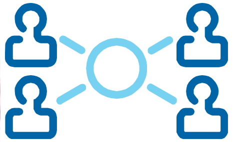


- An Adaptive Application may use different communication bindings underneath the ara::com common API.
- DDS is placed parallel to other network bindings such as SOME/IP.

Not standardized
- analog to
Com_SendSignal()

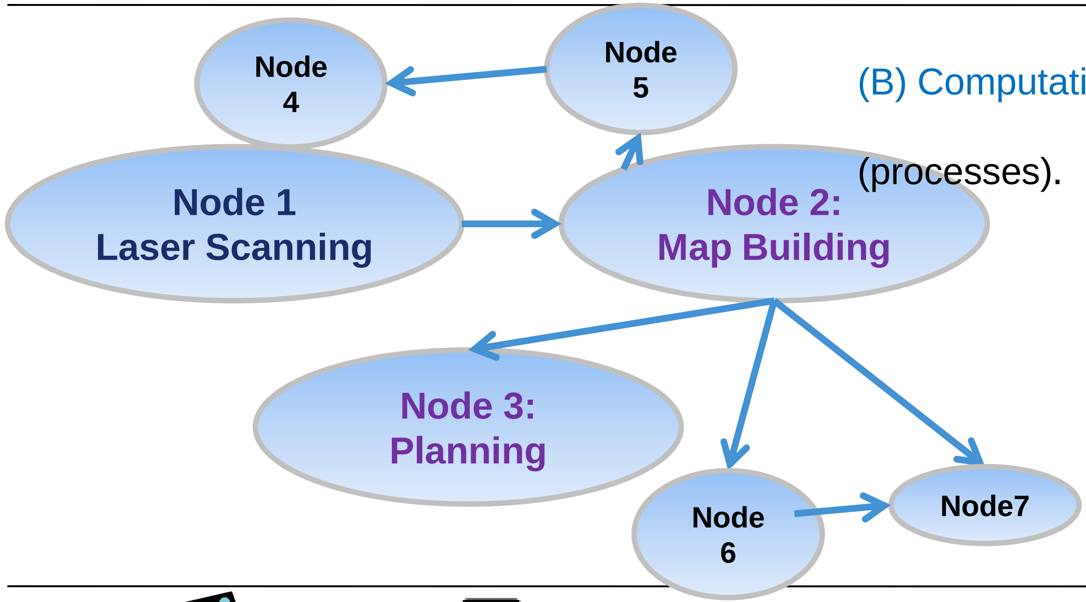
Source: AUTOSAR
AUTOSAR_AdaptivePlatformFor_EXP_TechnicalOverview

Service Oriented Middleware – ROS

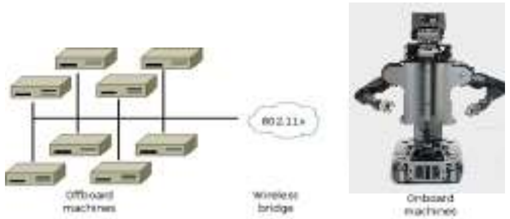


Carnegie Mellon

(A) ROS Community: ROS Distributions, Repositories

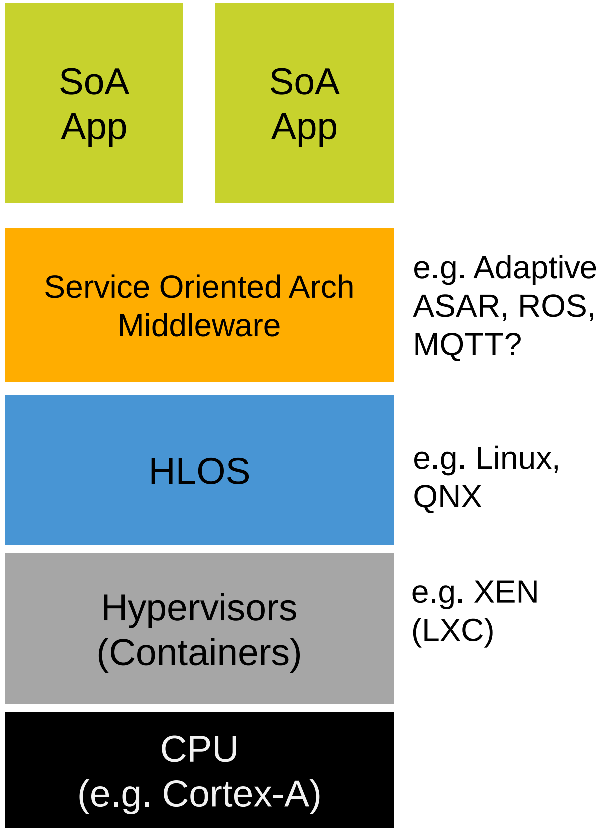


(B) Computation Graph: Peer-to-Peer Network of ROS nodes (processes).



(C) File-system level: ROS Tools for managing source code, build instructions, and message definitions.

SW Environment: SoA



Definition

- SoA: Service Oriented Architecture
  - Applications built with ‘service’ layer of abstraction
  - SoA App is not bound to specific OS, SOC, or even ECU
  - SoA Apps also referred to as ‘Services’
  - Framework that will transform how vehicle features are built and deployed – portability at forefront (static or dynamic)
- SoA Framework examples:
  - Adaptive AUTOSAR
  - MQTT
  - ROS

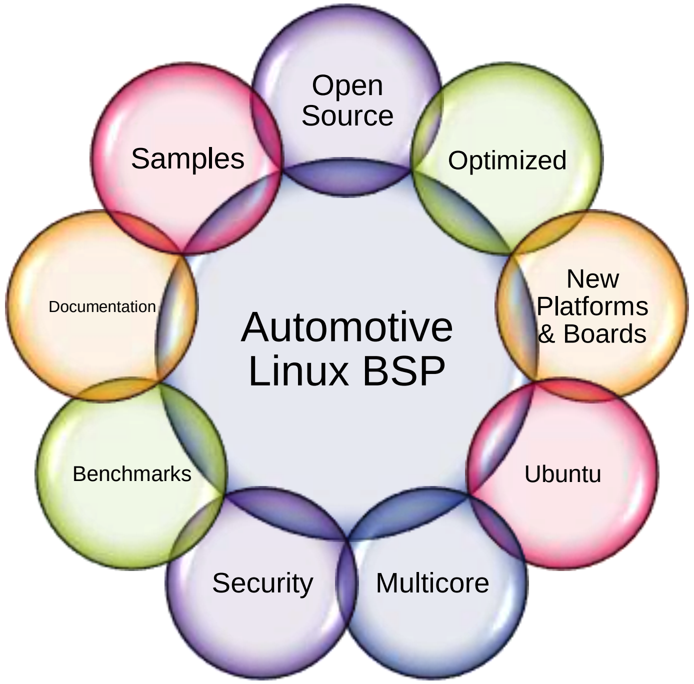
Why

- Motivation
  - Ease of development, deployment & integration
    - OEMs move away from deploy features by ECU, to features by SoA Apps.
    - Tier1 moves to deliver SoA Apps to OEMs, rather than ECUs.
    - Simplifies the OTA deployment
- Challenges for SOC Arch
  - Difficult to HW enforce isolation of SoA Apps for security / safety
  - **SoA Framework dictates performance, security & safety. Framework provider & SOC provider need to work closely to make use of hardware features.**

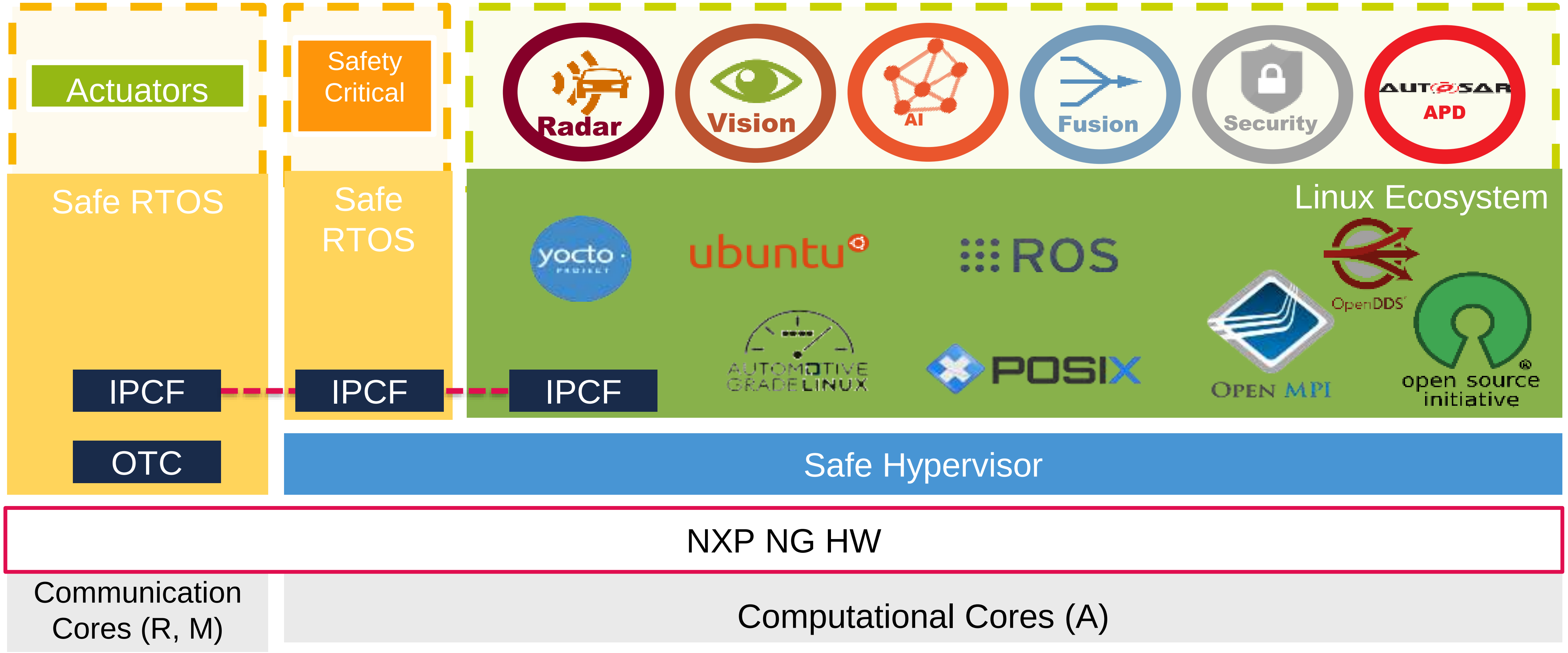
NXP’s Infrastructure for SoA Automotive Linux BSP

Overview of Automotive Linux BSP

- A Linux BSP for all NXP Automotive Platforms
- Targeting ADAS, C&S and Disty Market
- Integrated with SDKs (Vision, Radar, Ethernet)
- Quarterly Releases
- A single package for multiple SOCs

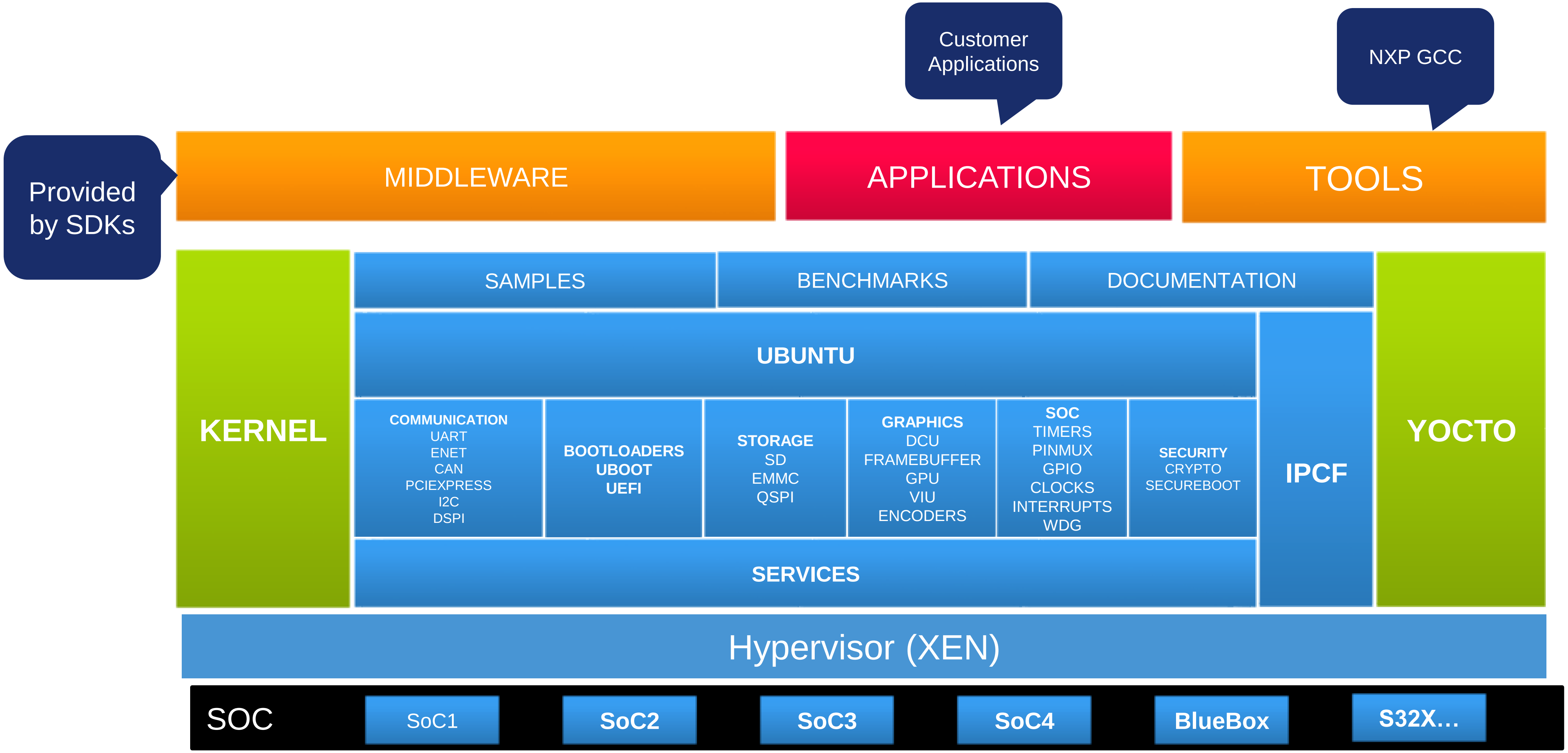


Automotive Linux BSP – Ready for SOA Prototyping



We are building an Infrastructure leveraging huge open source ecosystem and various communities targeted automotive software

Automotive Linux BSP - Product Architecture



Adaptive AUTOSAR – Reference Implementation

Adaptive AUTOSAR ready to use/build ecosystem

Adaptive Application

Adaptive AUTOSAR Foundation

ara::com
Communication Mgnt.
SOME/IP
IPC (local)
DDS

ara::rest
RESTful

ara::tsync
Time Synchronization

ara::per
Persistency

ara::phm
Platform Health Mgnt.

ara::core
Core Types

ara::exec
Execution Mgnt.

ara::iam
Identity Access Mgnt.

ara::log
Logging & Tracing

POSIX PSE51 / C++ STL
Operating System

ara::crypto
Cryptography

ara::sm service
State Management

ara::diag service
Diagnostics

ara::s2s service
Signal to Service Mapping

ara::nm service
Network Management

ara::ucm service
Update and Configuration Management

OS Abstraction Layer (OSAL)

Linux | QNX | Integrity

OS (+ BSP)

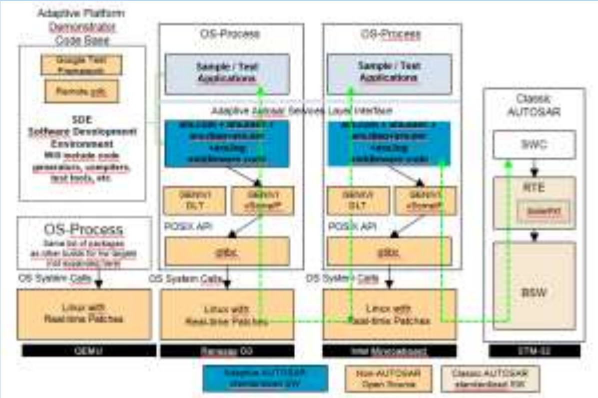
Linux BSP | QNX BSP

NXP Develop

NXP and/or 3rd party

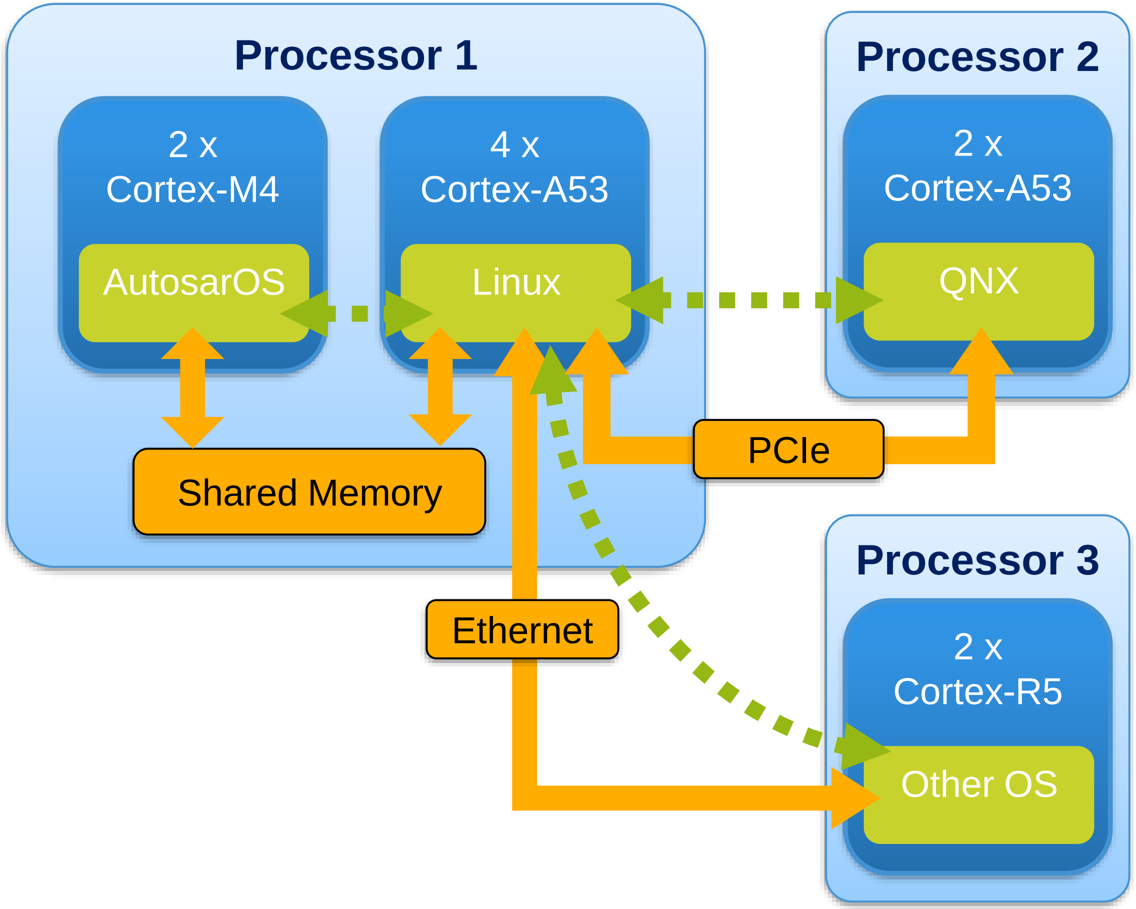
3rd party

Adaptive Platform Demonstrator

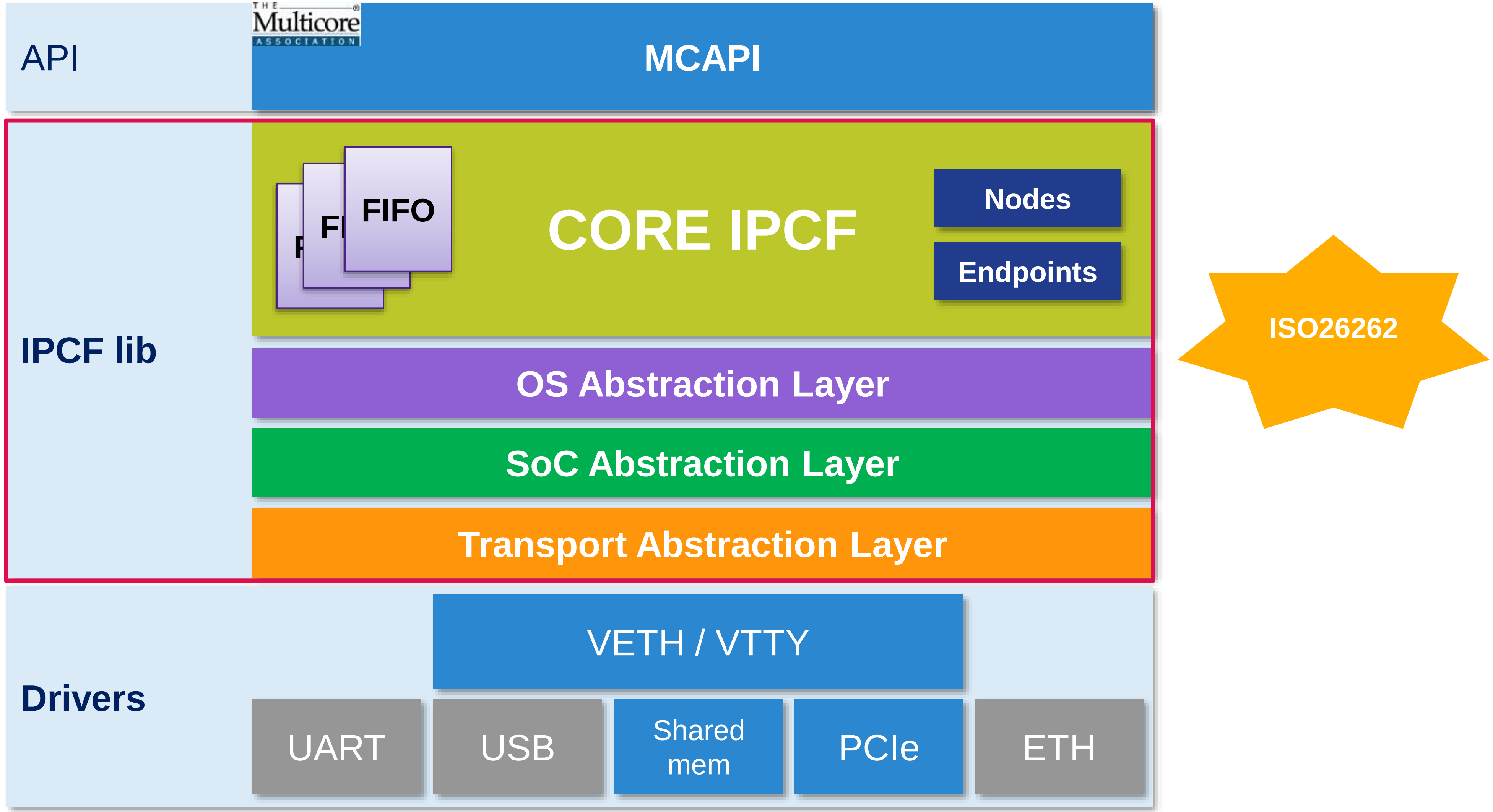


Inter-Platform Communication Framework (IPCF)

- Multiple homogeneous or heterogeneous processing cores
- Located on a single chip or on multiple chips in a circuit board
- Running multiple OSes
- Communicating over various interfaces:
  - Ethernet
  - PCIe
  - USB
  - UART, SPI
  - Shared memory

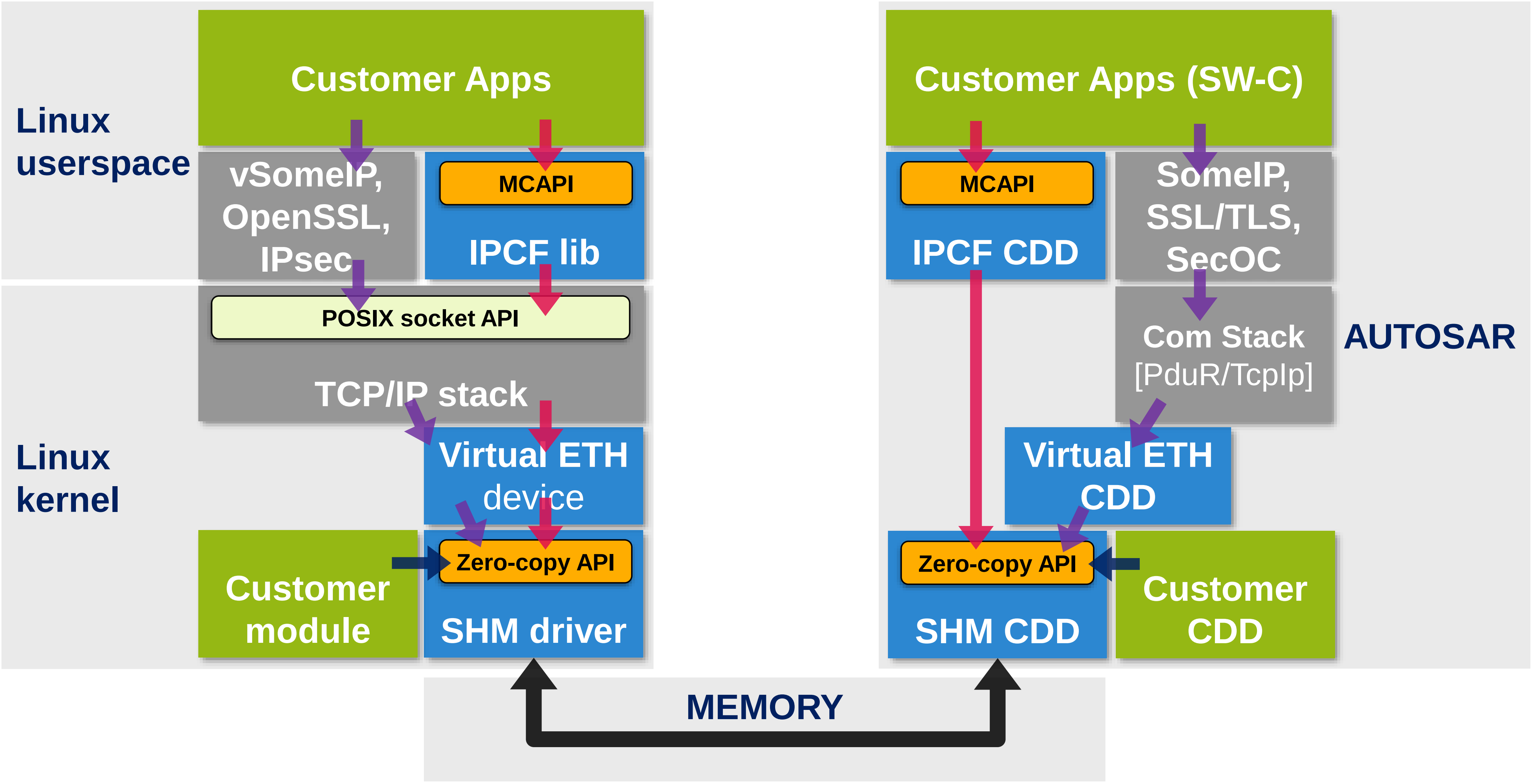


IPCF

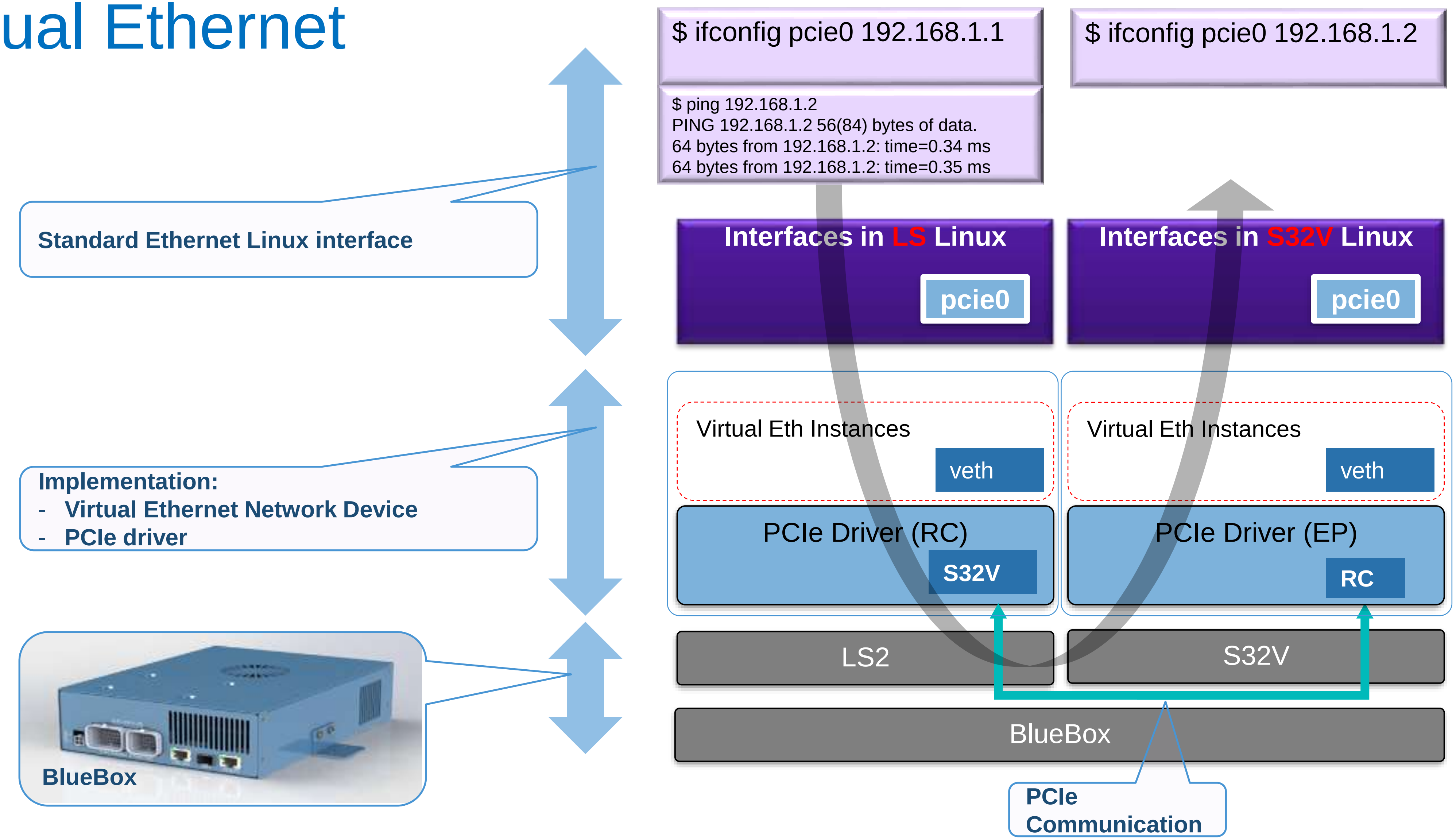


API
MCAPI
THE Multicore ASSOCIATION
IPCF lib
FIFO
CORE IPCF
Nodes
Endpoints
OS Abstraction Layer
SoC Abstraction Layer
Transport Abstraction Layer
Drivers
VETH / VTTY
UART
USB
Shared mem
PCIe
ETH
ISO26262

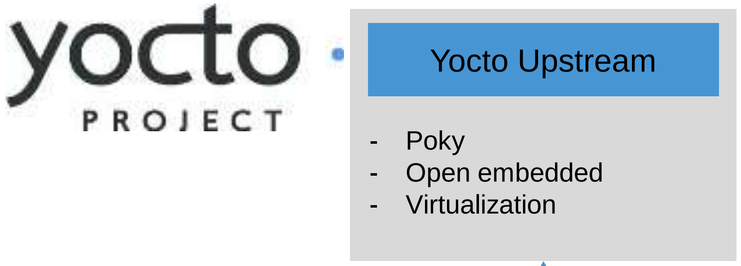
IPCF – Linux2AUTOSAR over Shared Memory



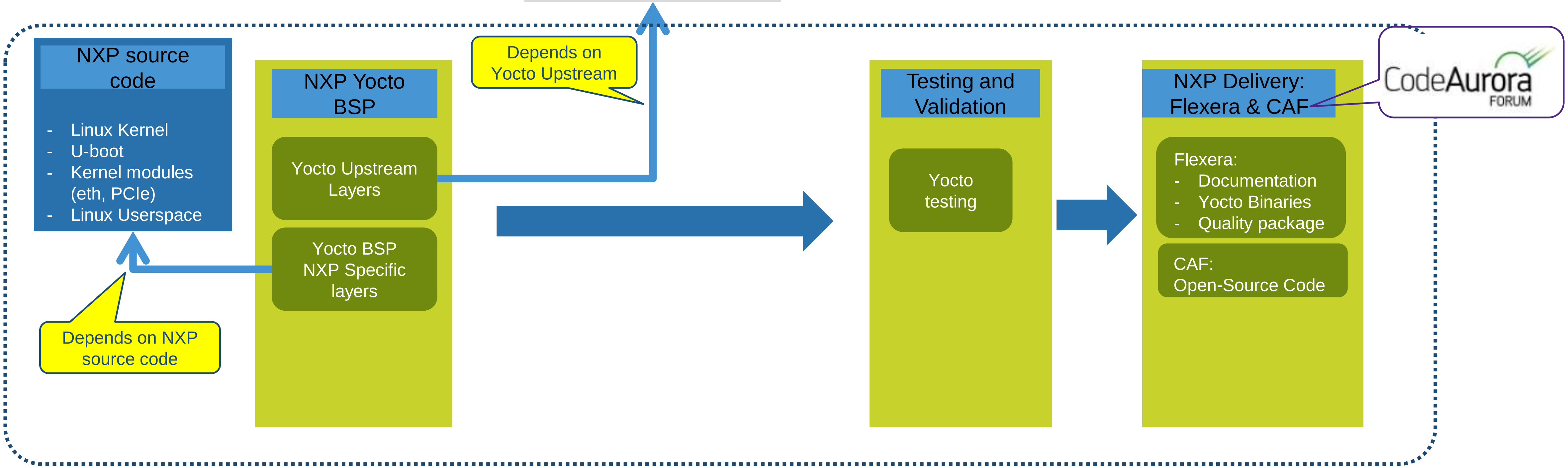
Virtual Ethernet



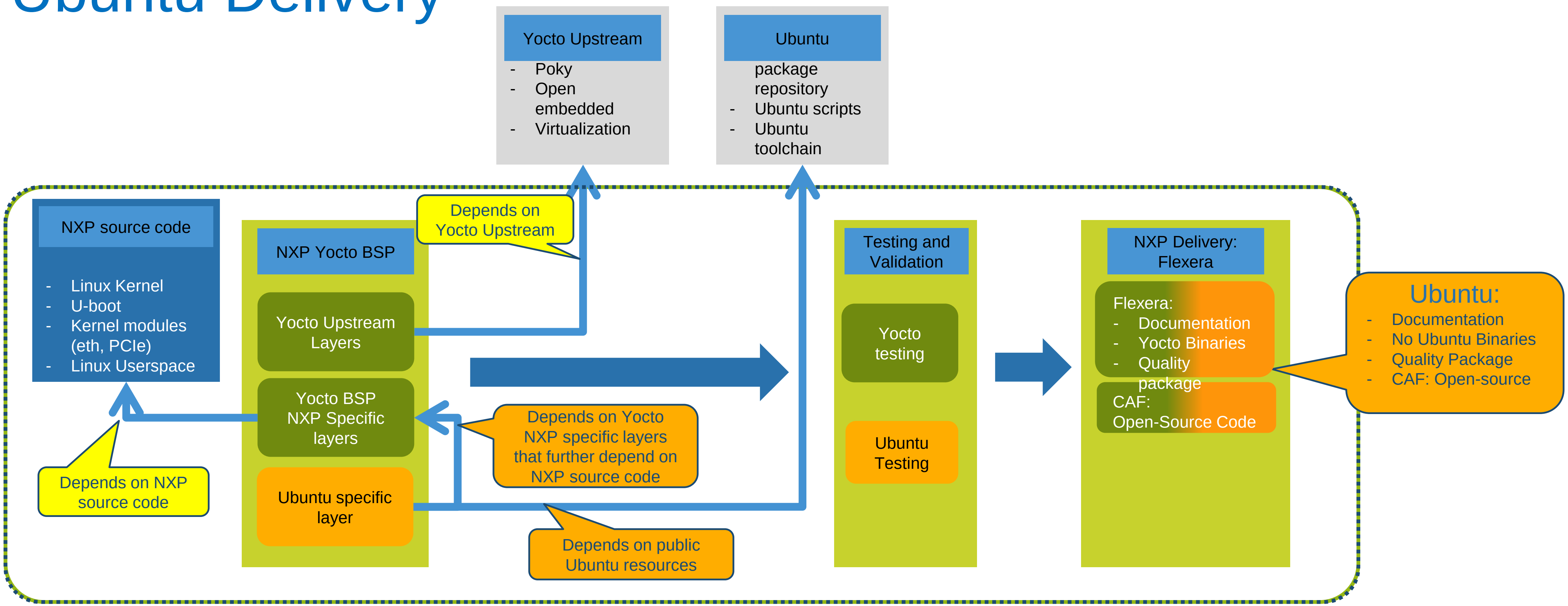
Linux BSP Delivery: Easy of Use Using Yocto



Yocto Project: An *open source* collaboration project that provides templates, tools and methods to help you create custom Linux-based systems for embedded products



Ubuntu Delivery



Ubuntu Delivery – The same delivery mechanism as for Yocto

- The Ubuntu is generated from Yocto build, with Yocto/bitbake commands. This includes
  - Getting the Ubuntu packages
  - Building the NXP specific source code

Customer Flow

Start Here:

nxp.com->Flexera

Flexera:
- Documentation
- Yocto Binaries
- Quality package
- No Open Source Archive

GPU User-space Libraries

Separate locations for Open Source code (CAF) and proprietary (Flexera)

Install Open Source Linux BSP using repo commands

Open Source components automatically downloaded from CAF

CodeAurora FORUM

GIT repository for Open Source components
- Linux
- U-boot
- Yocto
- Drivers & Apps

```
$ repo init -u https://source.codeaurora.org/external/autobsps32/auto_yocto_bsp
$ repo sync
```

Non-Open Source support:
Manually Download from Flexera
Example: GPU (Vivante)

```
$ # Download and enable GPU support  in Yocto
$ bitbake gpu
```

Service Oriented Architectures enabled by NXP's Automotive Linux BSP

NXP Bluebox: Central Processing Unit For Autonomous Driving

Highly Optimized Sensor Fusion

- Various sensor data streams: Radar, Vision, LiDAR, V2X
- S32V234 automotive vision and sensor fusion processor
- LS2084A embedded compute processor
- S32R27 radar microcontroller

High Performance per Power

- Up to 90,000 DMIPS at < 40 W
- Complete situational assessment
- Supporting classification
- Object detection and localization
- Mapping

Ease of Development

- ROS Space
- Open ROS Space Linux®-based system
- Programmable in linear C
- Easily customizable
- Development environment for mainstream vehicles

Decision Making

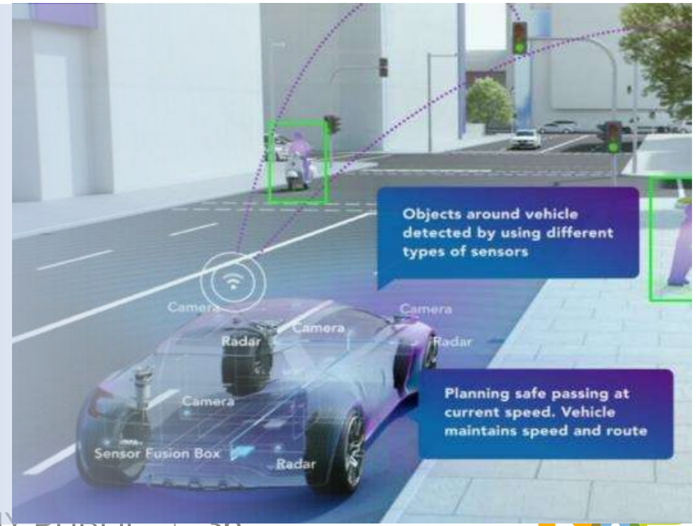
- Global Path Planning
- Behavior Planning
- Motion Planning

Security

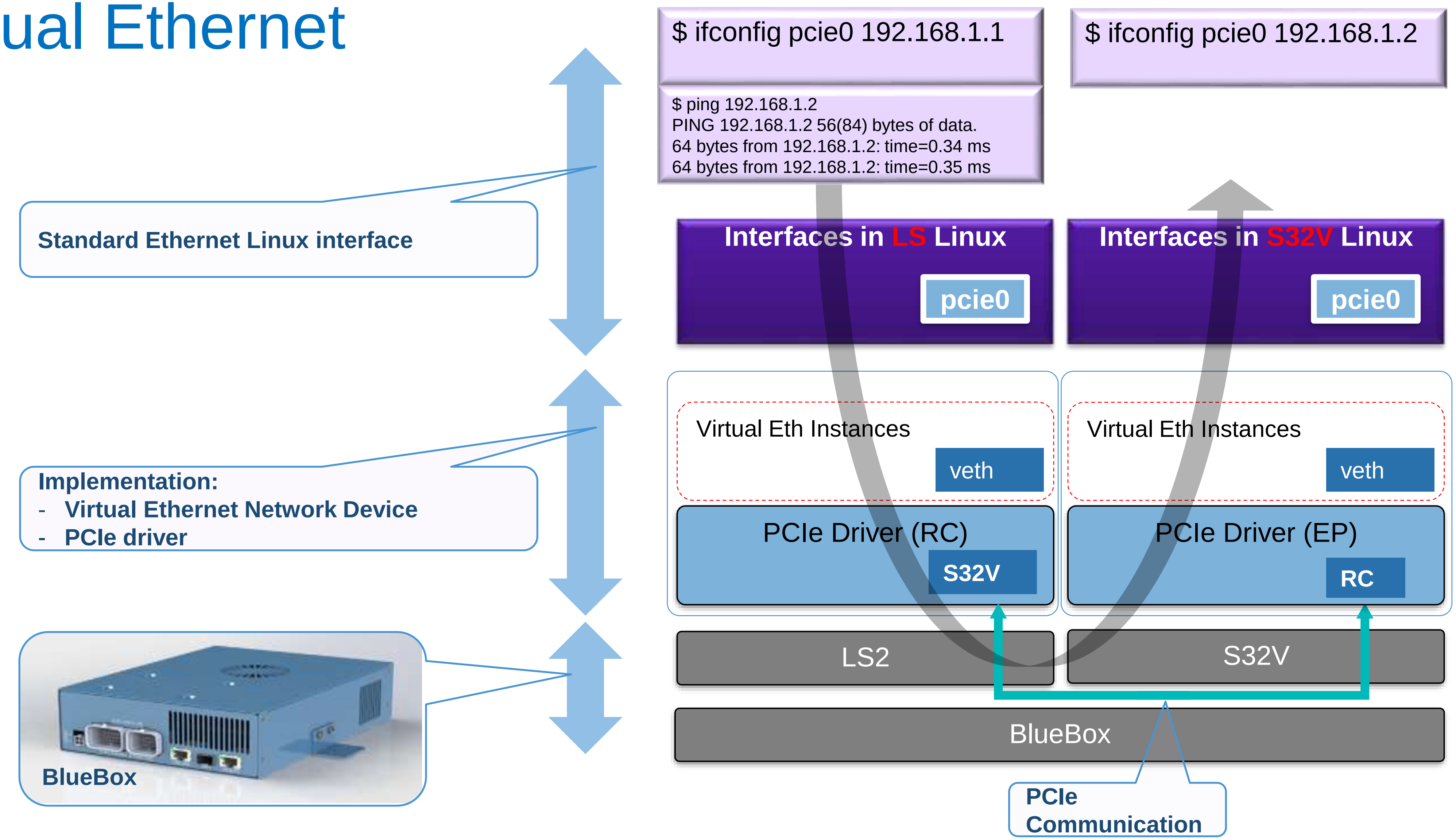
- CSE and ARM® TrustZone® technology

NXP Automated Drive Kit

- Computing: NXP BlueBox 2.0
- Vision: Front Camera Software with MIPI CSI2 Camera
- LiDAR: Selection of Lidars supported
- RADAR
- Inertial Measurement Unit & Integrated GPS
- Operating System
- Middleware: ROS (Robot Operating System)
  Adaptive AUTOSAR



Virtual Ethernet



MPC-LS VEHICLE NETWORK PROCESSING CHIPSET

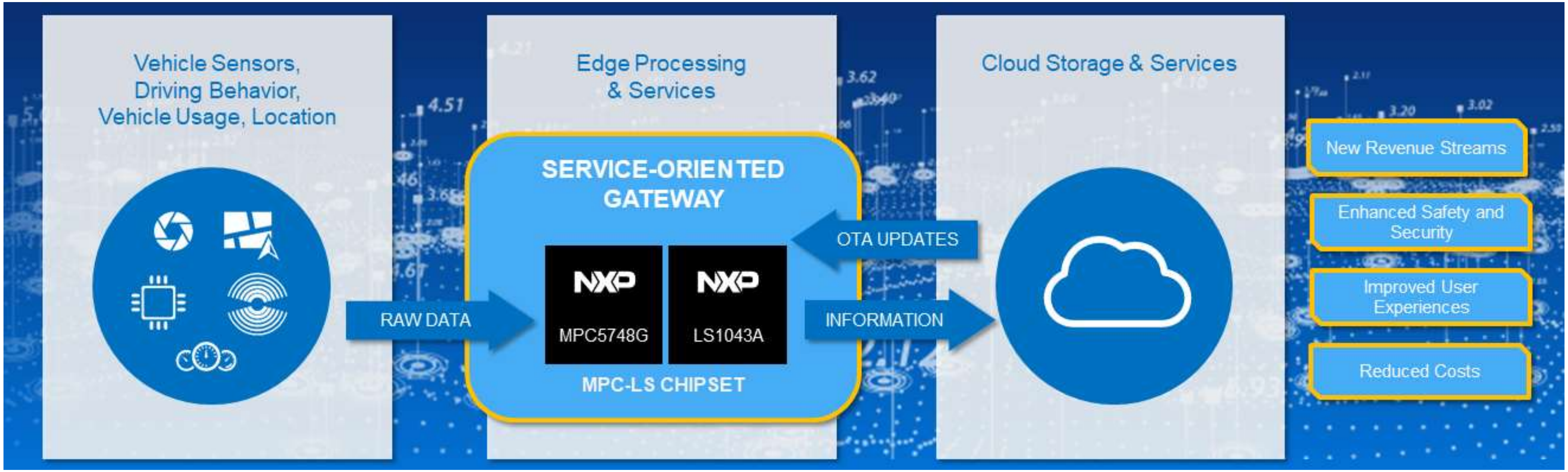
MPC-LS Vehicle Network Processing Chipset for Service-oriented Gateways

Heterogenous multi-core processing
- Real-time + high-performance applications

Automotive meets enterprise networking
- CAN FD, LIN, FlexRay™ interfaces
- Up to 10 Gigabit Ethernet with packet acceleration

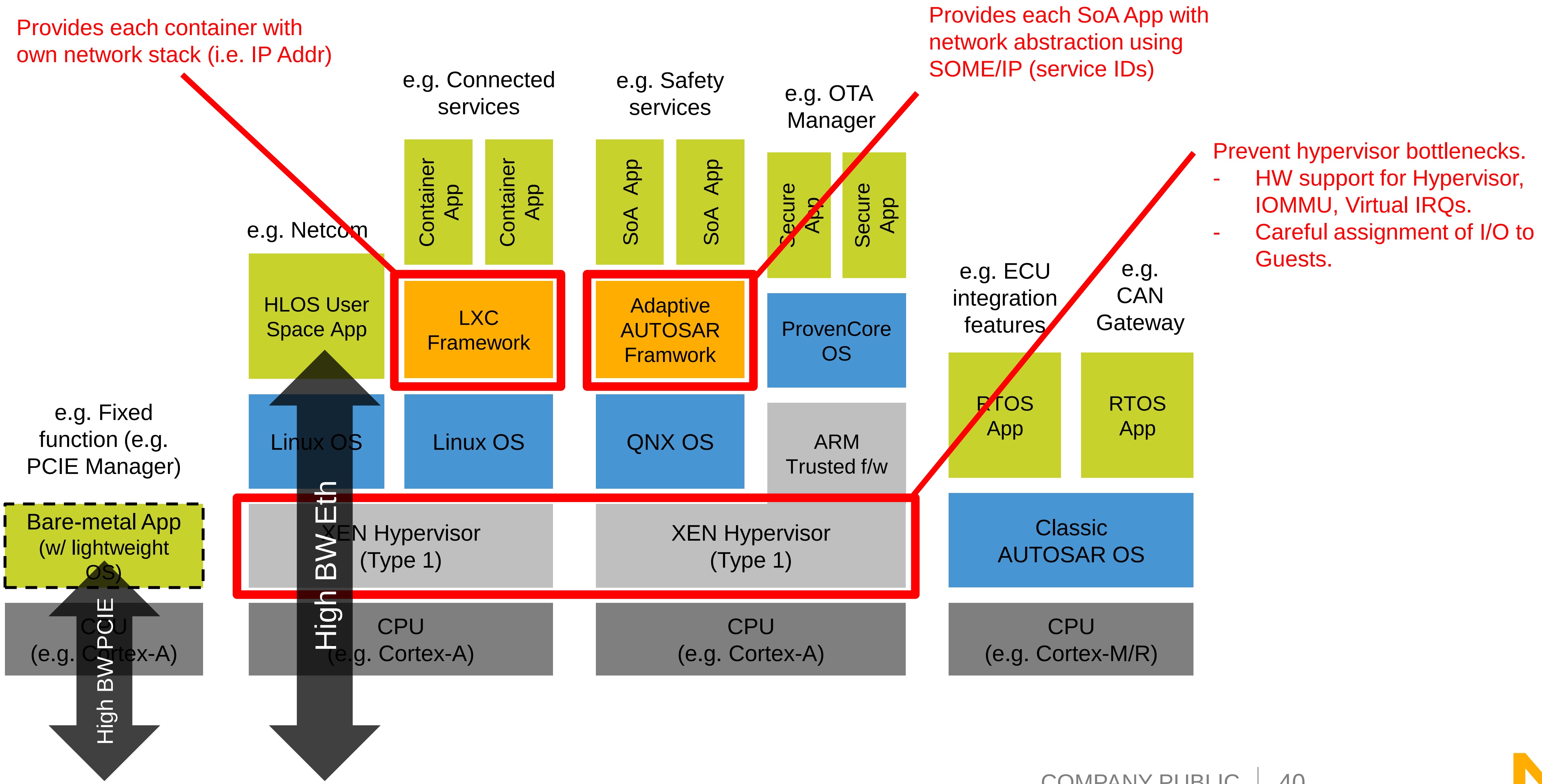
End-to-end security from vehicle to cloud
- Embedded Hardware Security Module for cryptography and secure key management

Vehicle Service-oriented Gateway Enables Opportunities



The NXP MPC-LS chipset enables service-oriented gateways

SW Environment: 'Potential' Use Case



Automotive Linux BSP – Ready Solution for SOA Prototyping

Service-orientated Architecture (SoA) is driving change in SW architecture across the vehicle

Moving to scalable, abstracted platforms

Optimal implementation

Optimized BSP items and the communication path to better leverage NXP's HW resources
(e.g. DDS Security offload using the Security and Ethernet)

Production (3rd party)

Productize strategic SW items

Strategic partnership for Production ready solution

SECURE CONNECTIONS
FOR A SMARTER WORLD