Proposal of Dynamically Configurable In-Vehicle Network as an Enabler of Software Defined Vehicle

Japan Automotive Software Platform and Architecture

IEEE SA Ethernet & IP @ Automotive Technology Day

JASPAR Next Generation High-Speed Network WG
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JASPAR, General incorporated association

Contributors

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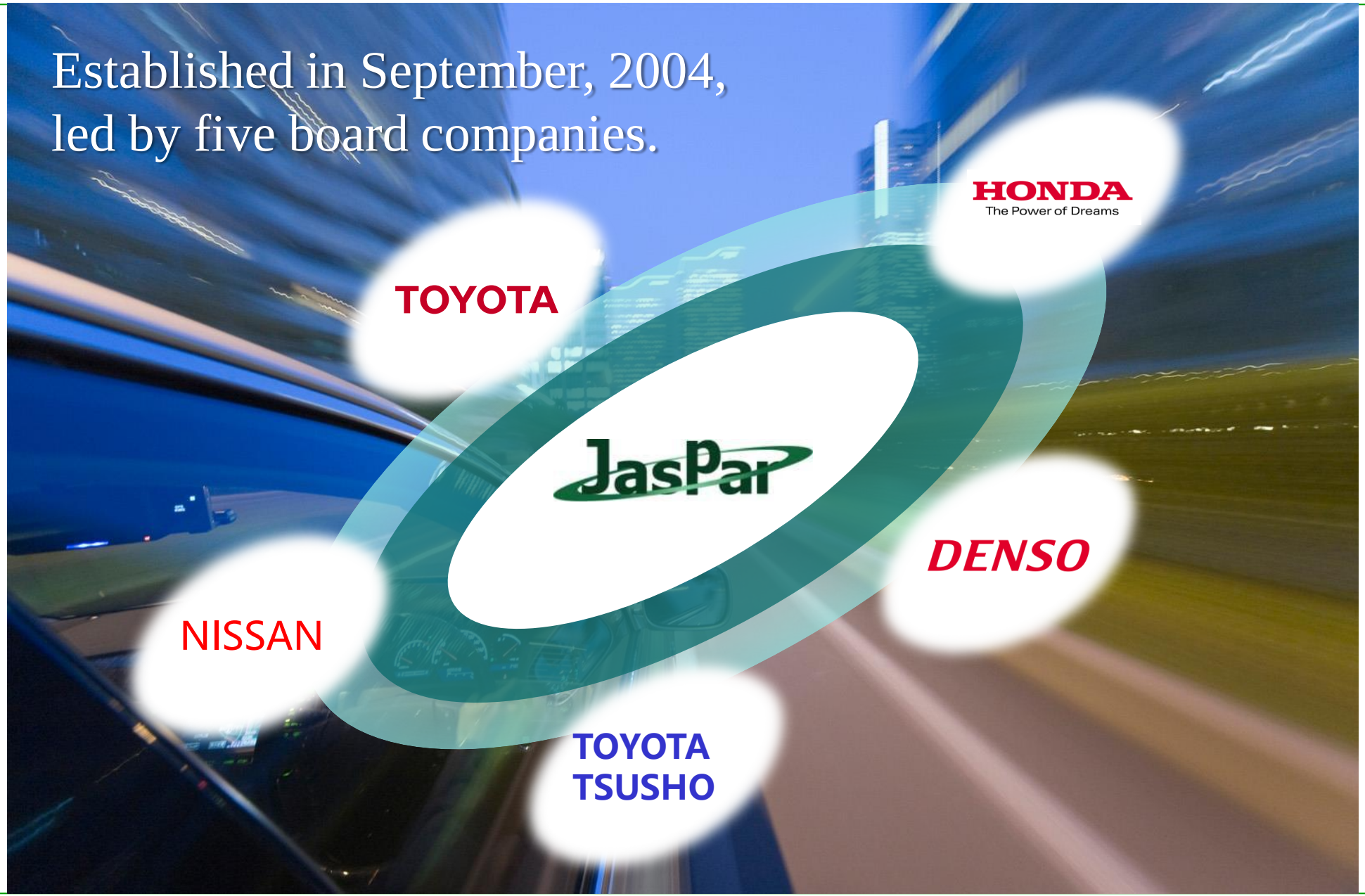
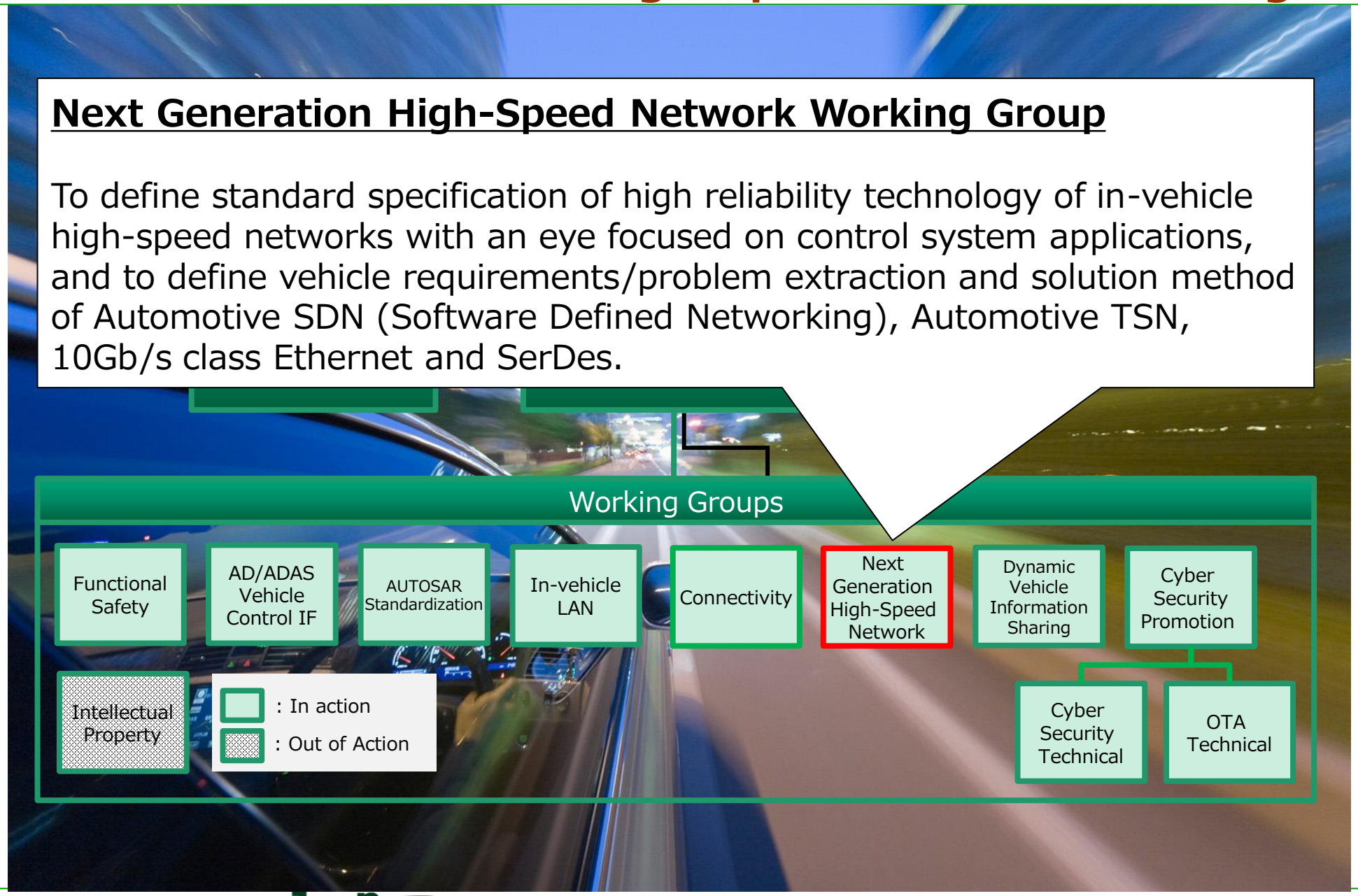
Introduction : About JASPAR



Introduction : Next Generation High-Speed Network Working Group

Next Generation High-Speed Network Working Group

To define standard specification of high reliability technology of in-vehicle high-speed networks with an eye focused on control system applications, and to define vehicle requirements/problem extraction and solution method of Automotive SDN (Software Defined Networking), Automotive TSN, 10Gb/s class Ethernet and SerDes.



Introduction : 3 Presentations From JASPAR

All layers are covered

OSI REFERENCE MODEL LAYERS	
7	APPLICATION
6	PRESENTATION
5	SESSION
4	TRANSPORT
3	NETWORK
2	DATA LINK
1	PHYSICAL

Next Generation High-Speed Network Working Group

WG is composed by 4 teams and 2 sub-teams

Next Generation Technology Study Team

- Next GenerationTechnology Study Team — ***SDN Sub-Team***
- ***Functional Development Team***
- ***Functional Verification Team***
- ***Hardware Team***
- Next GenerationTechnology Study Team — ***Next Gen. Physical Layer Sub-Team***

3 presentations from JASPAR

Automotive SDN
Proposal of Dynamically Configurable In-Vehicle Network as an Enabler of Software Defined Vehicle

Ethernet TSN
A study of Ethernet TSN profile based on JASPAR's automotive use cases

Optical Physical Layer
Concept of test points in in-vehicle optical physical layer standardization for multi-vendorization

Team Composition of Next Gen. High-Speed Network WG

Contents

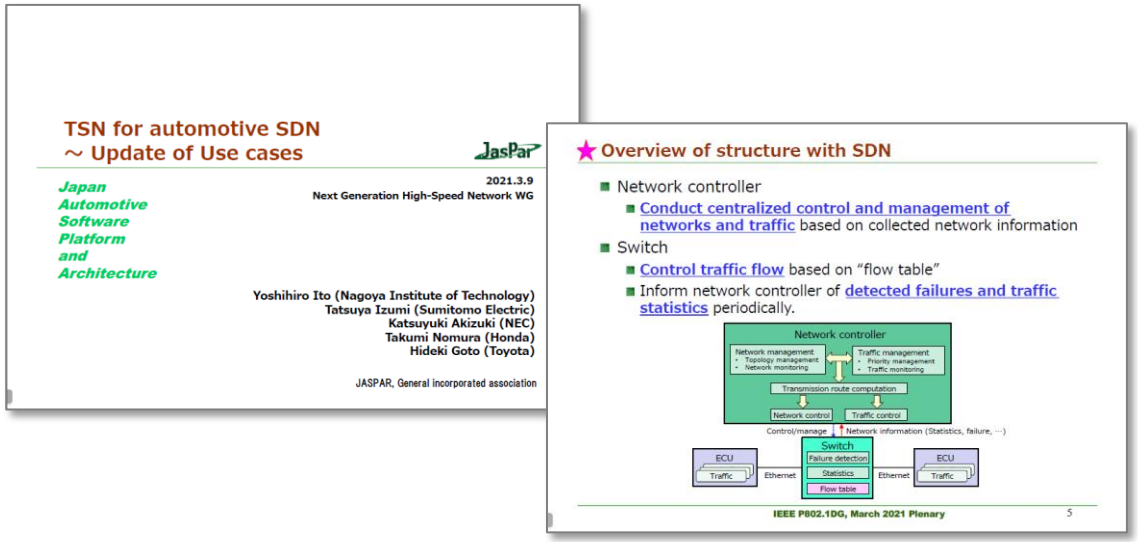
- Concept of JASPAR SDV
- Automotive SDN as a SDV network
- Mechanism and Functions of Automotive SDN
- Use Cases of Automotive SDN
- Requirements of Automotive SDN
- Future Work

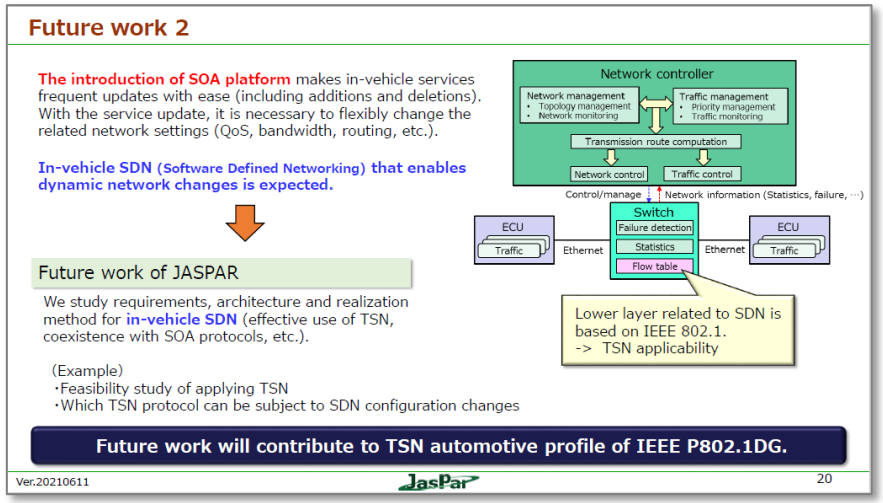
Background -History of JASPAR SDN

JASPAR has recognized the need to incorporate SDN into the automotive network early.
The application of SDN to in-vehicle networks is finally becoming a reality.

Furthermore, a new concept of Software Defined Vehicle is emerging and attracting attention now.
We'd like to show that SDN will be even more necessary for in-vehicle networks in the SDV era.
Hopefully, this presentation will accelerate broader discussion and standardization.

- We first discuss what should the network look like for SDV ?
- We then propose JASPAR's vision of Automotive SDN as an enabler for SDV.

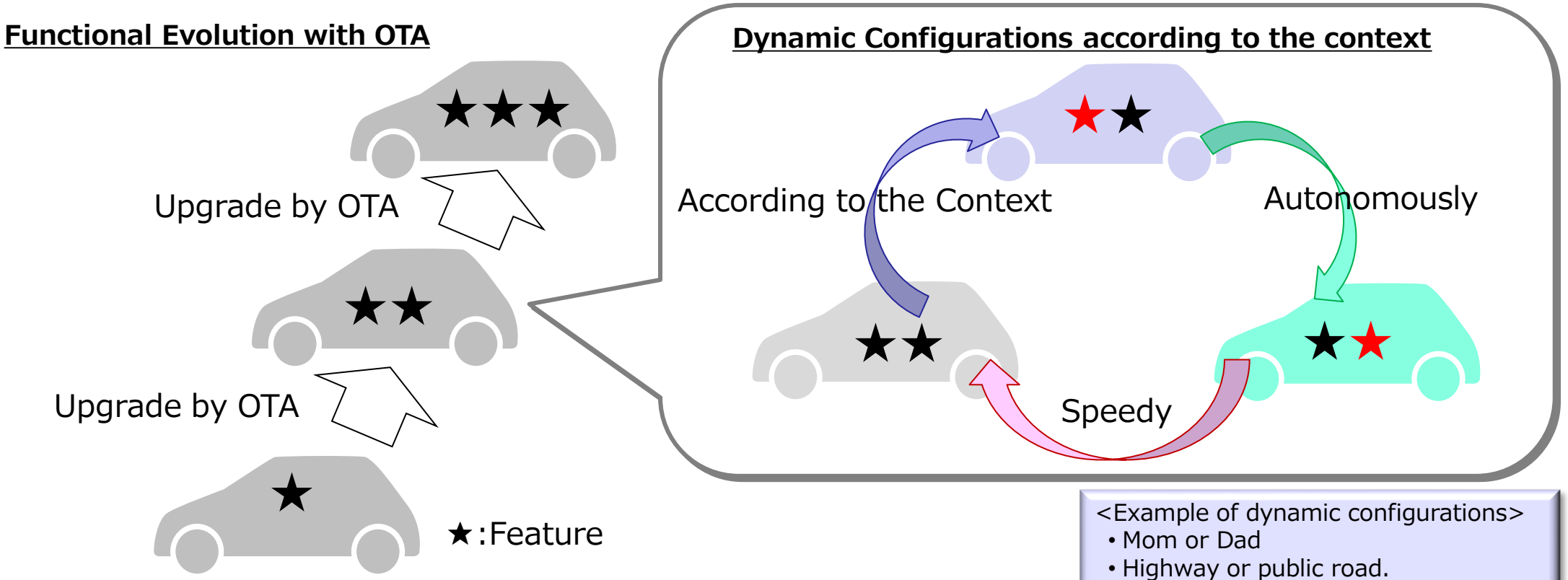




Y. Ito, et al. "TSN for automotive SDN –Update of Use cases," IEEE 802.1DG contribution, Mar. 2021.
T. Nomura, et al. "What is the conqueror in the SOA platform for the future in-vehicle networks? - A study based on JASPAR's automotive use cases," EIPATD Additional Presentation, 2021.

The Concept of JASPAR's SDV

JASPAR's SDV (as an evolution of OTA)
- Control according to the context
- Autonomous control (even if not connected to the cloud)
- Respond in a short time
- Changes in services and functions according to user requests



The concept of JASPAR's SDV

<Example of dynamic configurations>
- Mom or Dad
- Highway or public road.
- Pay and provide service immediately
- Subscribe, PnP

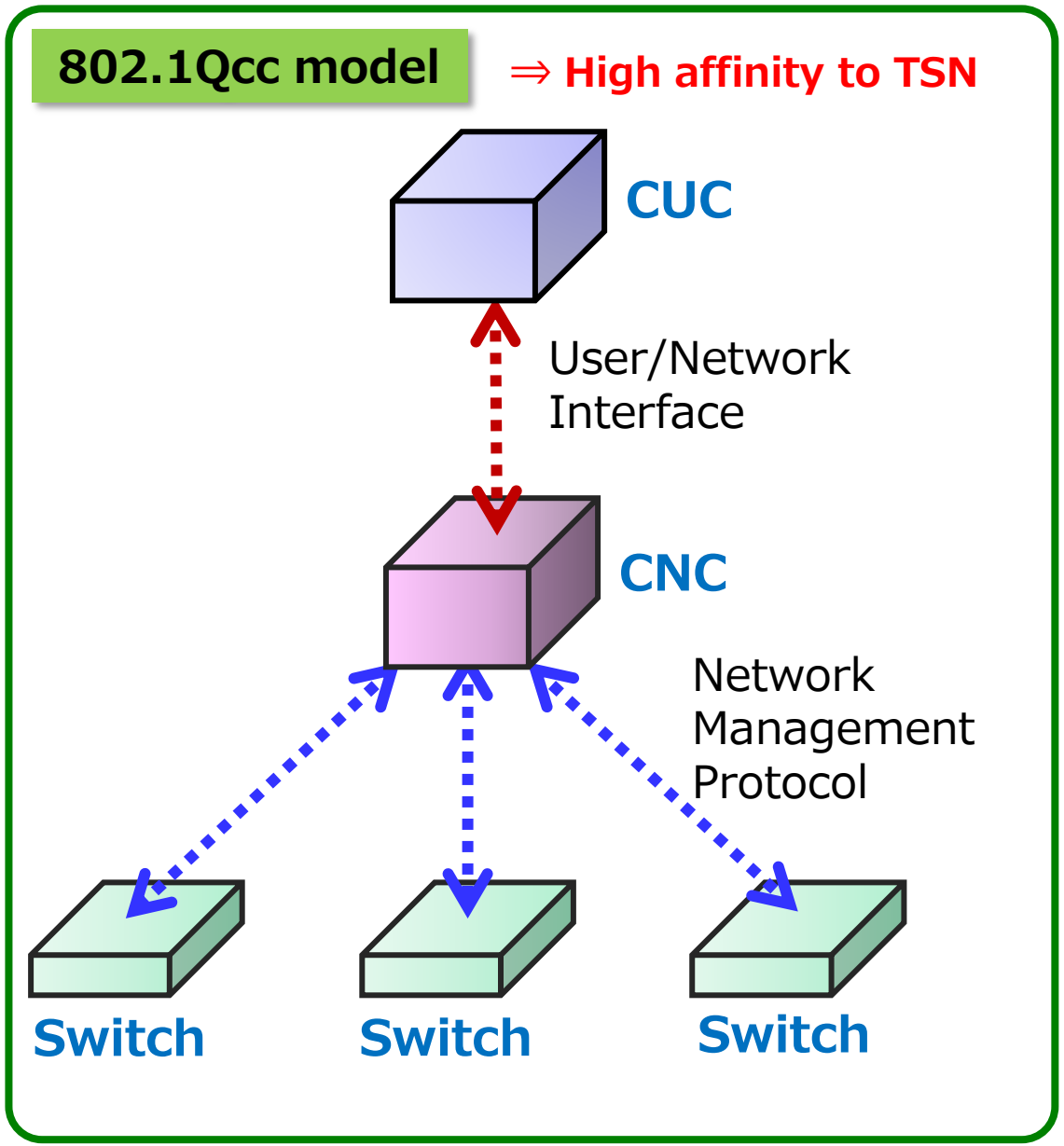
SDN as a SDV networks

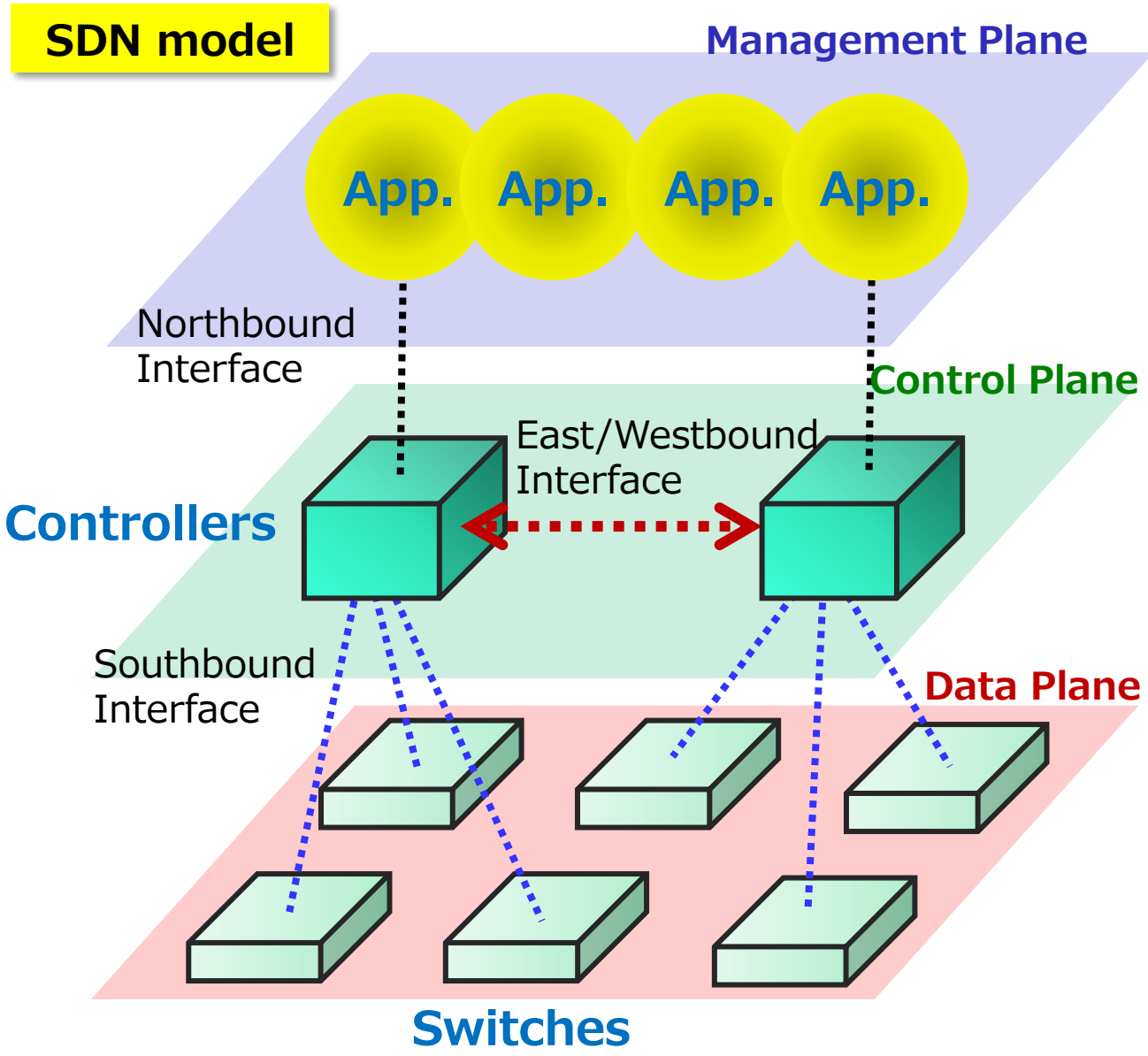
To realize the JASPAR's SDV, the Network should be as follows:

- The Network should have a mechanism that changes the network according to the context.
- The Network should be changed with sufficient immediacy to ensure the services. (Ex: in milliseconds)
- The Network doesn't need the connection to the cloud every time.

We call this new network as an enabler of SDV "Automotive SDN"

SDN model





Definition of Automotive SDN by JASPAR

Example of SDN definition *

SDN is a network architecture where (1) forwarding is decoupled from network control and (2) there is more freedom of choice in programming the forwarding logic.

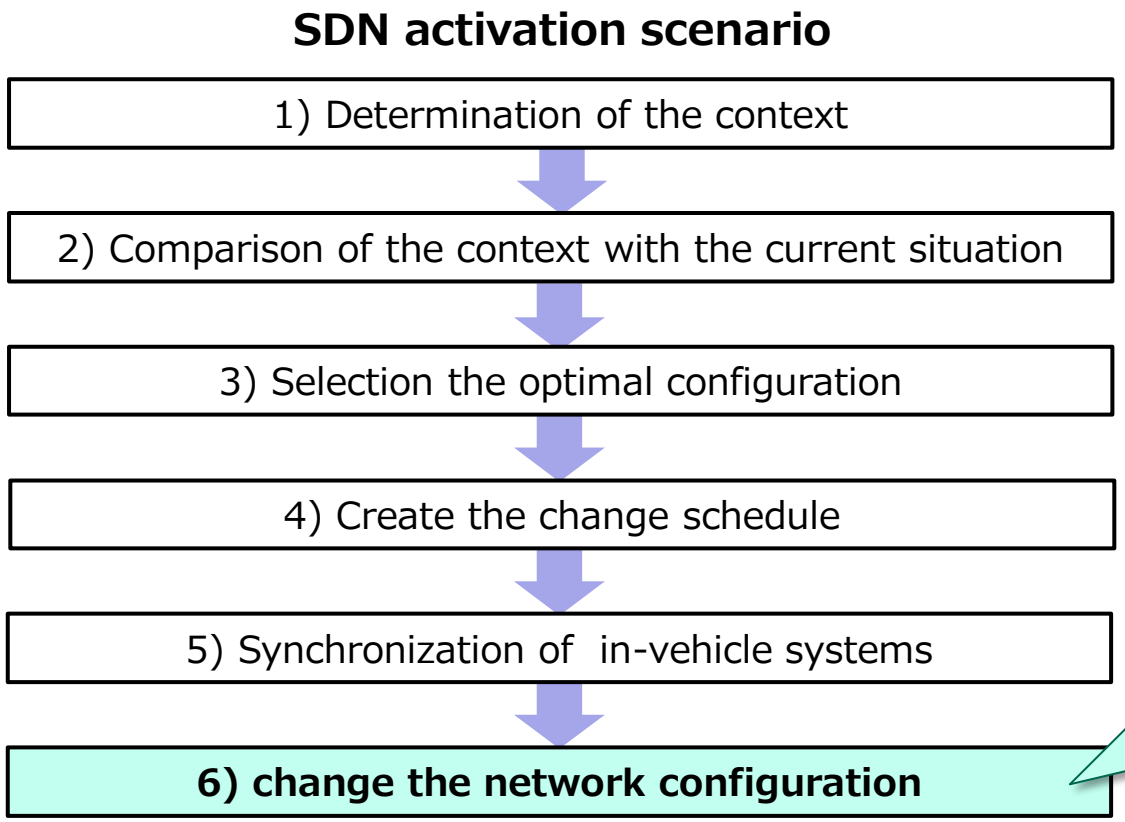
JASPAR's definition

JASPAR's SDN is a network architecture where forwarding is decoupled from network control and there is more freedom of choice in programming the forwarding logic for in-vehicle networks; it can realize dynamic configuration.

[*] B. Naudts, M. Kind, F.-J. Westphal, S. Verbrugge, D. Colle and M. Pickavet, "Techno-economic Analysis of Software Defined Networking as Architecture for the Virtualization of a Mobile Network," Proc. European Workshop on Software Defined Networking, 2022.

Basic mechanism of Automotive SDN

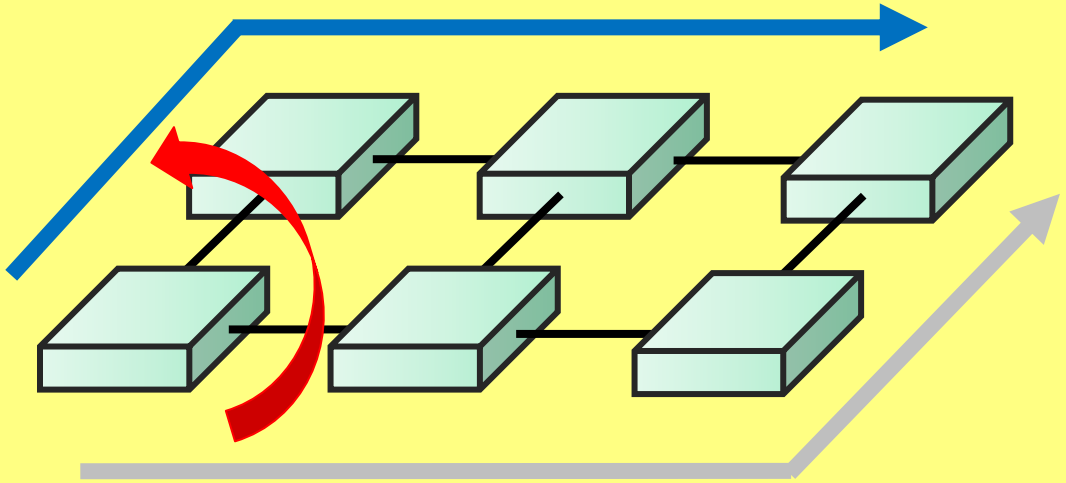
Since Automotive SDN controller has to control the network autonomously according to the context and demands, we need such a dynamically configurable network.



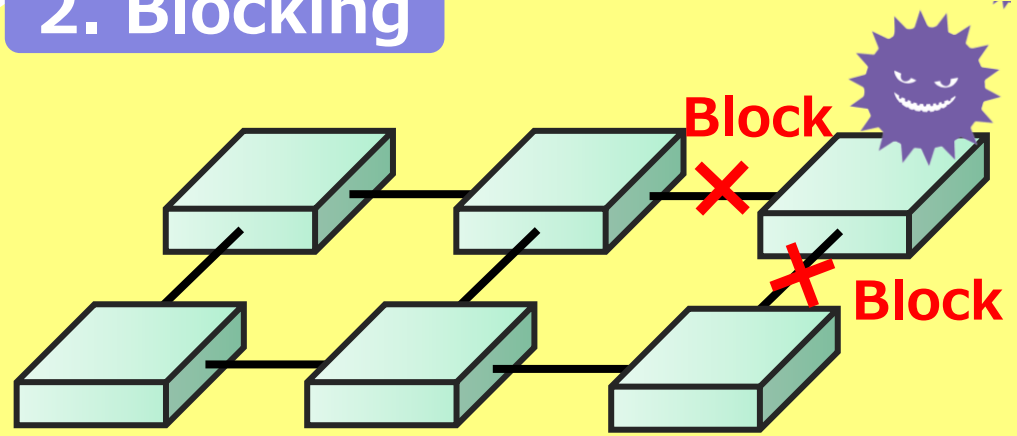
1. Dynamic Routing
2. Blocking
3. Flexible Redundancy
4. On-demand Bandwidth allocation

Examples of SDN Functions

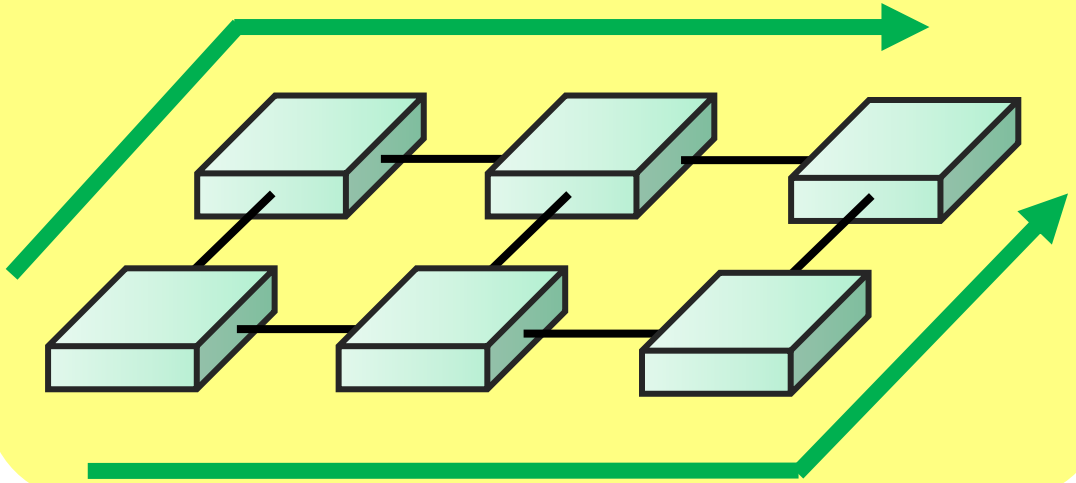
1. Dynamic Routing



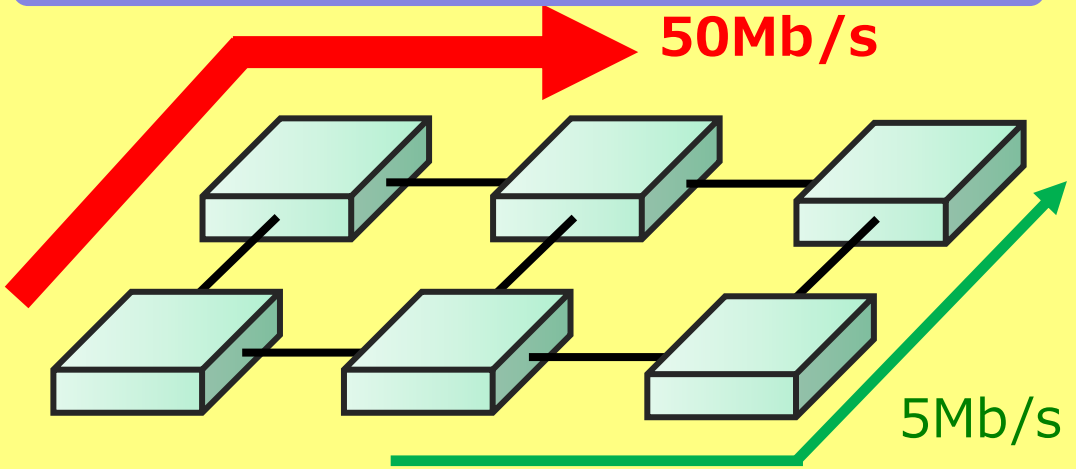
2. Blocking



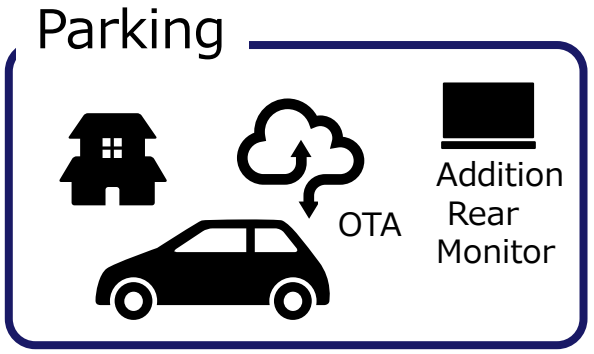
3. Flexible Redundancy



4. On-Demand BW Allocation

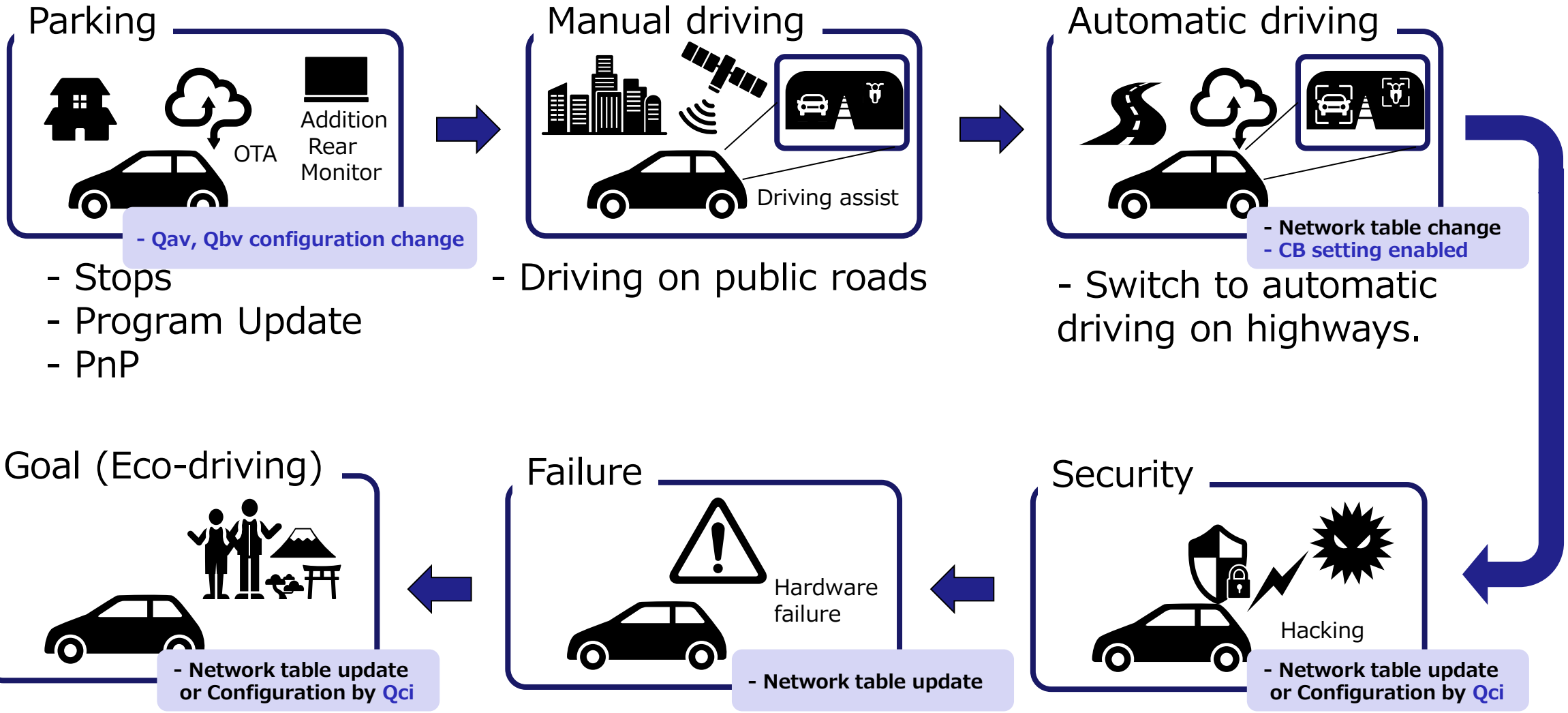


Use Case (OTA only)

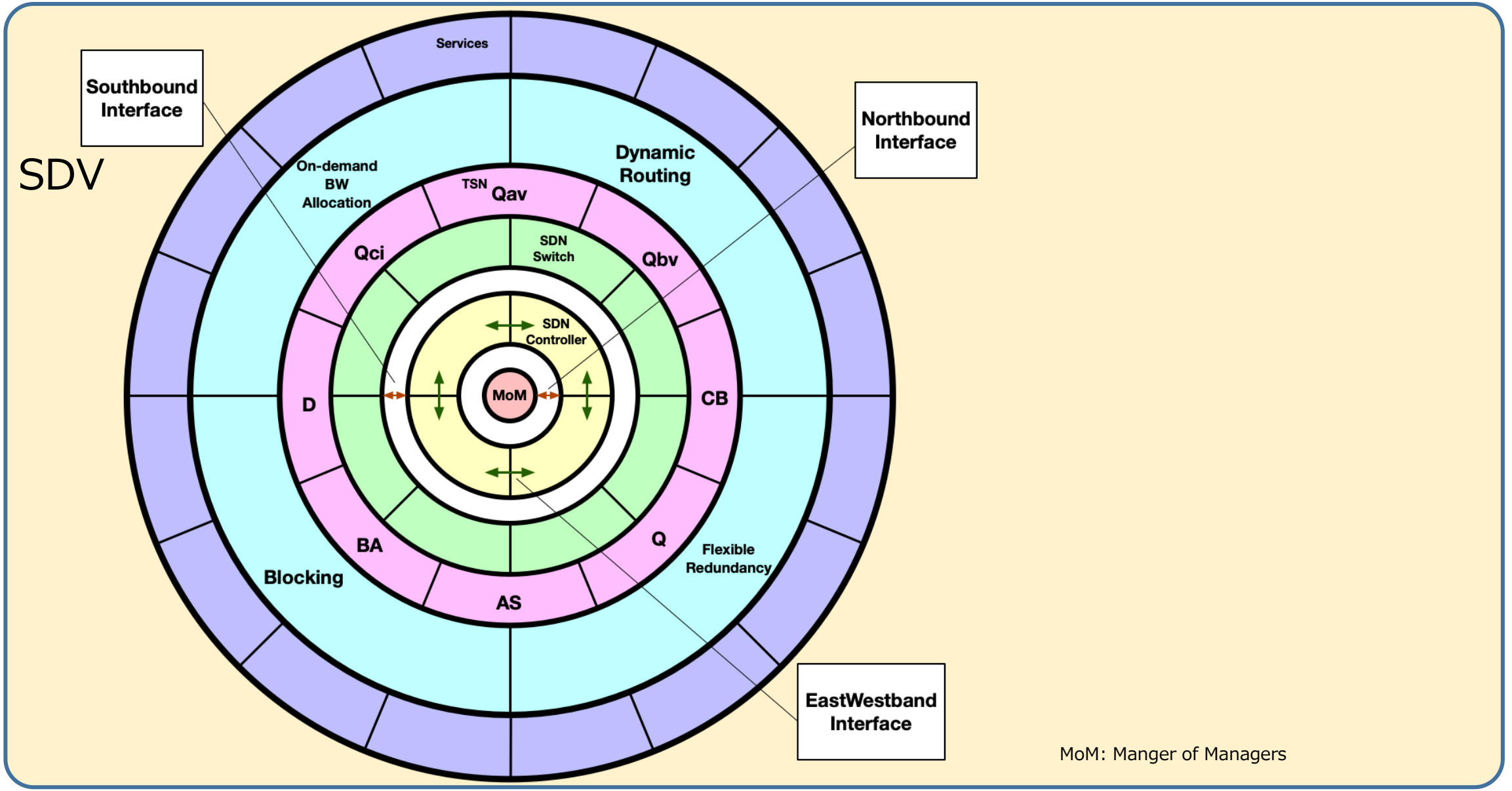


- Stops
- Program Update
- PnP

Use Case (OTA & SDN)

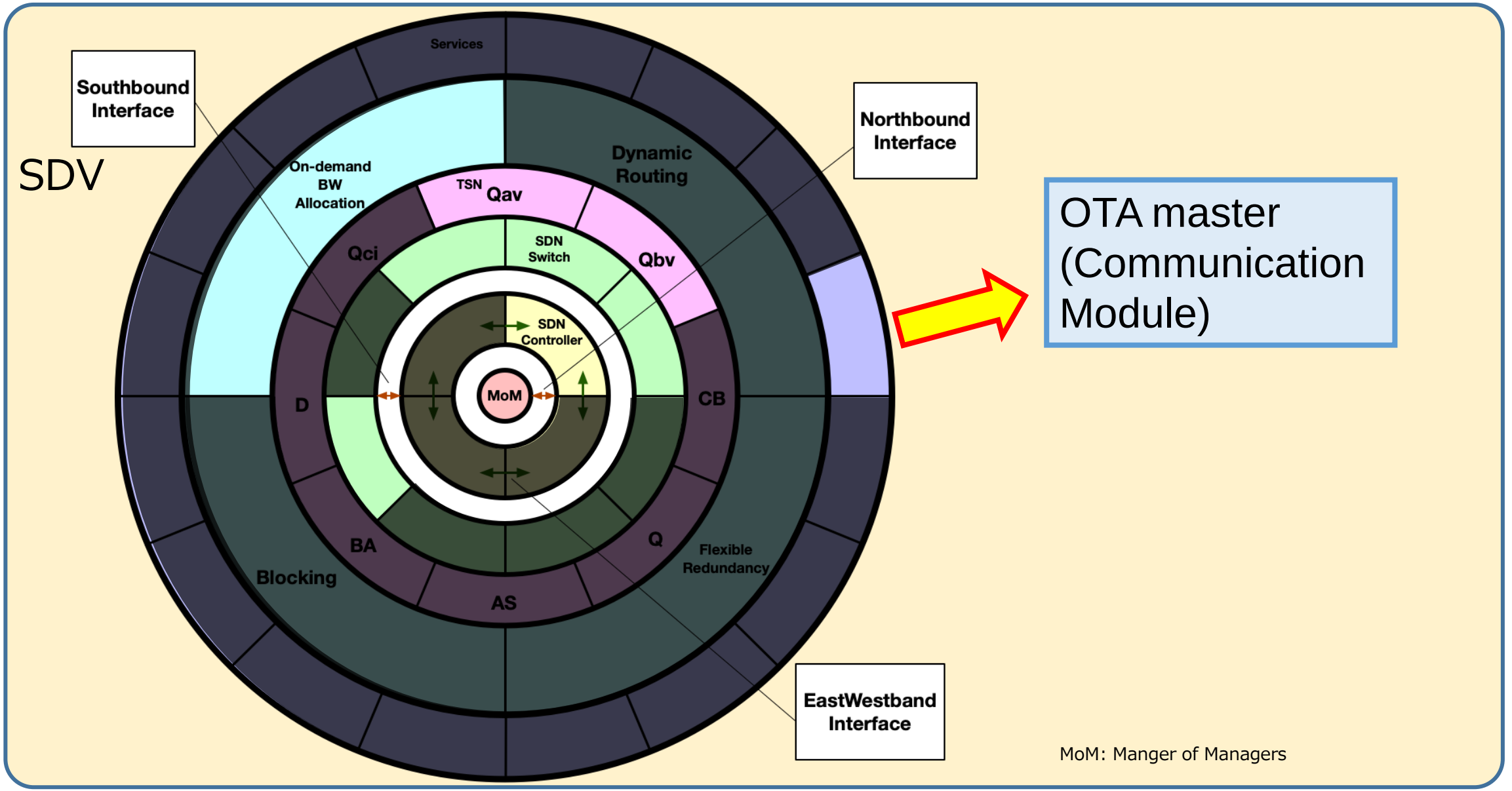


Use Case (OTA & SDN) Architecture

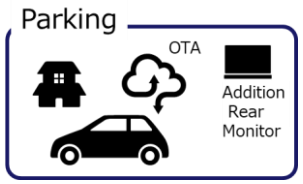


MoM: Manger of Managers

Use Case (OTA & SDN) Architecture



Use Case (OTA & SDN) Parking



Manual driving

Driving assist

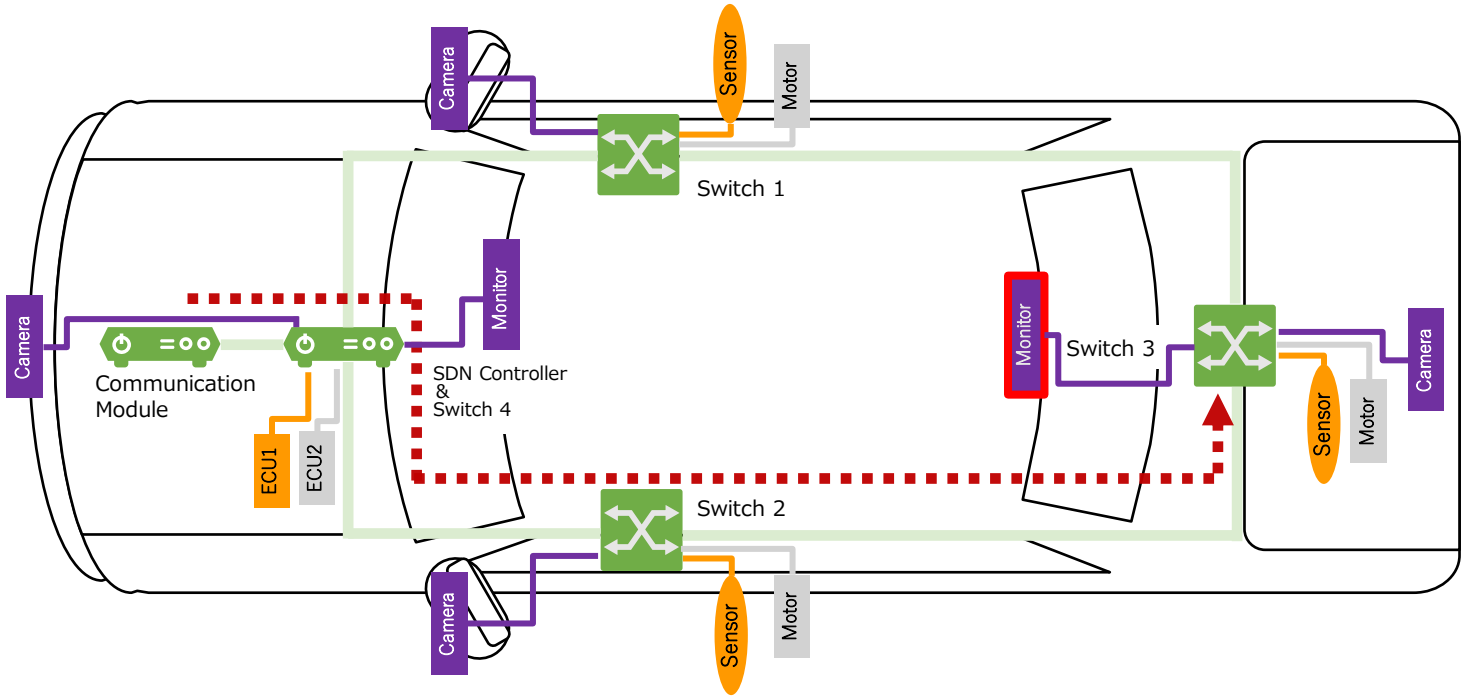
Automatic driving

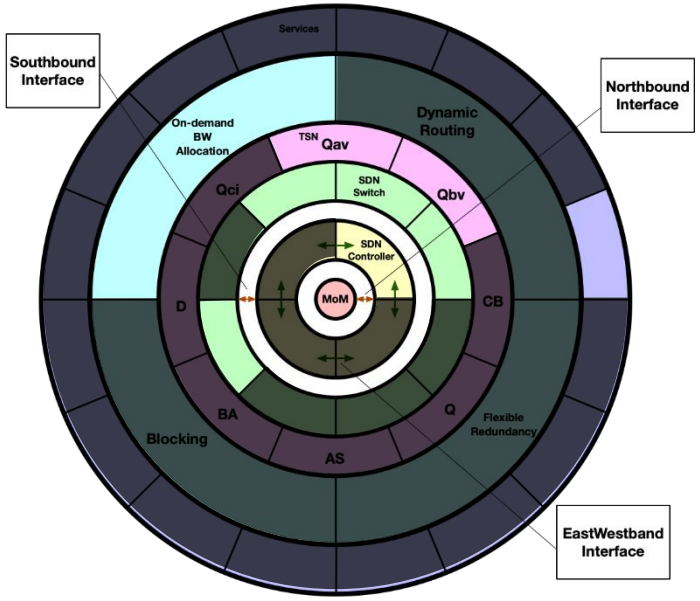
Security

Hacking

Failure

Hardware failure



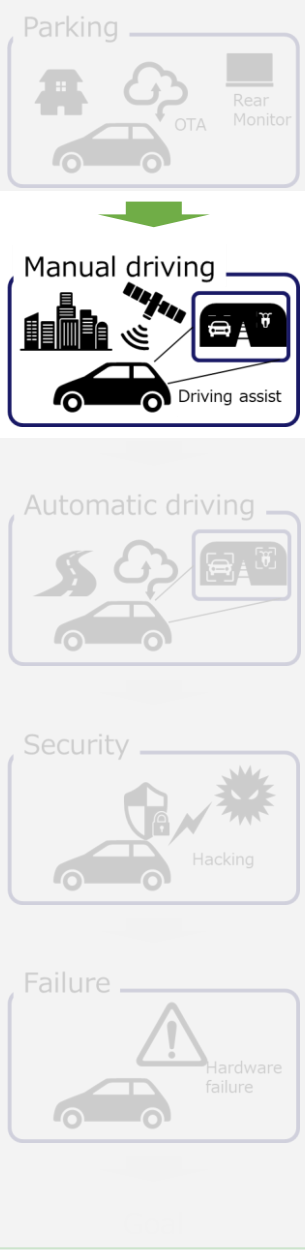


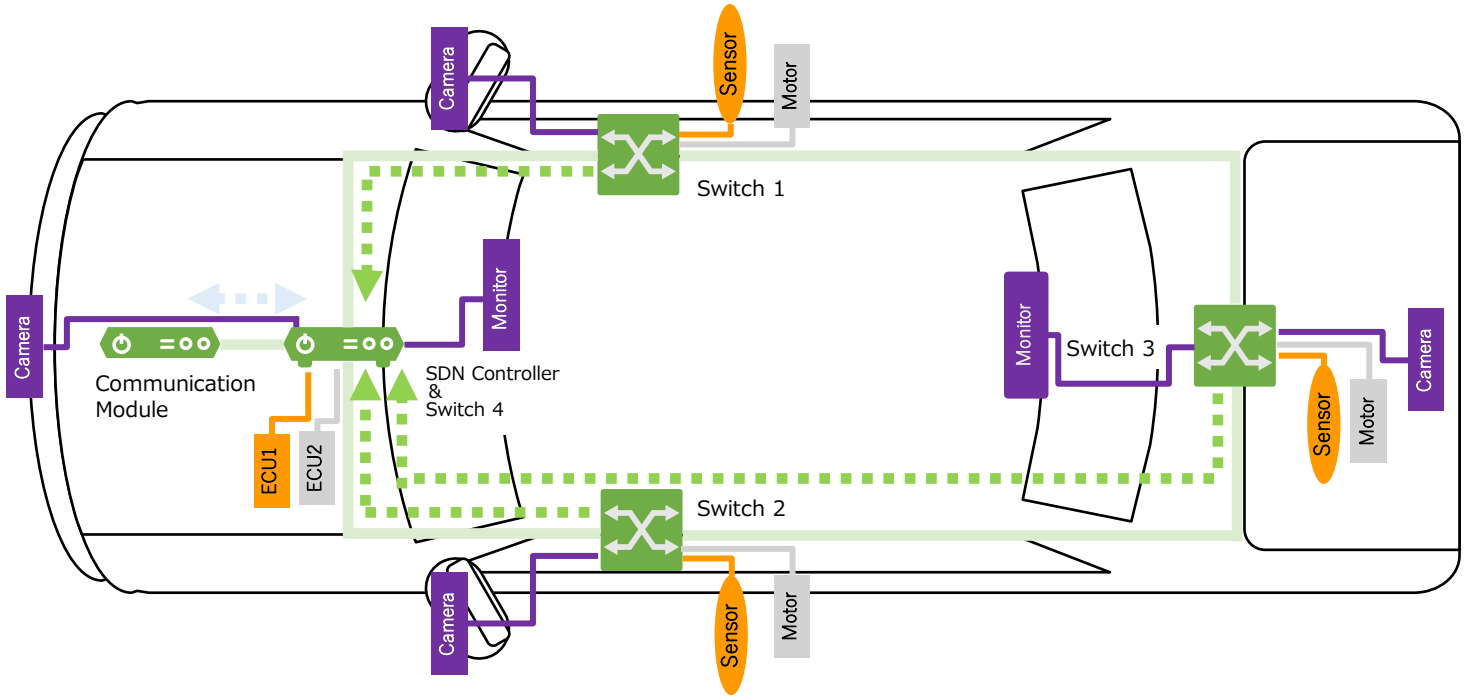
< Context >
Stop
OTA
Battery driven

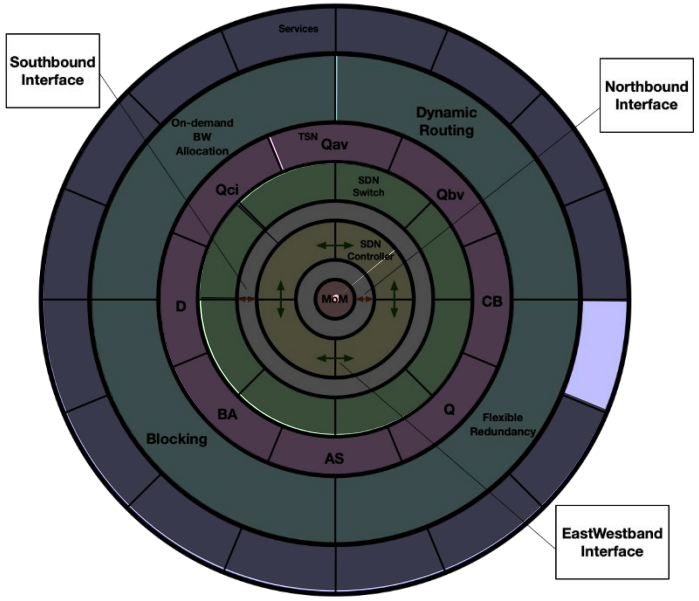
< Network configuration >
Efficiency & Power Saving
OTA Support Mode

SDN Requirement
1) The mechanism to change the networks according to the context is required

Use Case (OTA & SDN) Manual driving





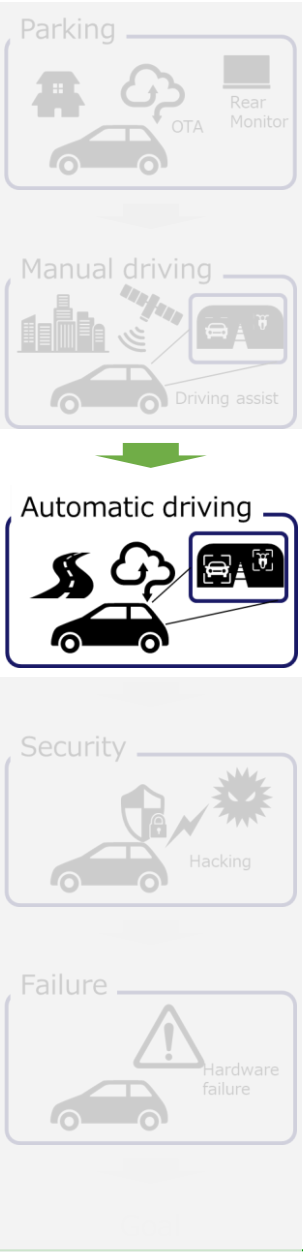


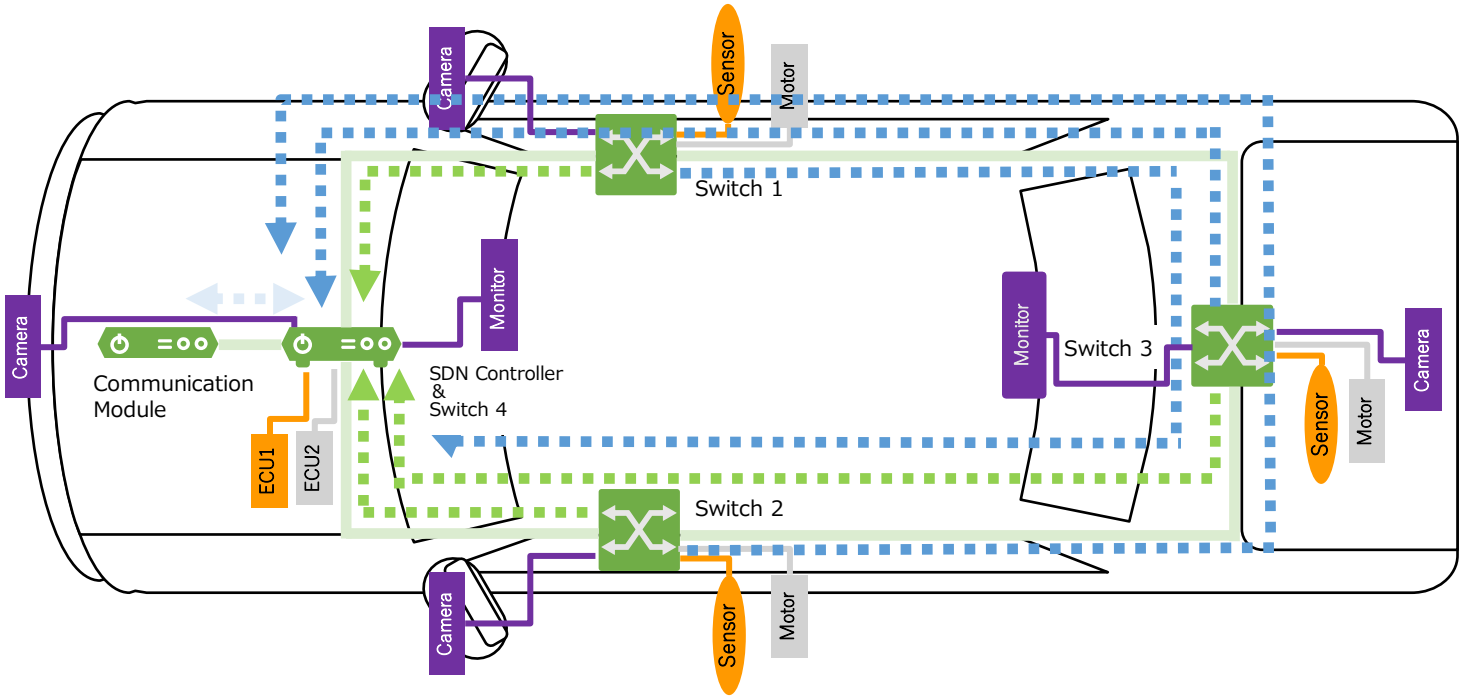
< Context >
Normal state
(vehicle speed ≥ 0)

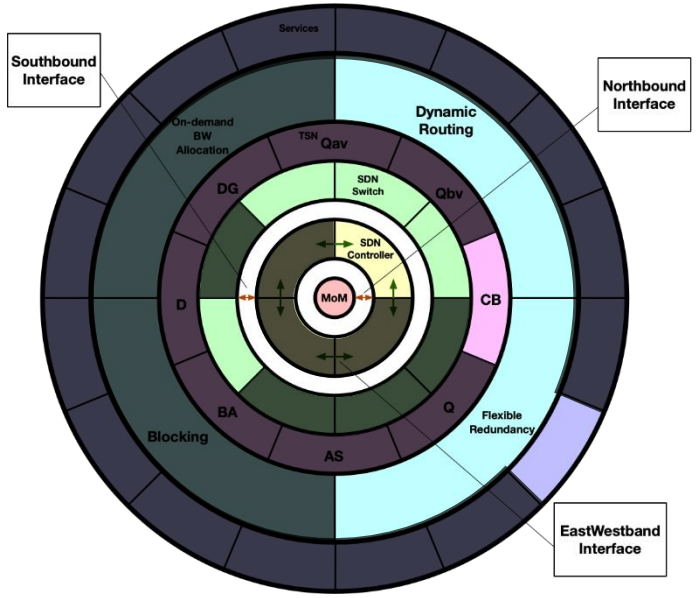
< Network configuration >
Default mode

SDN Requirement
-

Use Case (OTA & SDN) Automatic driving





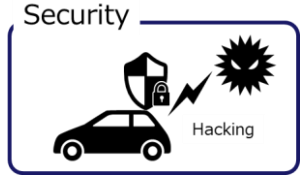


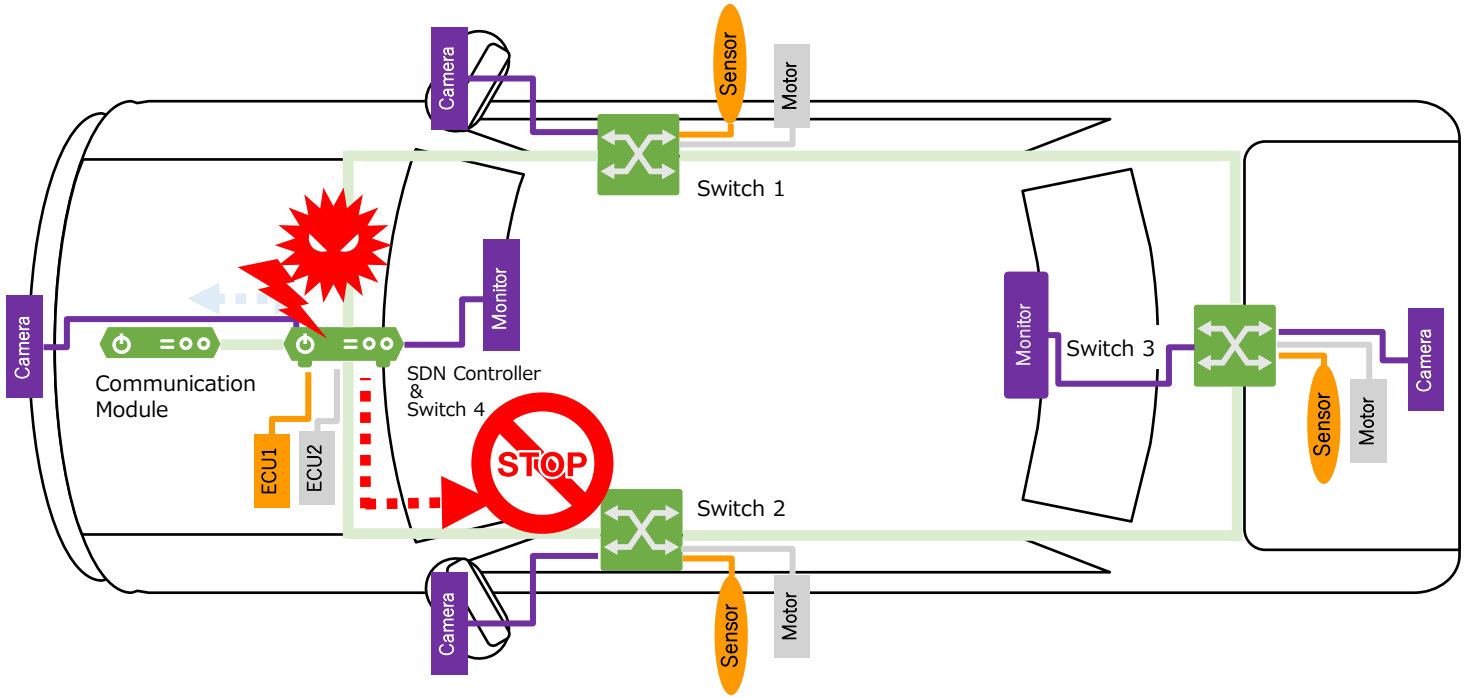
< Context >
Automatic Startup on highways

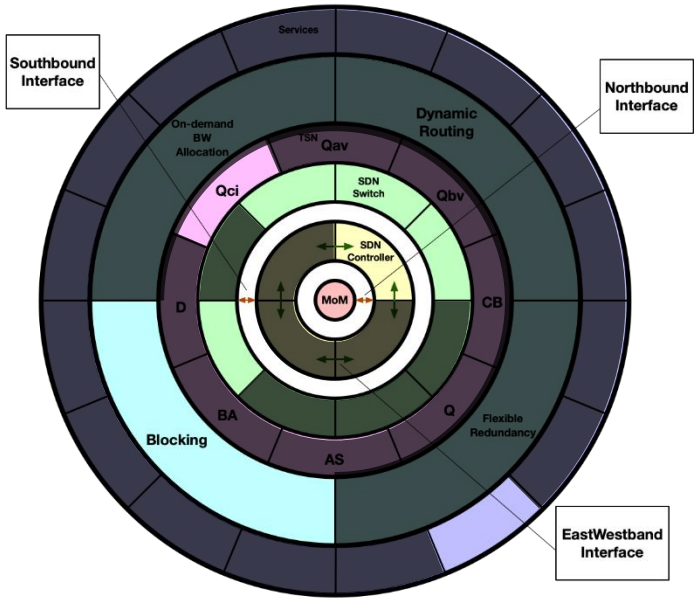
< Network configuration >
Automatic driving Mode

SDN Requirement
1) The mechanism to change the networks according to the context is required
2) To realize sufficient immediacy, the SDN controller should be mounted in the car.

Use Case (OTA & SDN) Security





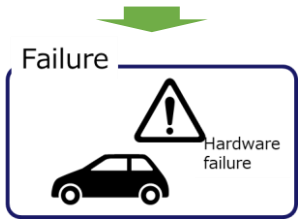


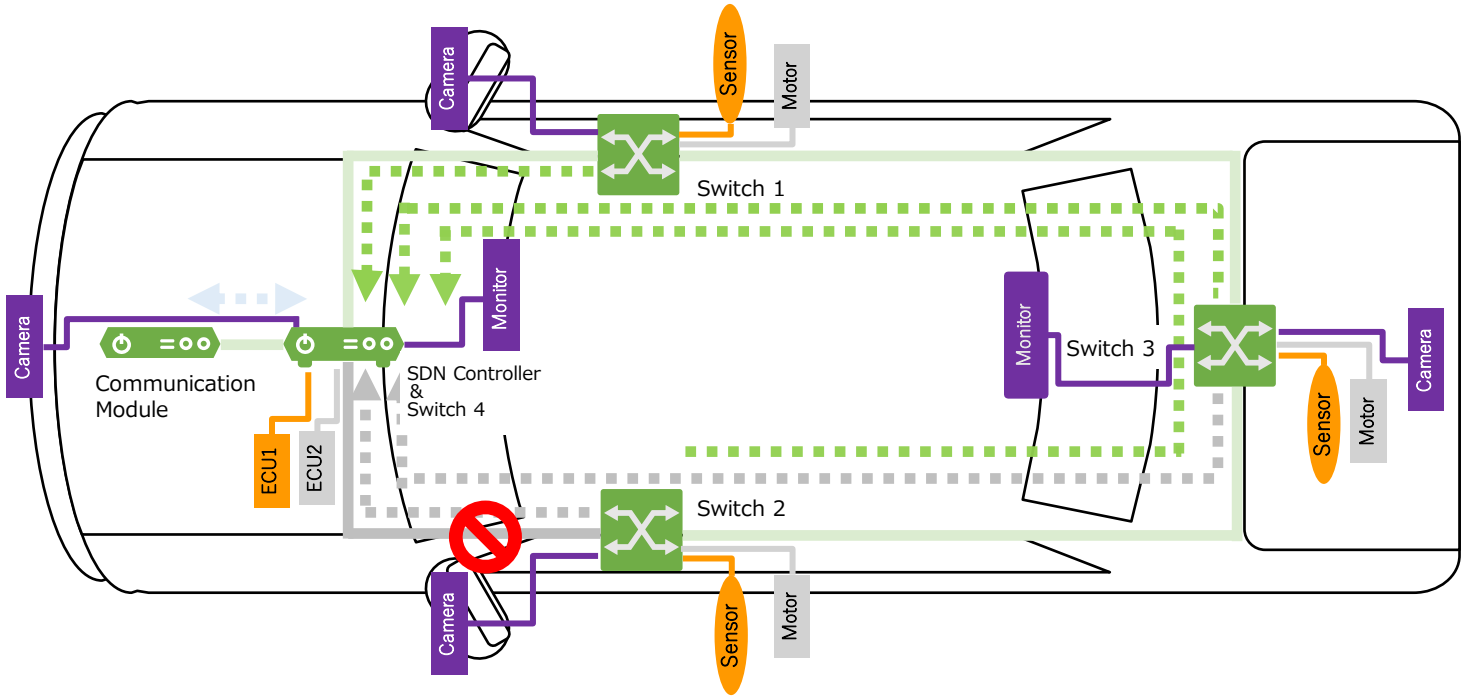
< Context >
Security Attack Detection

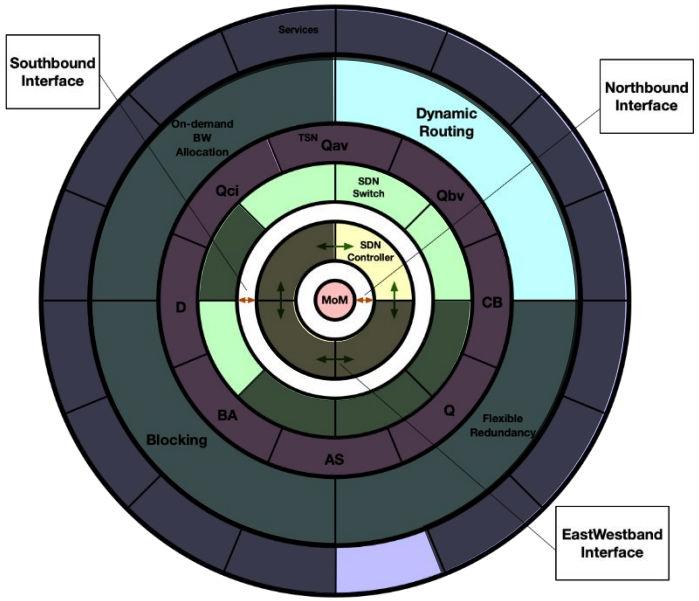
< Network configuration >
Defense Mode

SDN Requirement
1) The mechanism to change the networks according to the context is required
3) Based on the current context, the SDN controller should perform autonomously.

Use Case (OTA & SDN) Failure





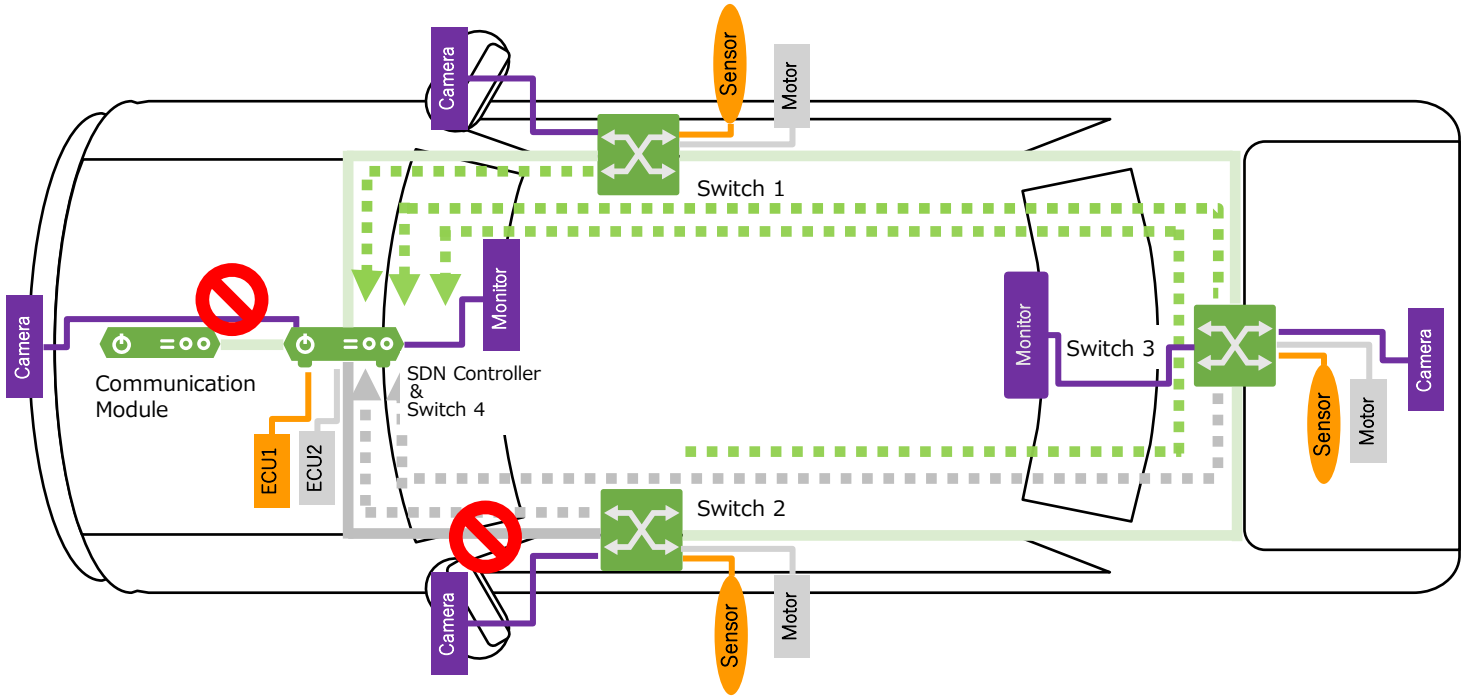


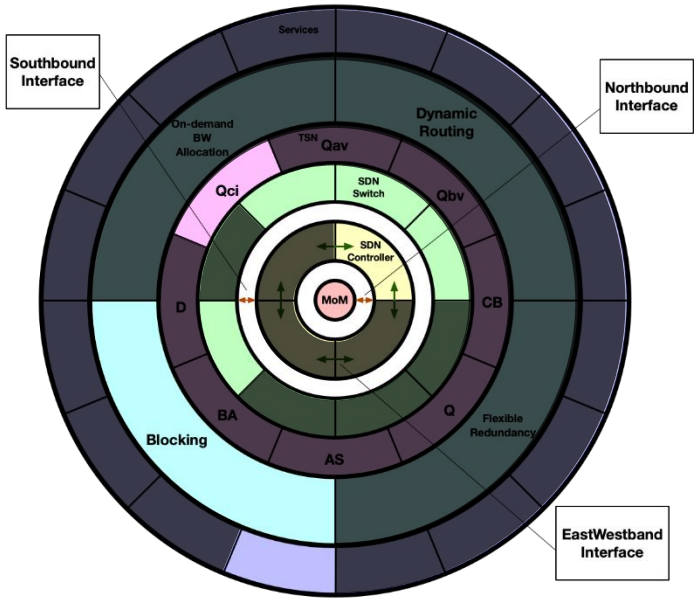
< Context >
Fault Retraction

< Network configuration >
Fault Retraction Mode

SDN Requirement
1) The mechanism to change the networks according to the context is required
2) To realize sufficient immediacy, the SDN controller should be mounted in the car.

Use Case (OTA & SDN) Goal (Eco-driving)





< Context >
Eco-driving

< Network configuration >
Energy Saving Mode

SDN Requirement
1) The mechanism to change the networks according to the context is required.

SDN requirements based on use cases

Based on our investigation of the use cases, we clarified some requirements as follows,

1) The mechanism to change the networks according to the context is required.
   - ✓ Re-Configure the TSN parameters will be an effective method.

2) To realize sufficient immediacy, the SDN controller should be mounted in the car.
   - ✓ Synchronization and Simultaneity will be required further.

3) Based on the current context, the SDN controller should perform autonomously.
   - ✓ External vehicle communication is not always possible.

We propose some requirements of "Automotive SDN“.
Further investigation is needed to clarify all the details.

Harmonize with TSN

Two types of SDN to be considered

- TSN **by** SDN (Control TSN parameters by SDN)
  - Bandwidth allocation (Qav, Qbv, Qcr, ?)
  - Block (Qci, ?)
  - Redundancy (CB, ?)
  - Dynamic Routing (Qci, ?)
- TSN **for** SDN (TSN's requirements for SDN)
  - Synchronization and Simultaneity (AS, Qav, Qbv, ?)
  - Platform (Qcc, ?)

We will propose TSN by/for SDN to IEEE 802.1DG

Conclusion

SDV needs Automotive SDN.

It would be fine if there was SDN instead of just OTA.

Future Works:

- **Security**
- **Architecture**
- **Protocols**
- **Evaluation**

We would like to call for positive and wide-ranging discussions and wholesome standardization.

If you want to create Automotive SDN, discuss with JASPAR !

Thank you for your kind listening.