Automotive SDN:
Prototype and Use-cases

Hyun taek Hong (LG Electronics Inc. ht.hong@lge.com)

Kilho Lee (Soongsil University khlee.cs@ssu.ac.kr)

LG Life's Good

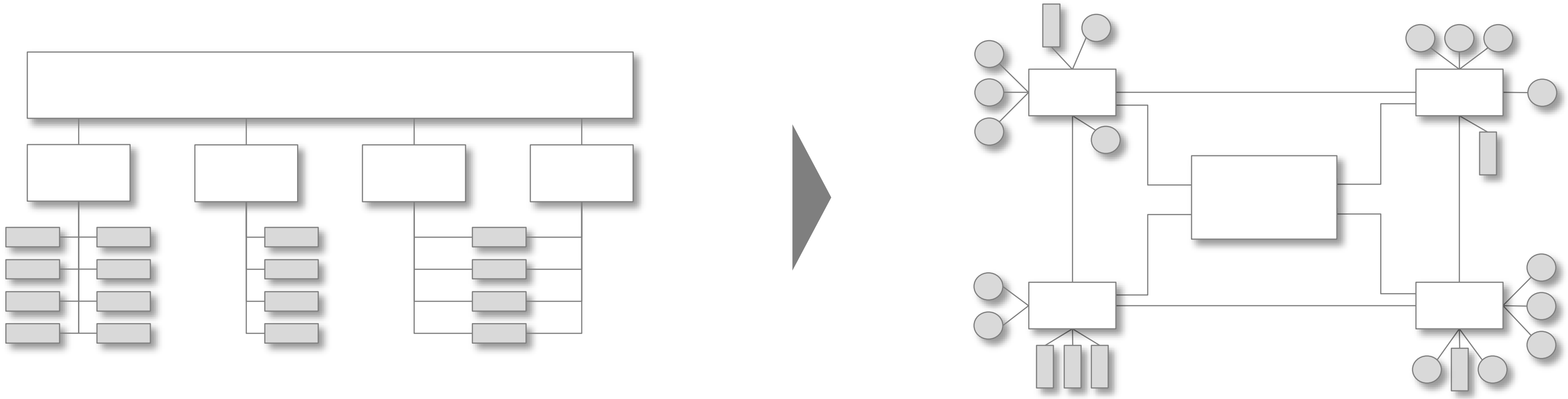
Soongsil University

Agenda

- ✓ Introduction
- ✓ Use cases
- ✓ Architecture
- ✓ Evaluation
- ✓ Conclusion

Why Automotive SDN ?

✓ Vehicle network architecture trend and future roadmap



- High Bandwidth
- Ethernet backbone among ECUs
- Heterogeneous network around zone ECUs

✓ Further consideration of future vehicle network

- Fail-over
- Dynamic bandwidth control
- Flexibility of future network capability

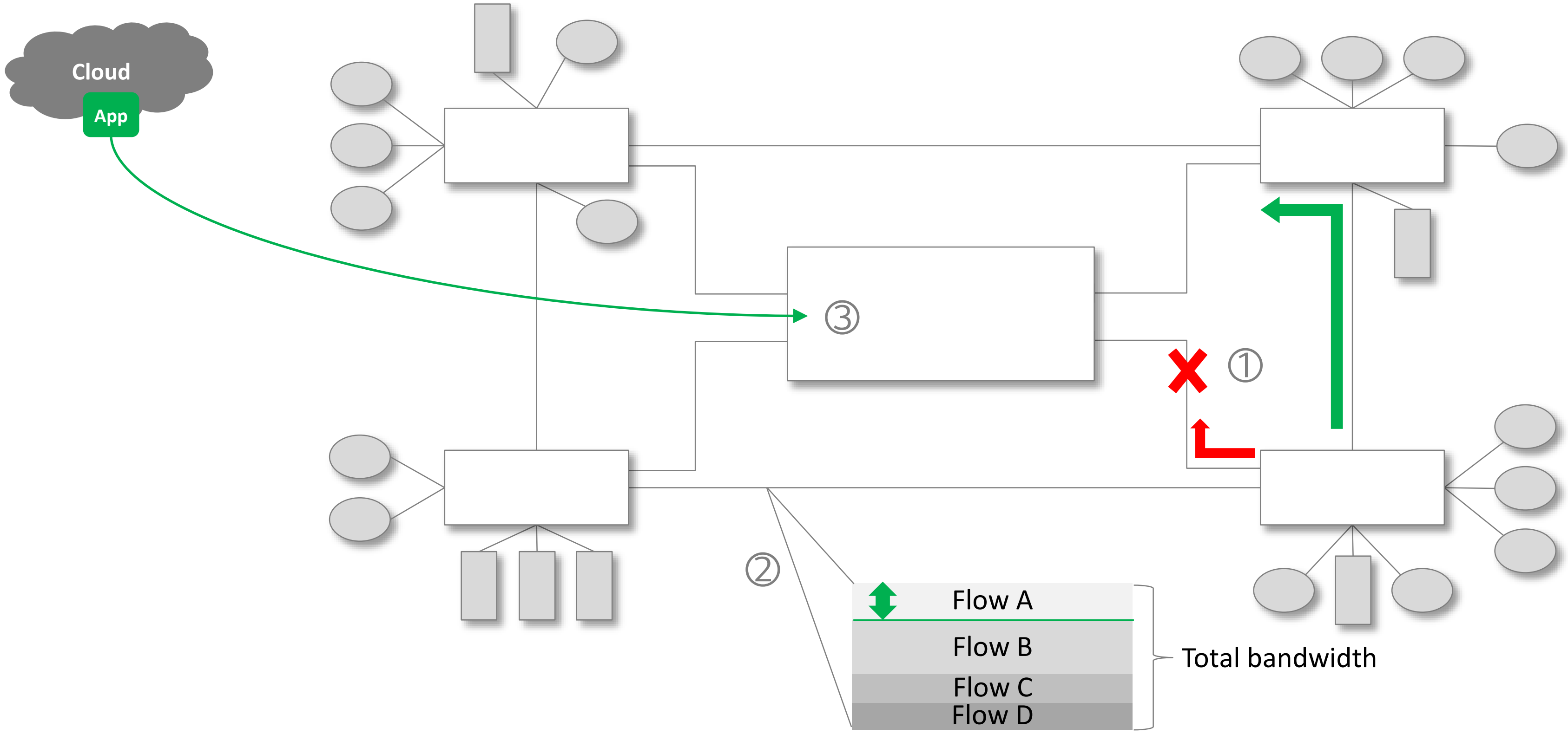
SDN as a solution

✓ Key characteristics of SDN

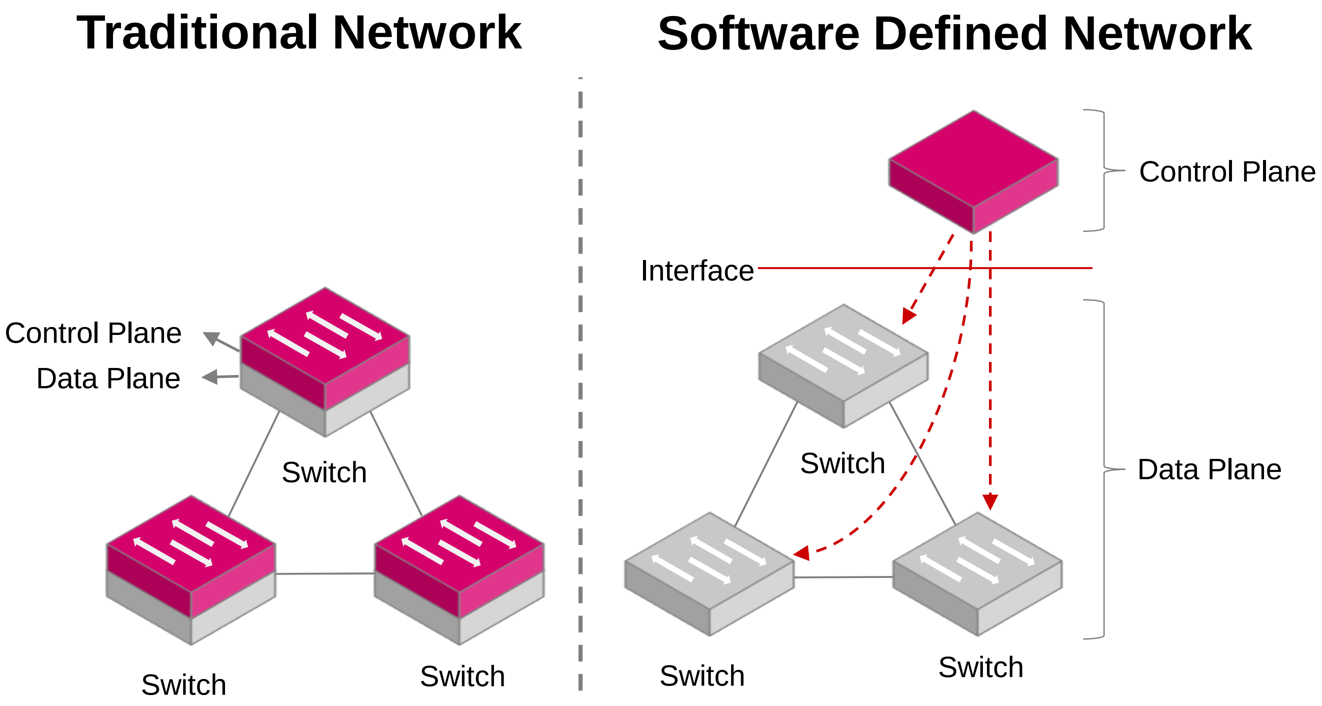
① SDN can provide fail-over operation in case of failure

② SDN can control bandwidth dynamically based on the vehicle situation

③ SDN can reconfigure the network after the new service is deployed



SDN in general



Category	Description
Control Plane	• Centralized software • Global view of the network
Data Plane	• Control by SW-based control application • Programmable

Protocol	Description
Open Flow	• Control packet forwarding table • Use case : Routing control
NETCONF	• Control network configuration • Use case : Bandwidth control

✓ Software Defined Network

- An alternative to the traditional switch-based network
- Centralized Control
- Programmability

Considerations for Automotive SDN

✓ Relatively small compared with traditional data center

- Number of network nodes for end-to-end communications are small

✓ Hardware upgrade is limited

- Once the vehicle is delivered to customer, it should be maintained more than 10 years

✓ The possibility of physical damage is higher than the legacy IT system

- Crash can be happening a lot compared with traditional systems

✓ Co-existance with legacy network like CAN

- Legacy network traffic is combined with Ethernet traffic

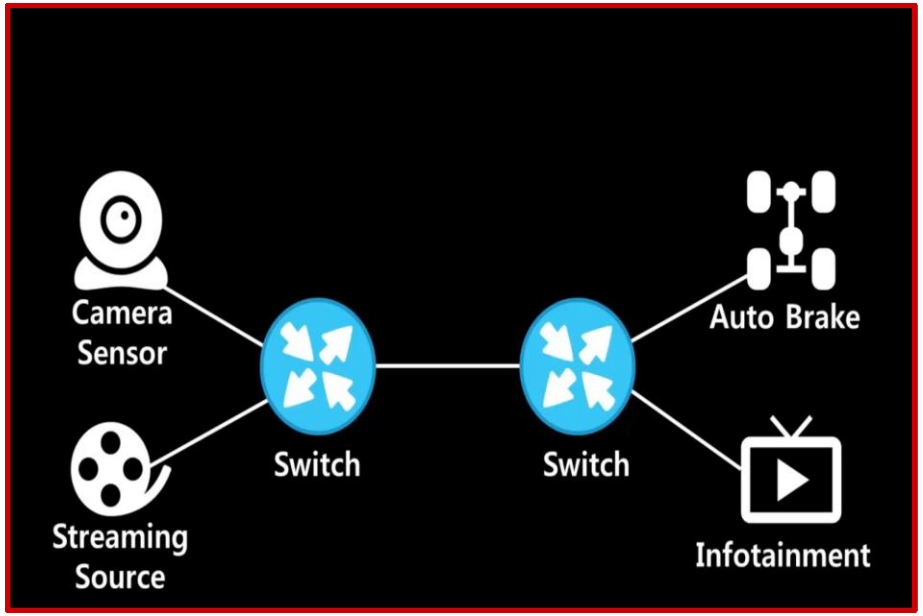
✓ Energy efficient network management

- Minimal network operation according to the given situation

Previous study of Automotive SDN

✓ MC-SDN (Mixed-Criticality SDN)

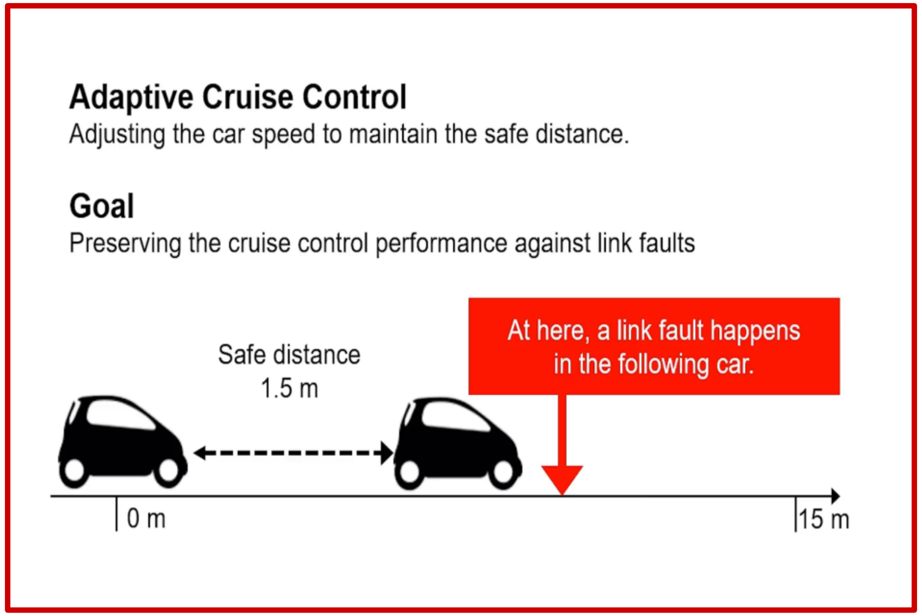
- Network flows with different levels of criticality
- Dynamic scheduling policy depending on the system mode



<Full version>
https://youtu.be/4iAPk9lTe8Q

✓ FR-SDN (Fault-Resilient SDN)

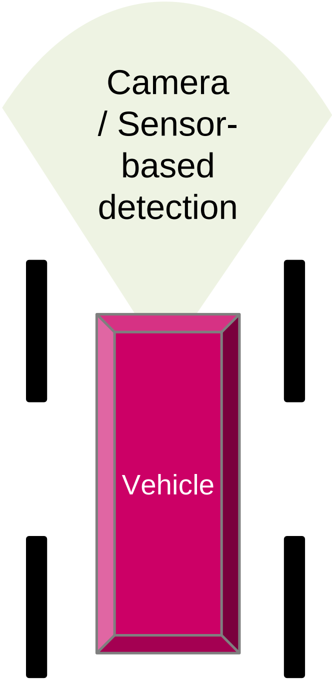
- Recover from link failure by finding alternative routes
- Perform path restoration from SDN controller-driven to switch-driven

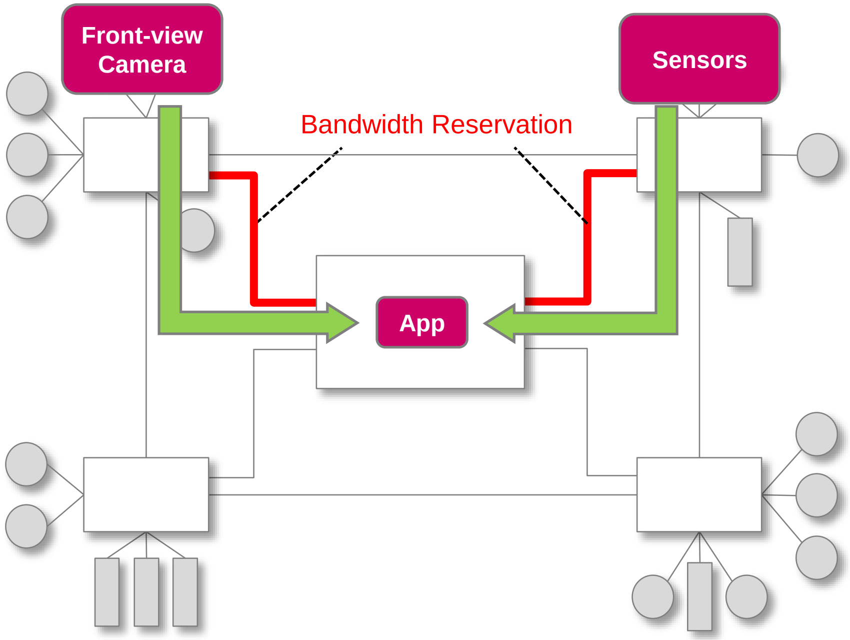


<Full version>
https://youtu.be/m2GmAq1F5gQ

SDN use-case 1: Dynamic bandwidth/priority control

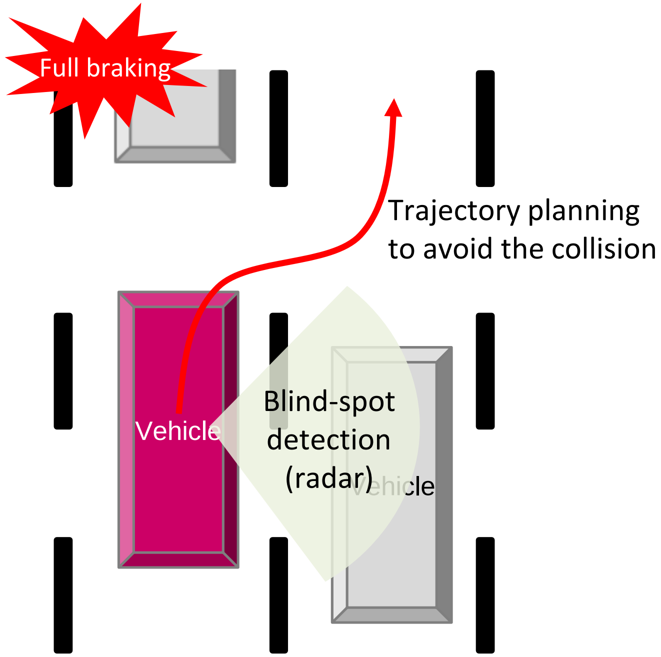
- ✓ Scenario
  - Reserve bandwidth to the front camera / sensors when emergency event is detected
- ✓ It dynamically manages bandwidth/priority guarantees according to the runtime network usages
- ✓ Bandwidth/Priority controls
  - Queue management

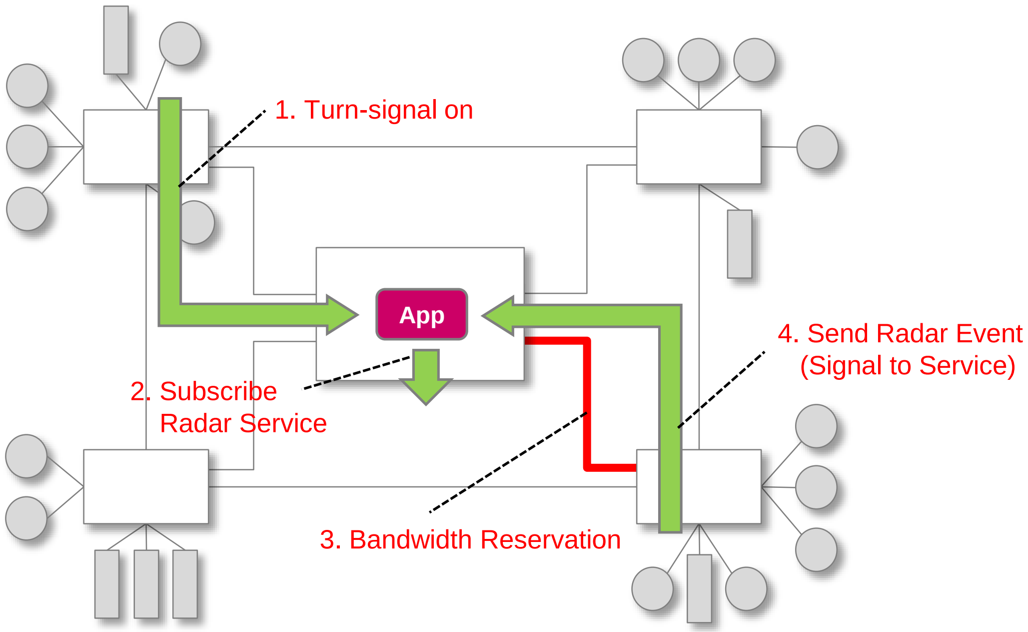




SDN use-case 2: CAN signal transfer with priority

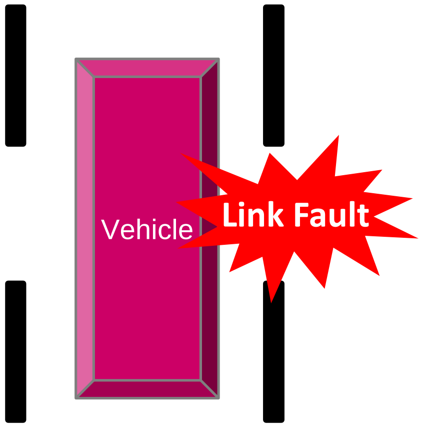
- ✓ Scenario
  - Radar signal transfer when lane-change is triggered
- ✓ There will still be CAN signals as it will take a long time to eliminate legacy parts
- ✓ Priority controls
  - Select relevant priority when transferring
  - Transfer frequency control
  - Packet size control

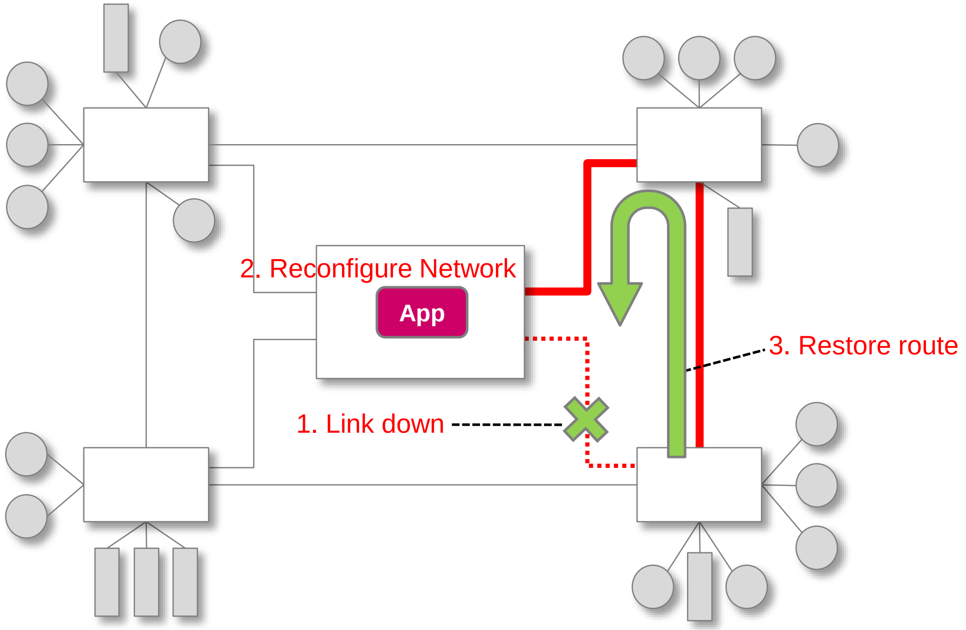




SDN use-case 3: Maintain reliable communication

- ✓ Scenario
  - It maintains reliable communication even if a fault happens on some network link/node
- ✓ Upon detecting a fault, it then establishes an alternative path to detour the fault.
- ✓ Path reconfiguration
  - Flow table update
  - Measure QoS
  - Control path re-establish

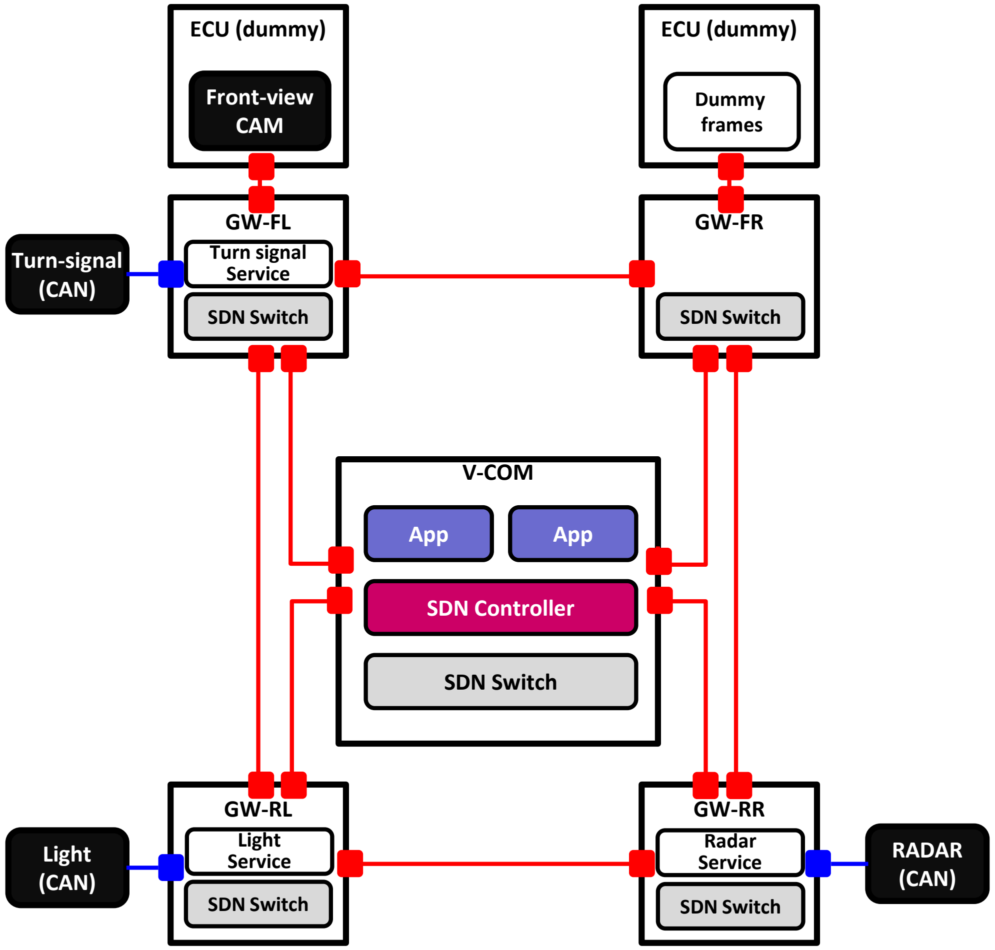




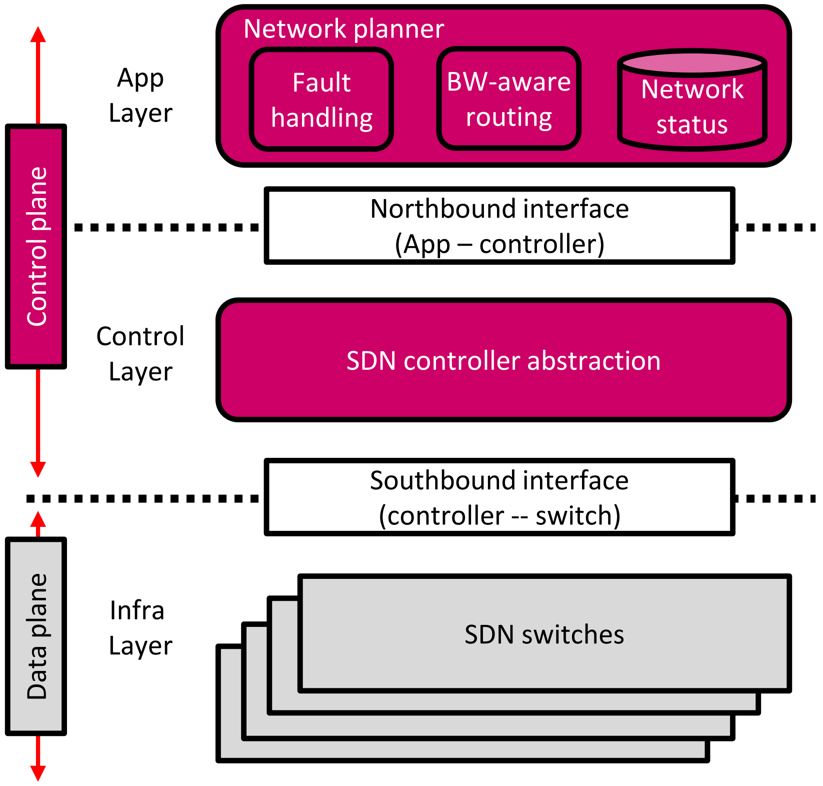
Reference architecture: Overall design

✓ Draft architecture considering 3 scenarios

System Architecture



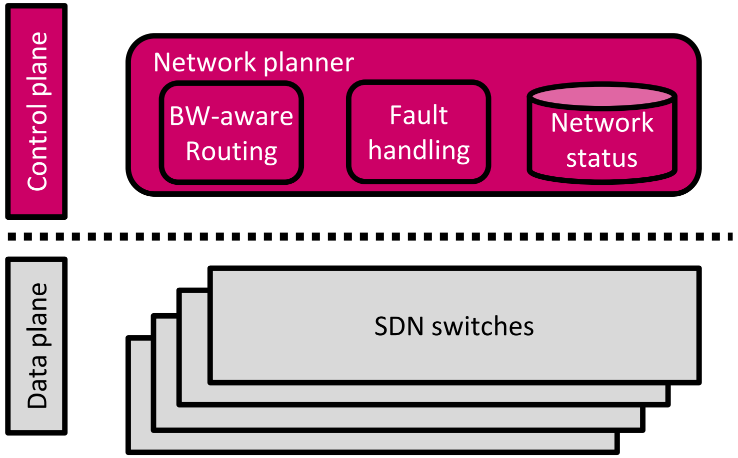
SDN 3 Layers



Reference architecture: Network planner

✓ Role of Network planner

- Monitors & maintains the global information of all the network nodes
- Reserves the bandwidth for a specific flow by controlling multiple nodes
- Reconfigures the path by monitoring each network node status



✓ Considerations for Network planner for automotive networking systems

- Dynamic bandwidth reservation & packet prioritization
- Reliable communication based on runtime fault recovery

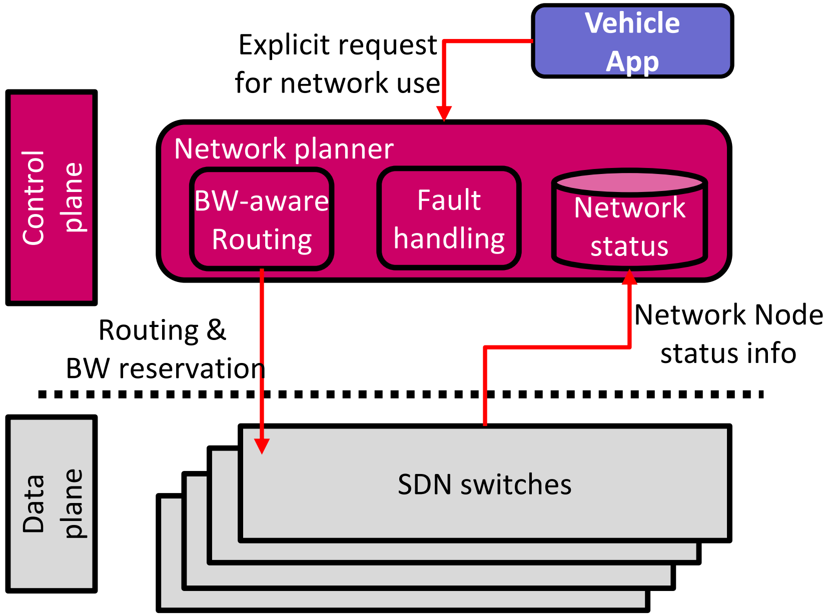
Reference architecture: Routing

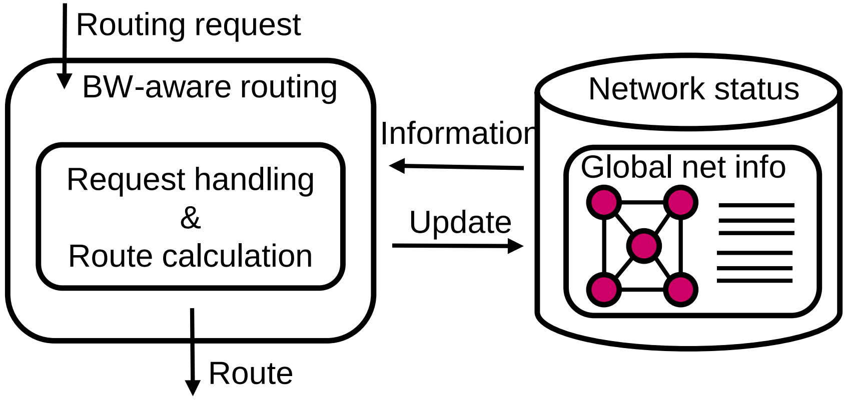
✓ Role of the routing component

- Determines a proper route subject to the flow requirement

✓ Considerations for the routing component

- Responsiveness
- QoS/timing requirements
- Runtime dynamic routing





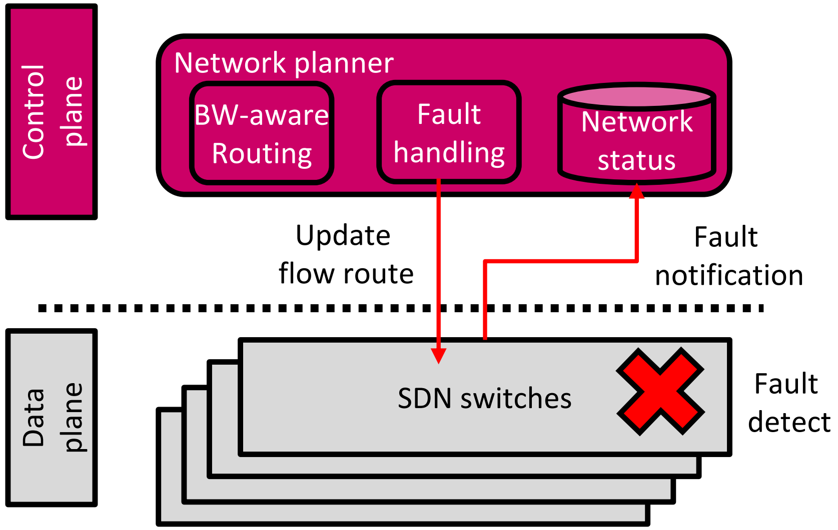
Reference architecture: Fault handling

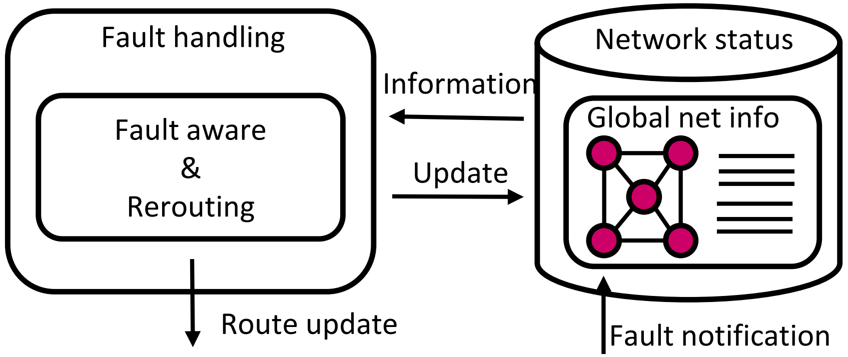
✓ Role of the fault handling component

- Restores flow routes upon link/node faults

✓ Considerations for the fault handling component

- Fault detection
- Responsive route update
- Control channel recovery





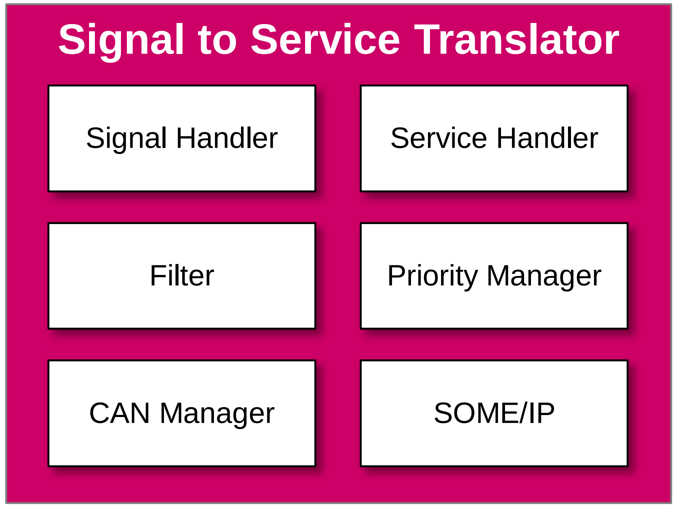
Reference architecture: Signal to Service Translator

✓ Role of Signal to Service Translator

- Focusing on deterministic transmission of CAN signals with priority control logic

✓ Considerations for Signal to Service Translator

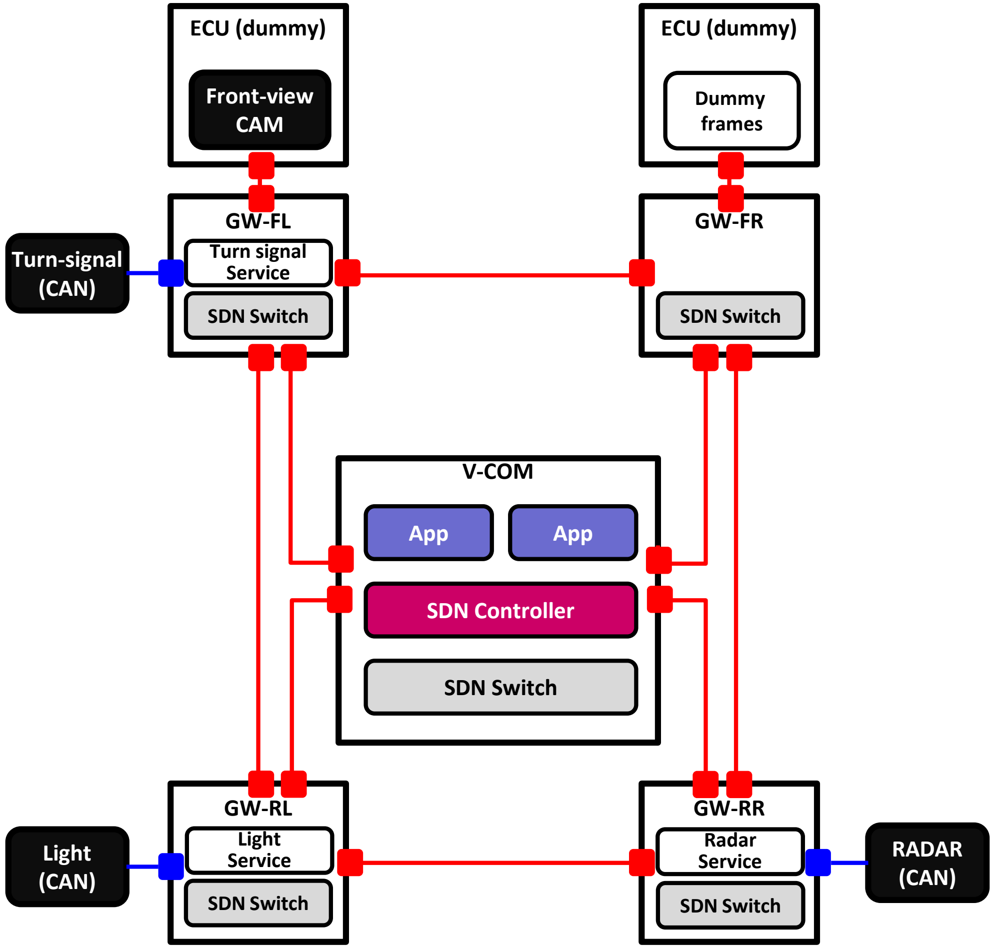
- Priority control
- Filtering while translation (eliminate duplication, scenario based filtering)
- Relationship with SOA

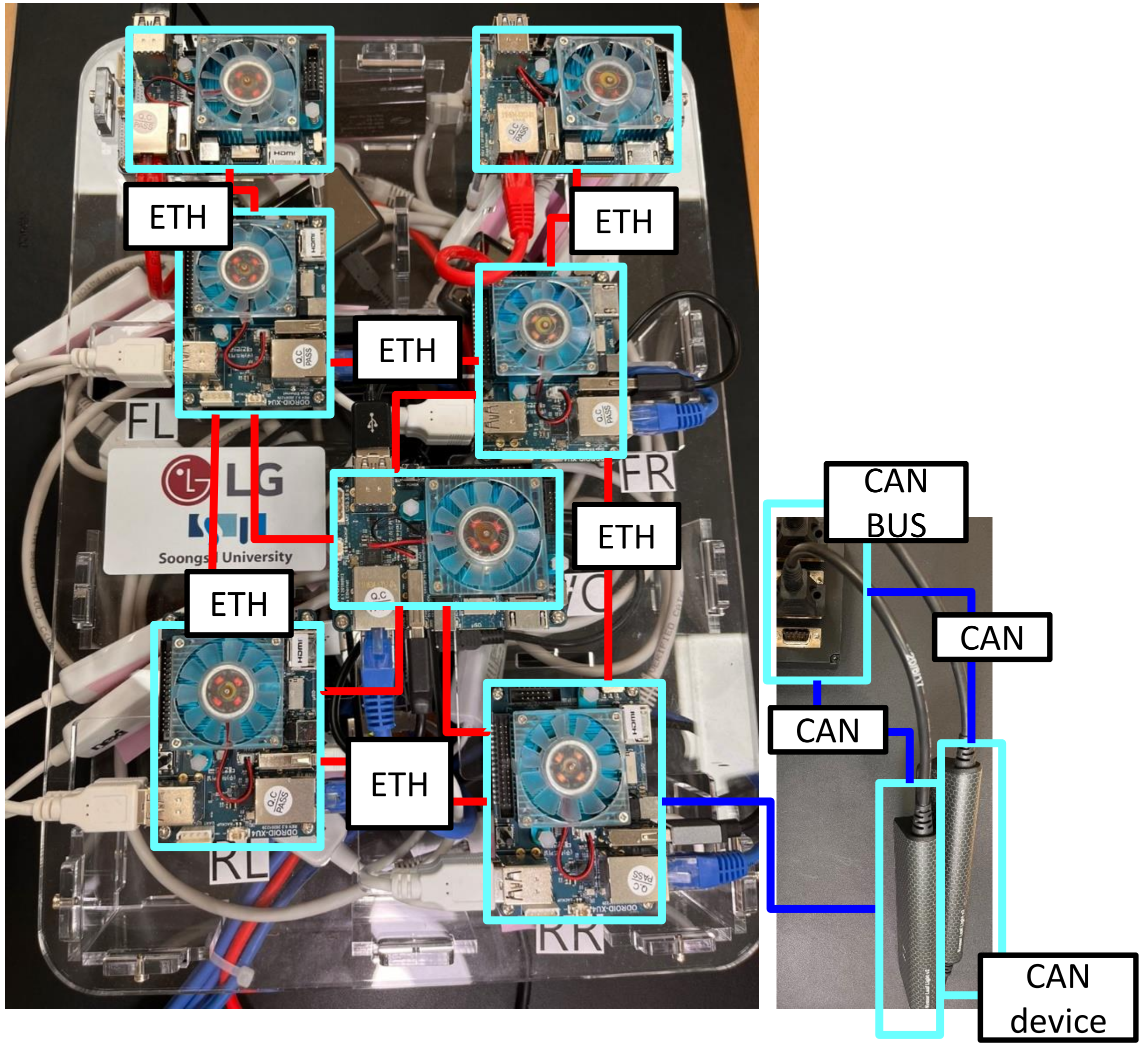


Component	Description
Signal Handler	• Translate CAN signal to Service message
Service Handler	• Translate Service message to CAN signal
Filter	• Filter CAN signal to translate
Priority Manager	• Assign priority to Service message
CAN Manager	• Send / Receive CAN signal
SOME/IP	• Send / Receive Service message

Reference architecture: Experiment

✓ Prototype implementation
- Networked embedded nodes
- Physical Ethernet & CAN communications

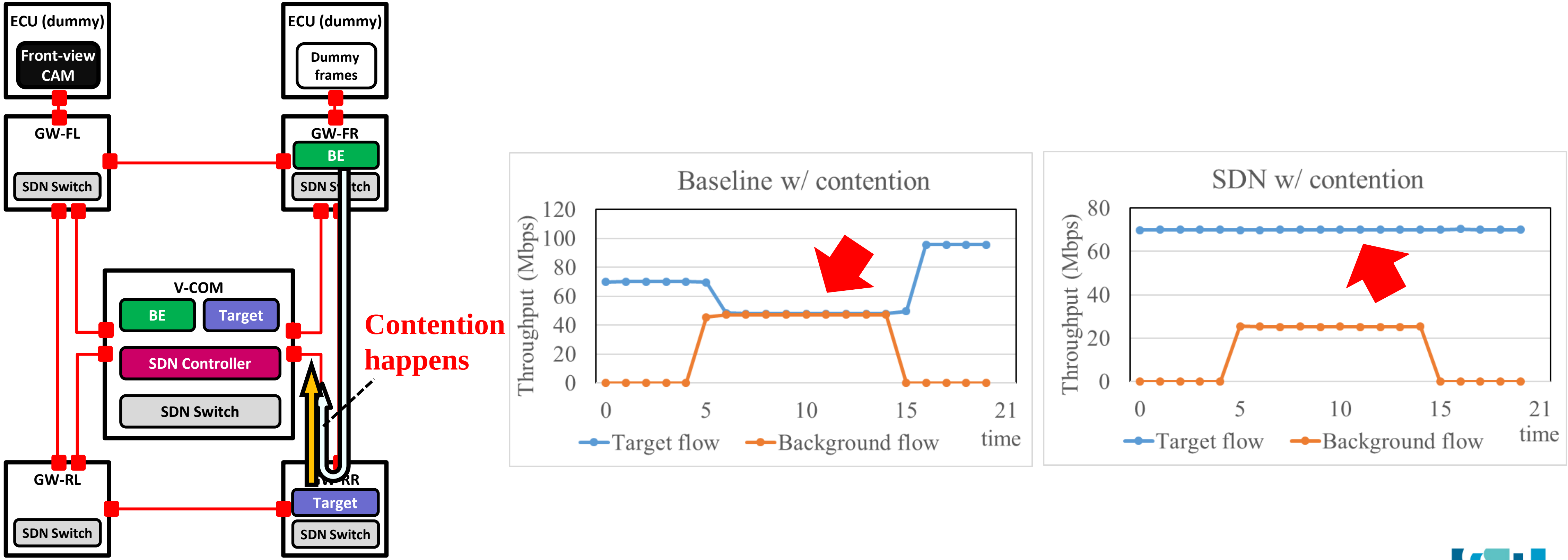




Evaluation: bandwidth reservation

✓ Efficacy of routing & bandwidth reservation
- The target (safety- or mission-critical flow) effectively reserves the bandwidth.
- Despite the contending best effort flows.

✓ Setup
- Target flow: RR → V-COM, UDP, 70Mbps
- Background: FR → VCOM, TCP, BE (up to 100Mbps)

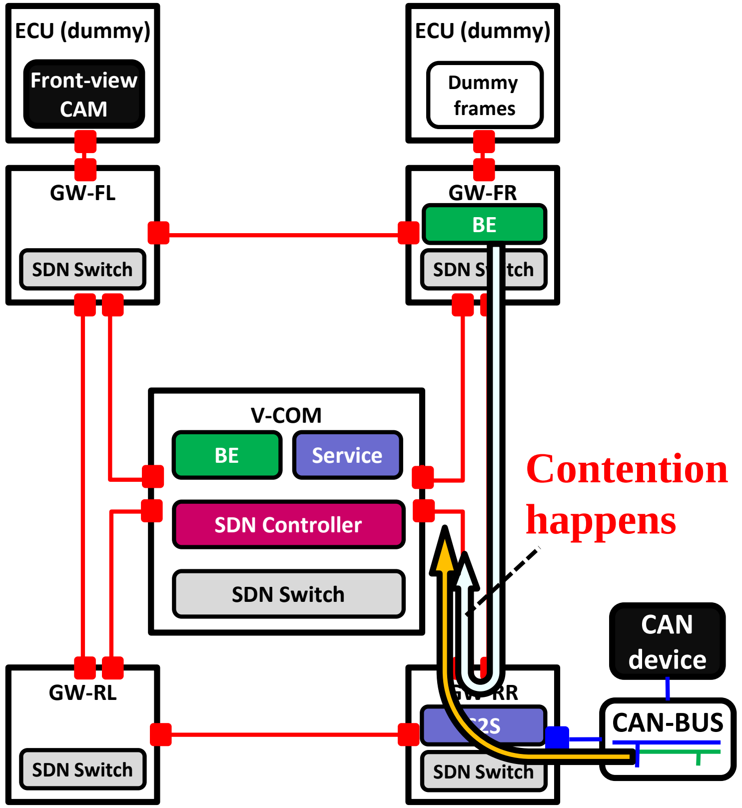


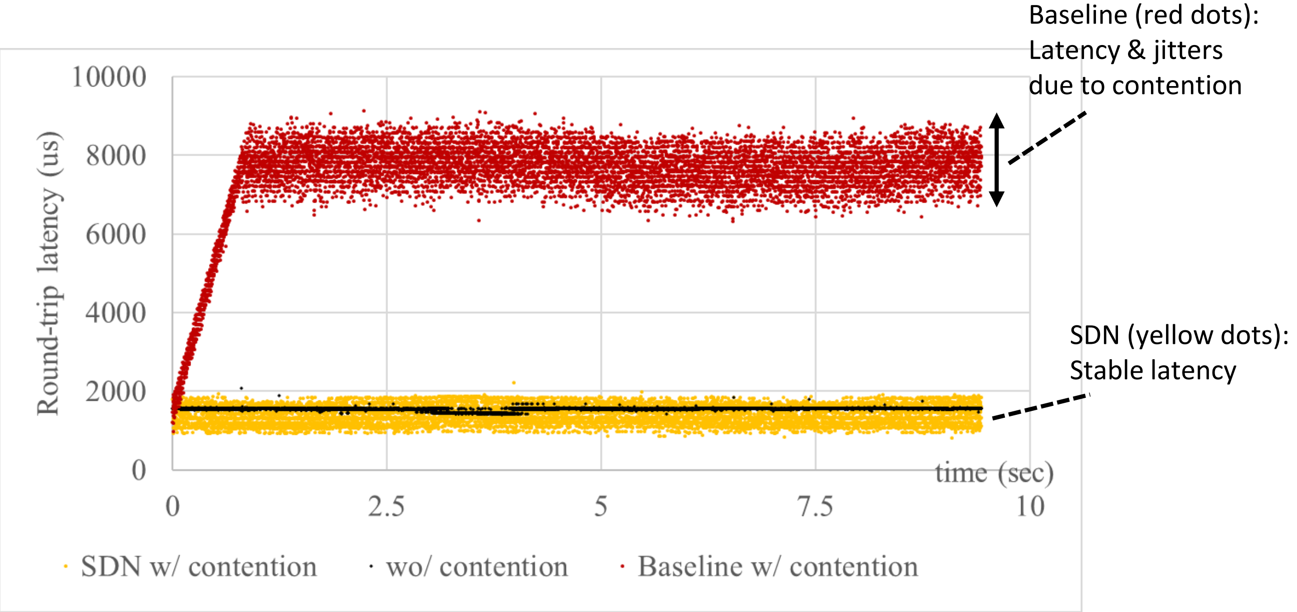
LG Life's Good

Soongsil University

Evaluation: CAN signal prioritization

- ✓ Efficacy of CAN signal prioritization
  - The safety-critical CAN signal shows stable latency
  - Despite the contending best effort flows.
- ✓ Setup
  - Target CAN signal: CAN device → CAN-BUS → RR(S2S) → VCOM (8 Bytes@1000 Hz, UDP encap.)
  - Background: FR → VCOM, TCP, BE (up to 100Mbps)

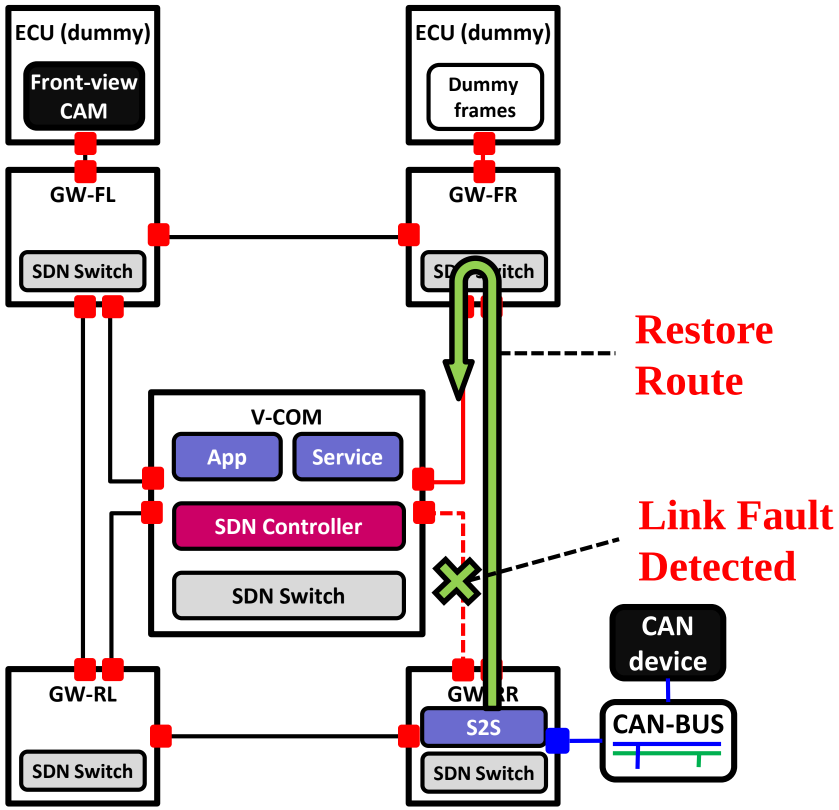


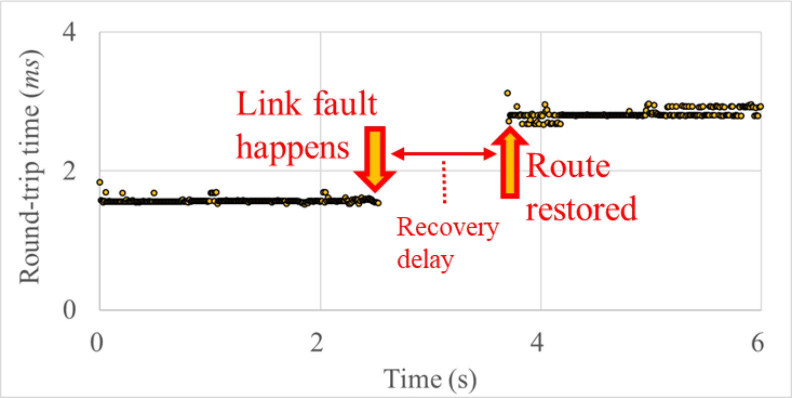


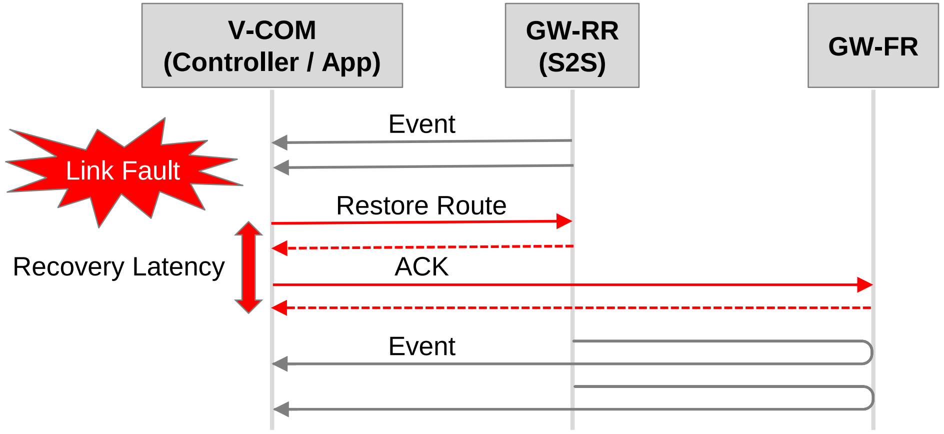
LG Life's Good
Soongsil University

Evaluation: Fault handling

- ✓ Efficacy of Fault handling
  - Effectively restores flow route upon link failure.
- ✓ Setup
  - Target CAN signal: CAN device → CAN-BUS → RR(S2S) → VCOM







Conclusion

✓ Recap: automotive SDN

- Key issues and use-cases
- Reference architecture
- Prototyping & evaluation

✓ Implications

- Better flexibility, efficiency, and reliability → essential features for SDV.

✓ Discussion & further considerations

- Security
- Functional Safety
- Better SDN interfaces for automotive
- Integration with the automotive software architecture

Q&A

Hyun taek Hong

Research Fellow / Architect
Vehicle component Solutions Company
LG Electronics Inc.

ht.hong@lge.com

Kilho Lee

Assistant Professor
School of AI Convergence
Soongsil University, Korea

khlee.cs@ssu.ac.kr