

**“Service-Oriented Gateway:
Connecting Automotive Ethernet and Cloud
for Efficient Development of Connected Car Services”**

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Contents

❖ Service-oriented Gateway

- End-to-End Service-oriented Architecture
- External Connectivity : Challenges & Approach
- Structural Concept
- Software Architecture

❖ Features of Service-oriented Gateway

- Protocol Conversion – Service Communication
- Protocol Handling – Service Discovery
- Edge Processing
- Policy & Access Control
- Network Utilization

❖ Connected Car Service Example

- Door Control Service
- Emergency Alarm Service

❖ Concluding Remarks

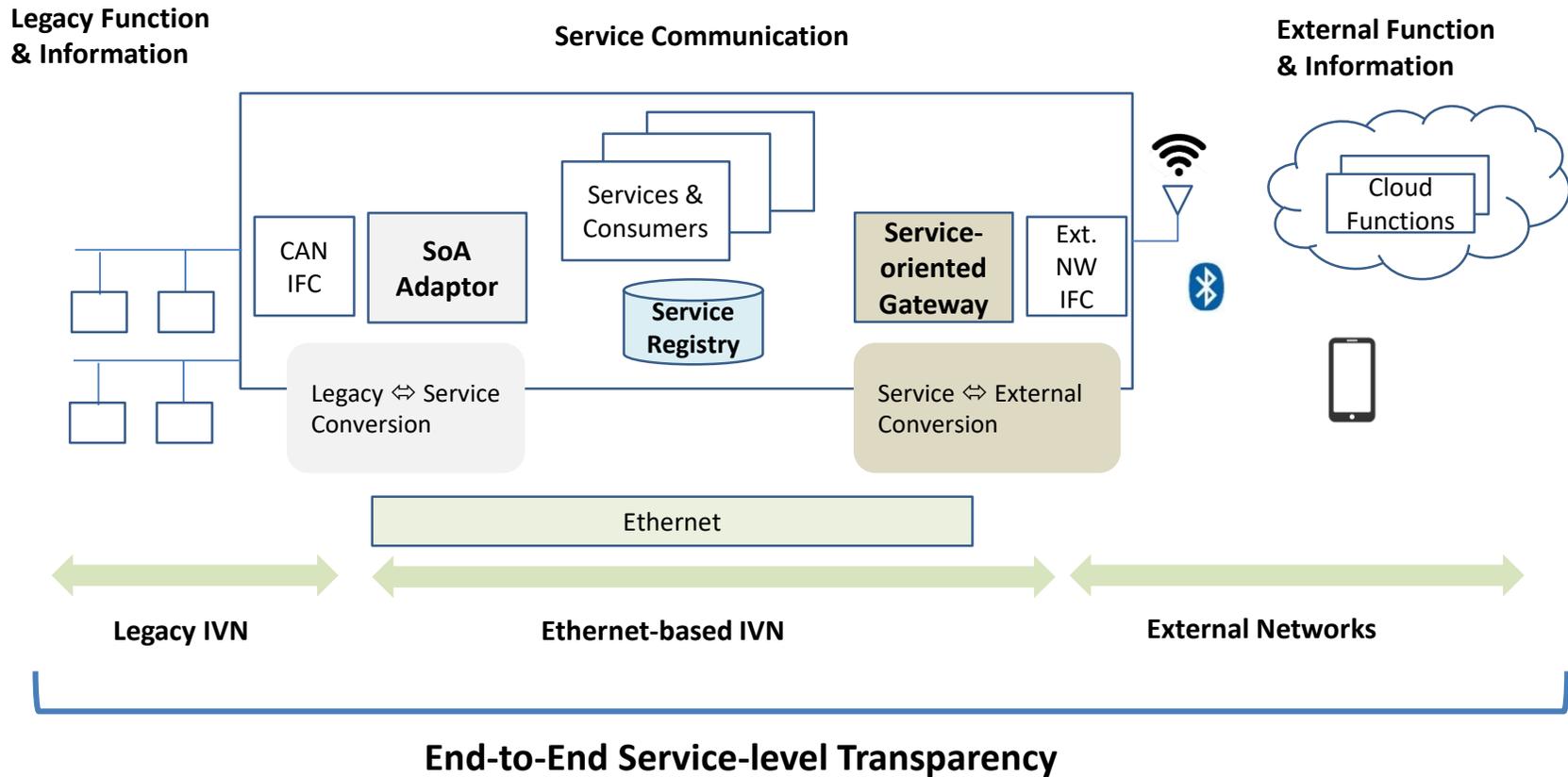
Service-oriented Gateway

- End-to-End Service-oriented Architecture
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End-to-End Service-oriented Architecture

❖ End-to-End Service-oriented Architecture

- Extended Service-level Transparency and Integrated Service Design



External Connectivity : Challenges and Approach

❖ External Devices on **External Network**

- Vehicle needs to interwork with external devices like **cloud servers** and smart devices.
- Interworking need gets much larger for ADAS and other connected car services.
- External networks have very different characteristics compared to IVN
: availability, bandwidth, latency, cost, etc.
- Application Protocols for external connectivity are usually different from those for IVN in general.
- High-risk security issues when interworking through external networks.

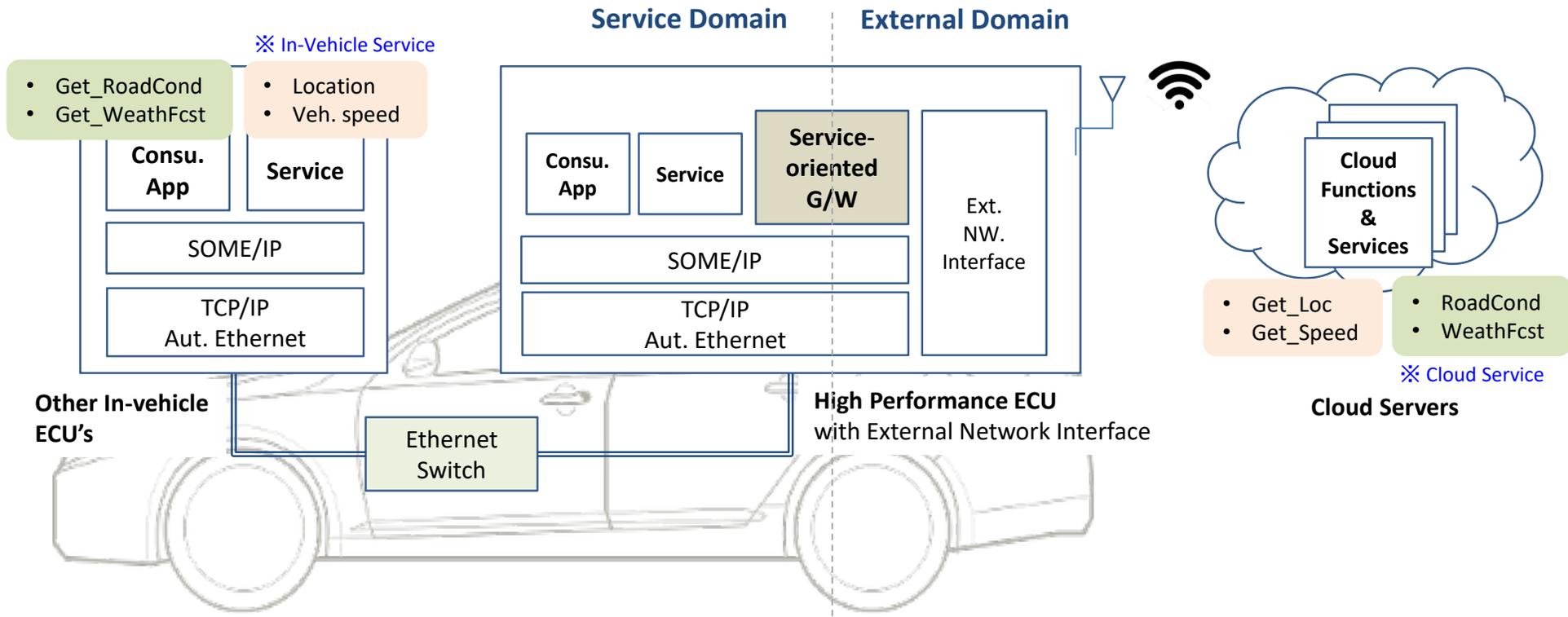
❖ **Service-oriented Gateway**

- Handles issues related with external device/network interworking.
- **Converts Application Protocols** and Translates Services.
- **Caches external information** to deal with availability & cost issues of external networks.
- Applies **Policy** and Performs Service-level **Access Control**.
- Should be implemented on ECU with external connectivity.

Structural Concept

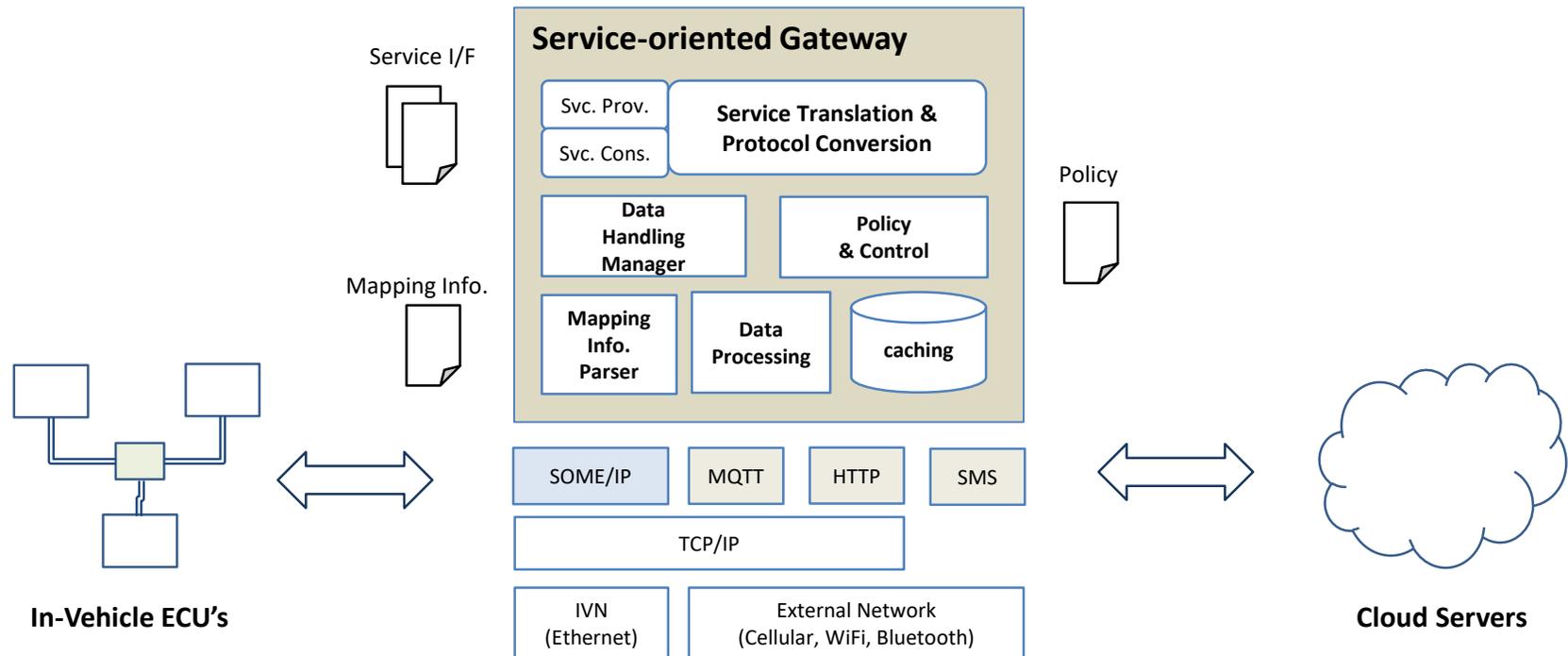
❖ Structural Concept of Service-oriented Gateway Interworking with Cloud Functions & Services

- In-vehicle Service Applications use Data/Functions from Cloud
- Cloud uses Data/Functions provided by In-vehicle Service Applications



Software Architecture

- ❖ Service-oriented G/W relays information between External Devices and In-Vehicle ECU's
 - With external devices: HTTP/MQTT/SMS depending on communication pattern
 - With in-vehicle ECU's: Service-oriented communication based on SOME/IP



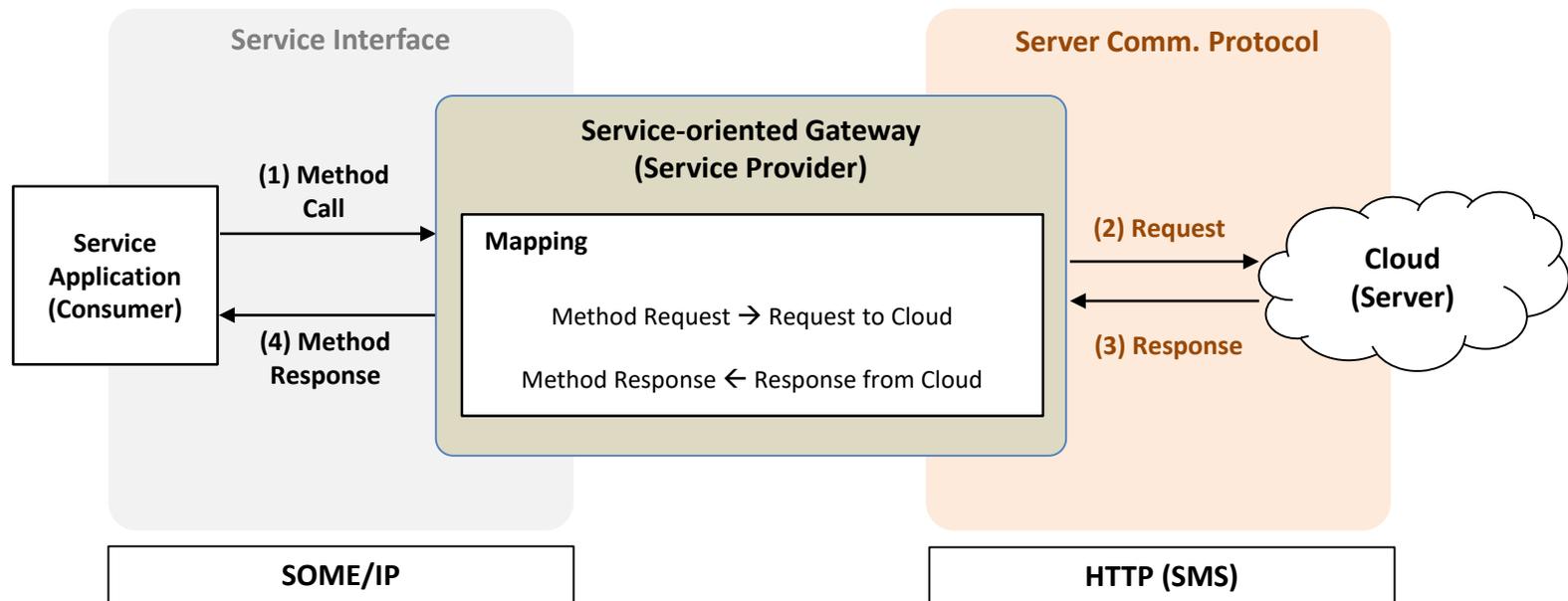
Features of Service-oriented Gateway

- Protocol Conversion – Service Communication
- Protocol Handling – Service Discovery
- Edge Processing
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Protocol Conversion: Service Communication

❖ Two-way Communication : Vehicle Origination

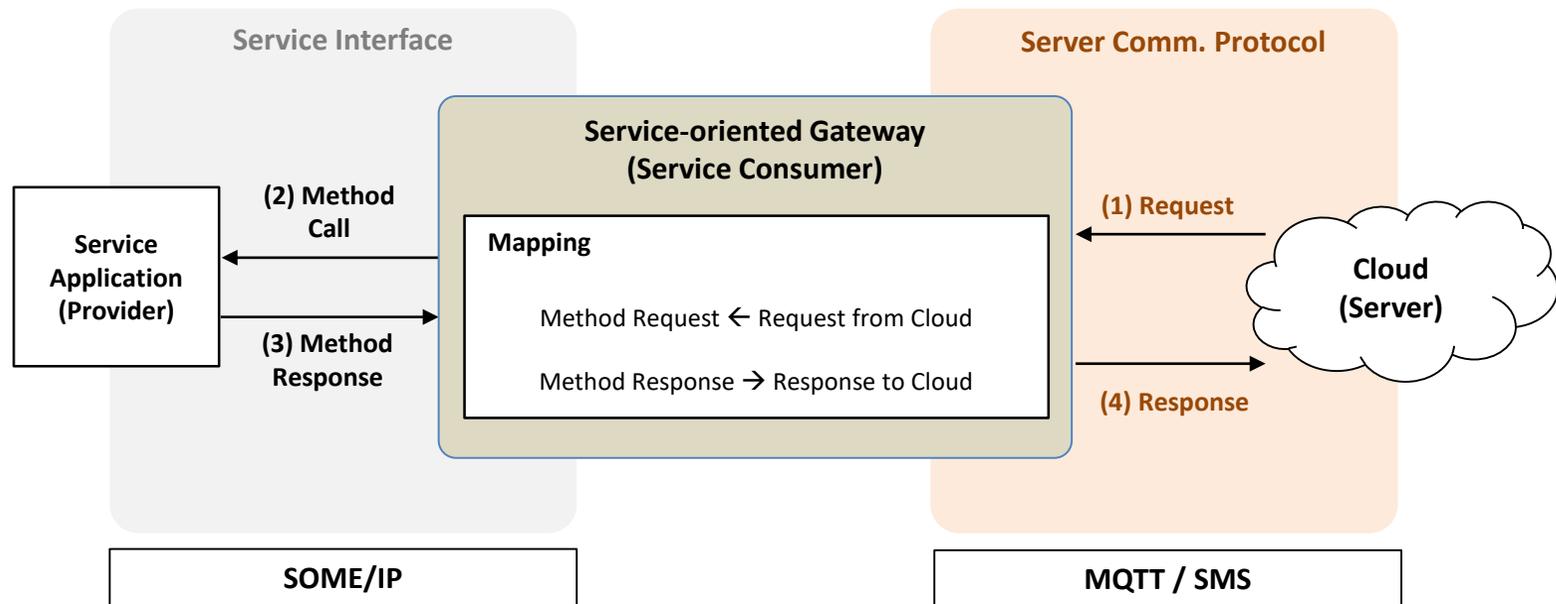
- Service Consumer makes method requests to G/W and the requests are relayed to External Networks using HTTP.



Protocol Conversion: Service Communication

❖ Two-way Communication : Vehicle Termination

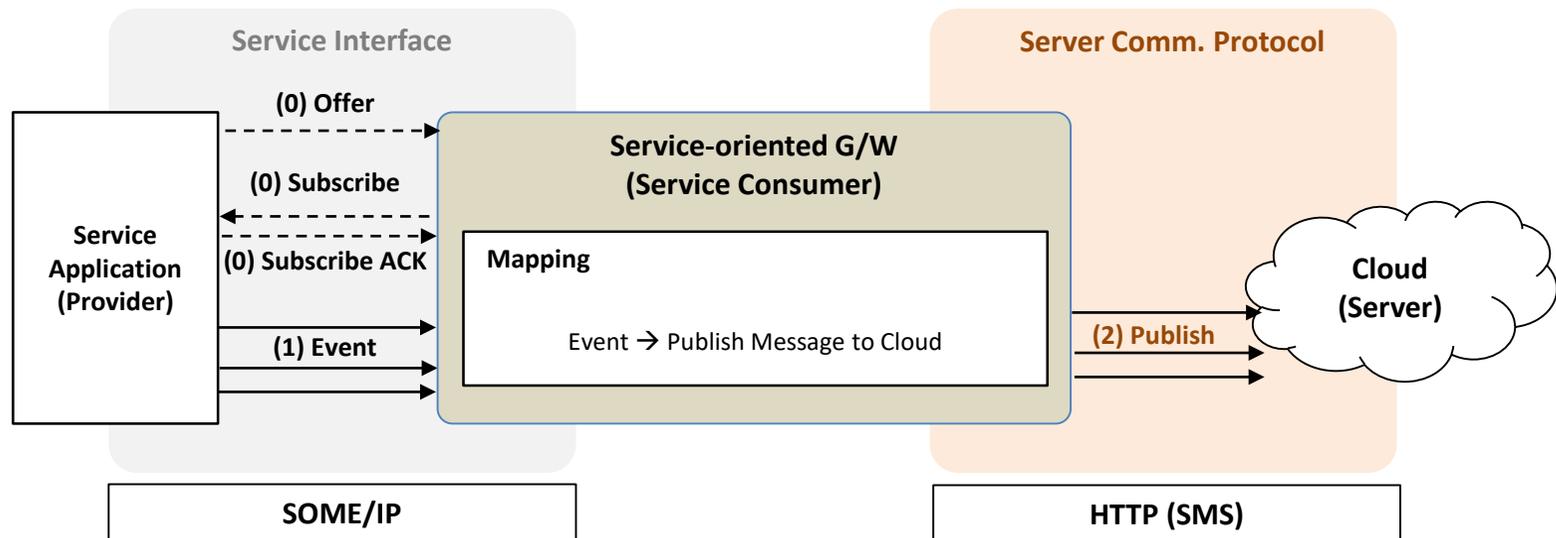
- After receiving requests from Cloud, G/W makes corresponding method calls to an appropriate Service Provider and relays the responses to Cloud



Protocol Conversion: Service Communication

❖ One-way Communication : Vehicle Origination

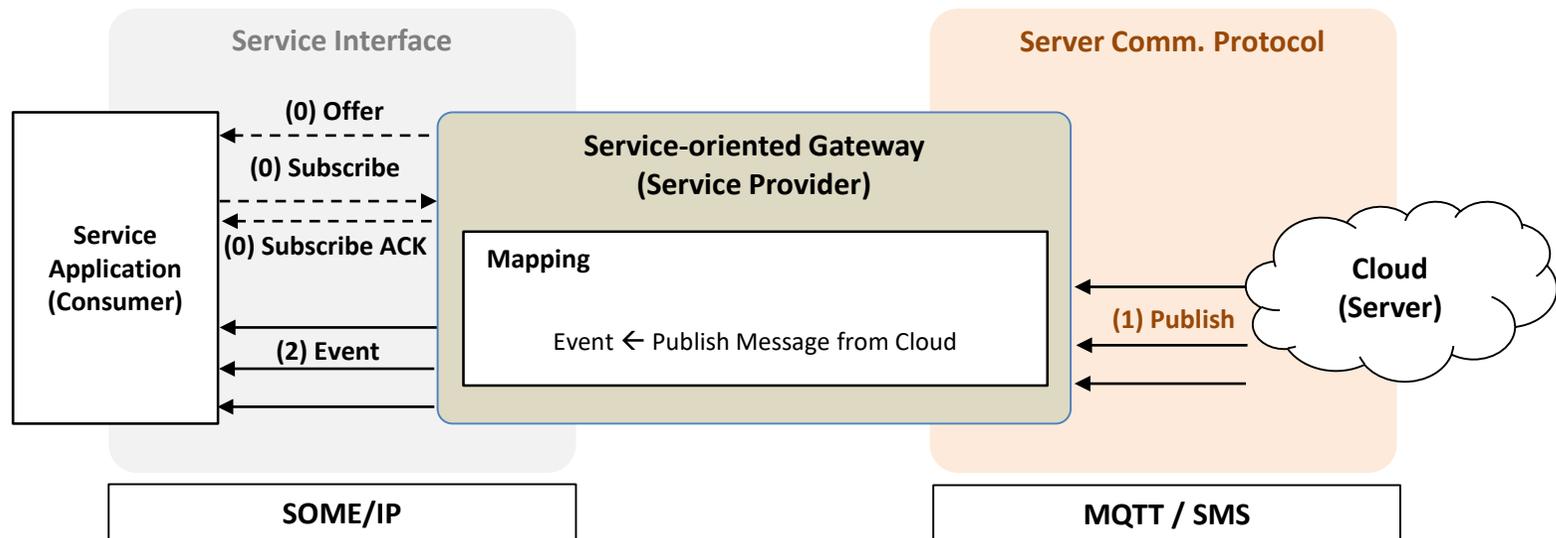
- Service Provider fire an event to G/W and then G/W relays the event data to Cloud using HTTP
- To facilitate communication with In-vehicle ECU, G/W utilizes SOME/IP SD to subscribe to events



Protocol Conversion: Service Communication

❖ One-way Communication : Vehicle Termination

- G/W relays data from Cloud to In-vehicle ECU's as event notification

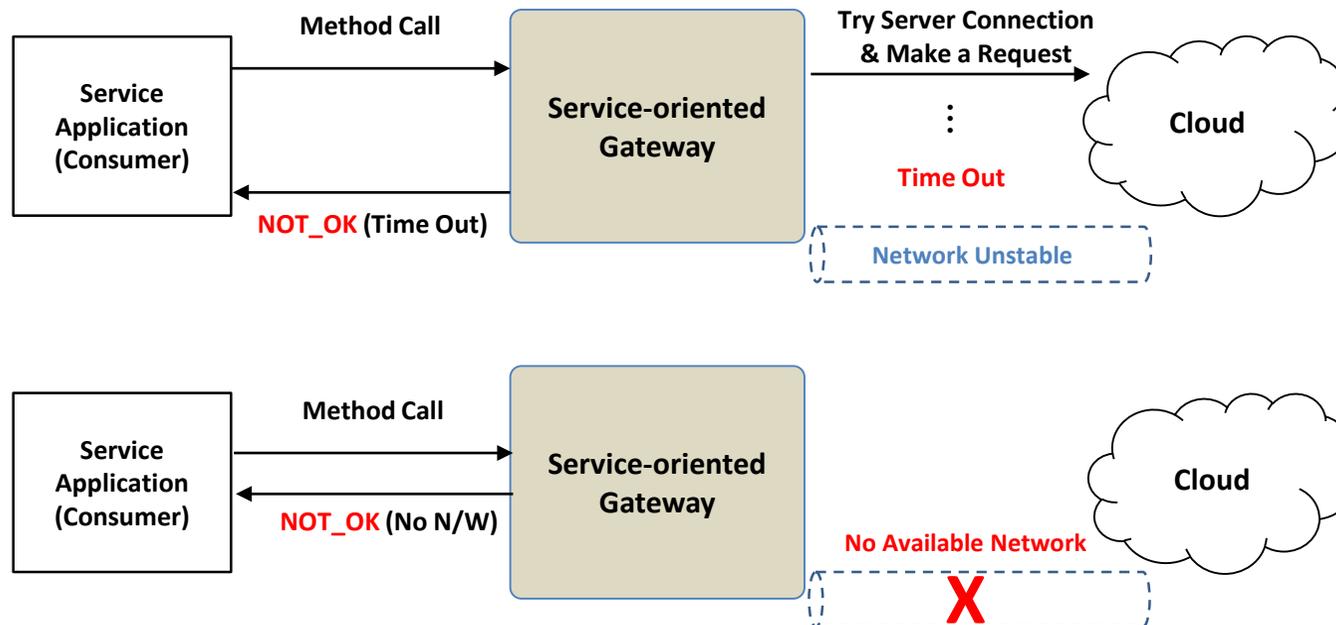


Protocol Conversion: Service Communication

❖ External Connection Status is mapped to corresponding Service Domain Behavior

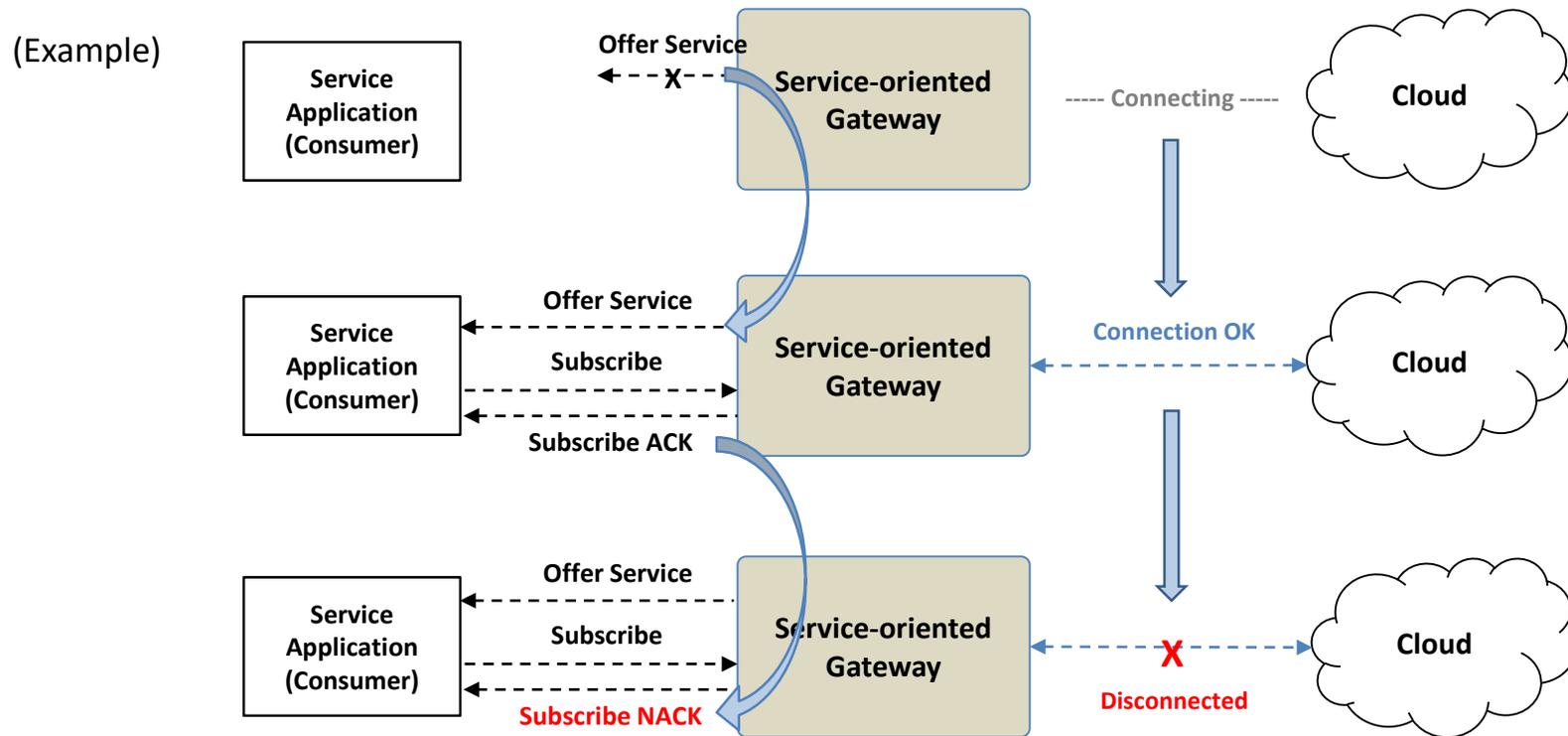
- Example

- In case of unstable network or busy server: Retry Server Connection (NOT_OK if Time out)
- In case of no available network : Respond with NOT_OK



Protocol Handling: Service Discovery

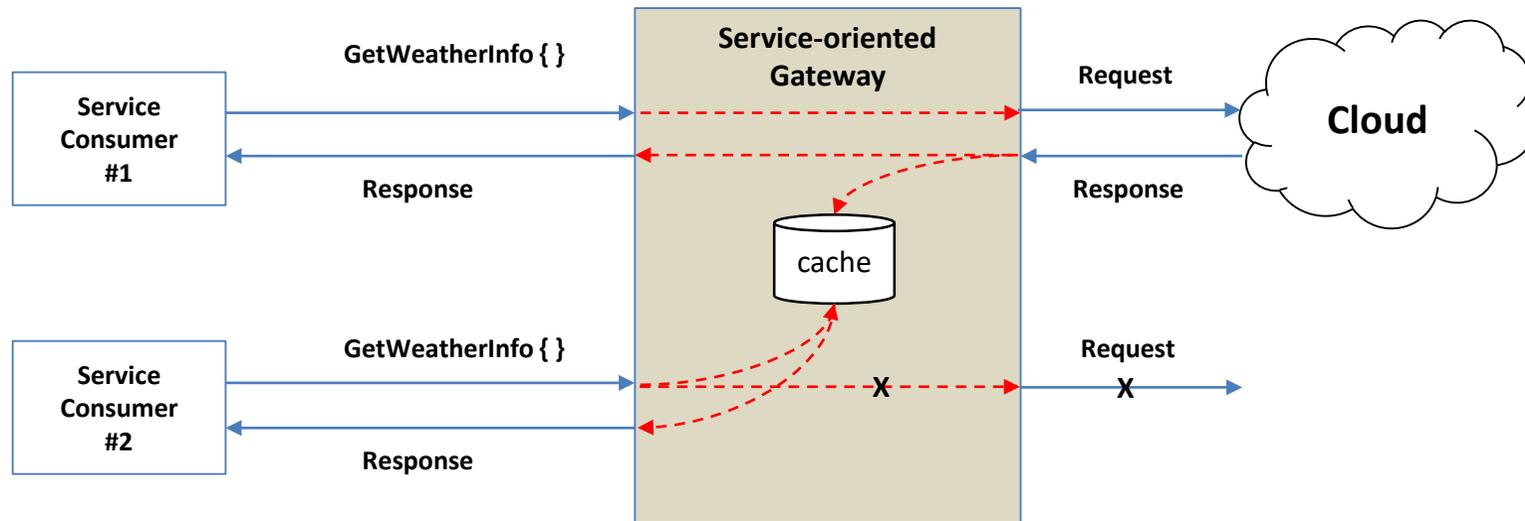
- ❖ G/W performs Service Discovery for service-oriented communication with In-vehicle ECU's
 - Uses SOME/IP SD Protocol
 - Adaptive Operation Timing and Behavior Modes in accordance to External Network status



Edge Processing

❖ Caching Responses from External Networks

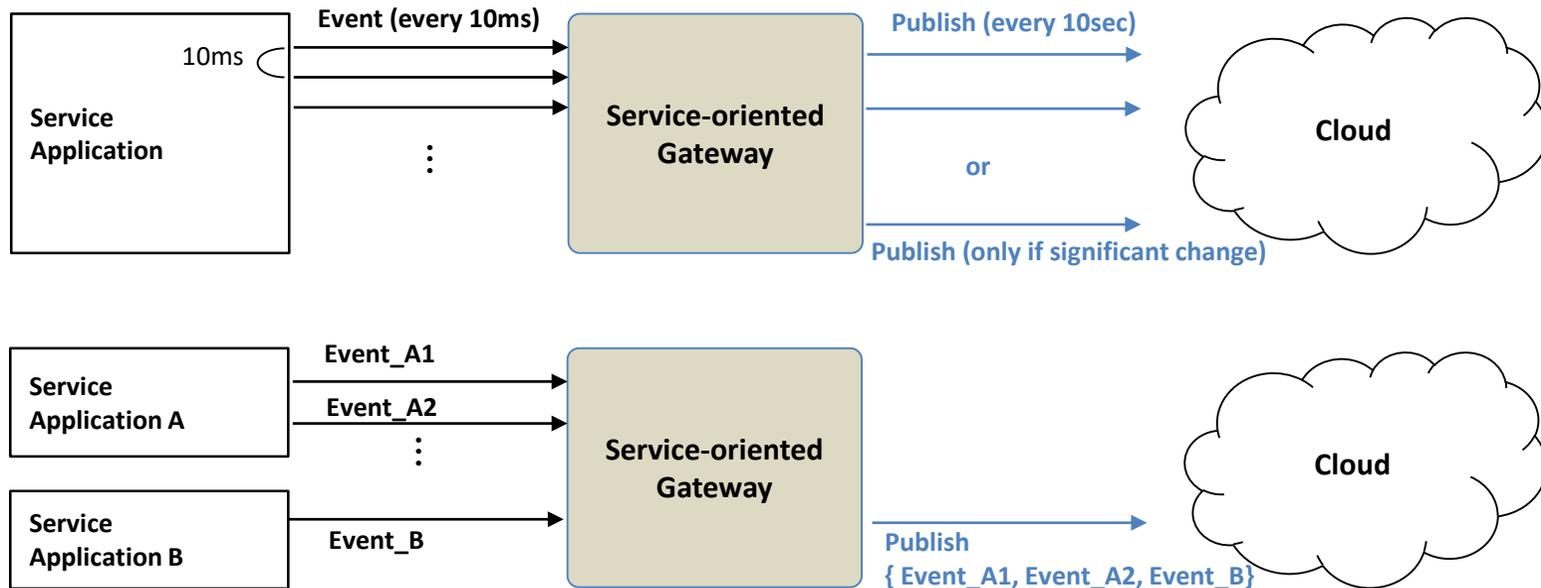
- Prevents unnecessary excessive connections to external networks
- Improves Responsiveness & Reduces Network Cost



Edge Processing

❖ Filtering & Aggregation

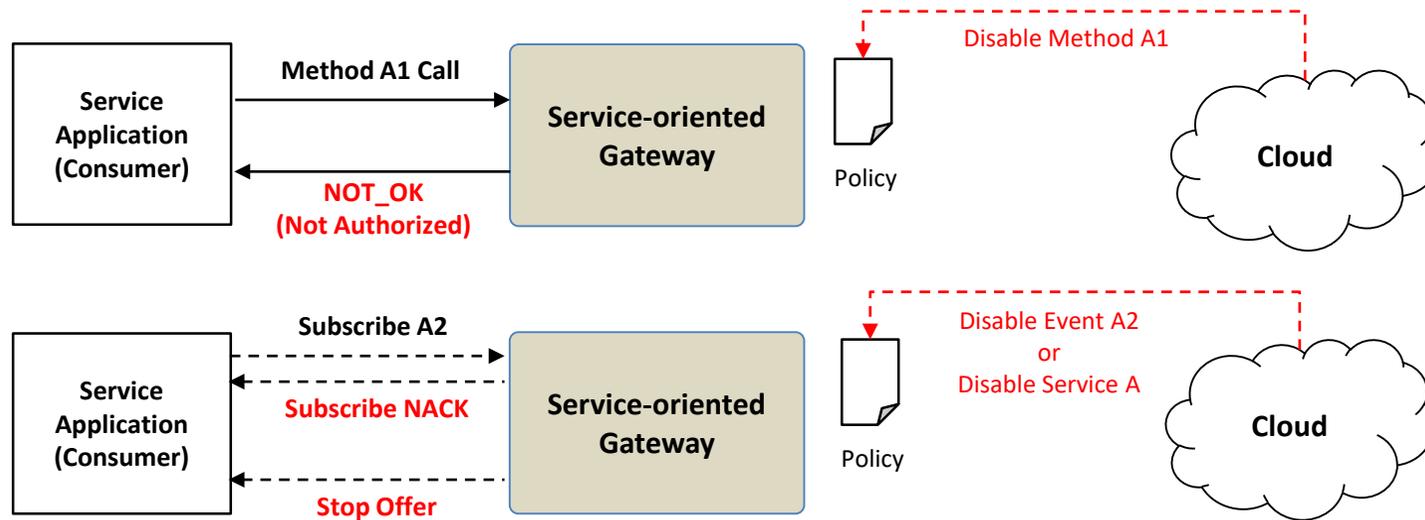
- Relays **less data and less frequently** to Cloud than received from in-vehicle ECU's
- Performs Period-based or Contents-based Filtering
- Aggregates Multiple Events from One or Several Service Applications
- Reduces Communication loads and Network costs



Policy & Access Control

❖ Service-level Access Control

- Access Control at Service Level or Service Element Level (e.g., for each method or event)
- Access Control Policy can be applied Statically or Dynamically from Cloud



❖ Operation Policy

- Policy can be applied for other G/W operations like Filtering, Caching, and Network Mapping.

Connected Car Service Example

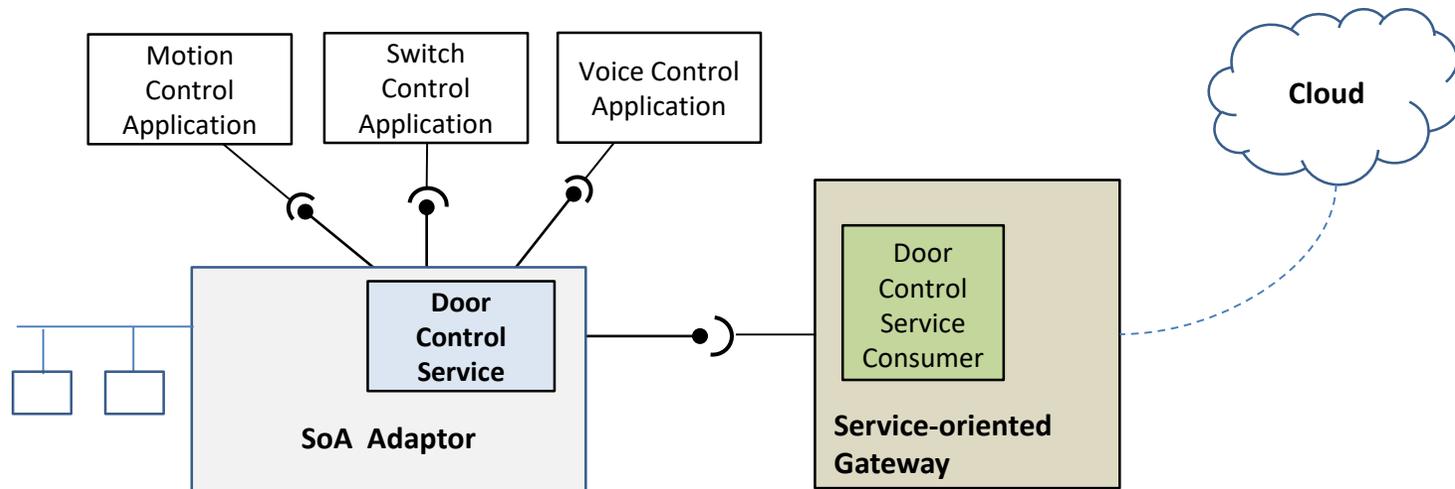
- Door Control Service
- Emergency Alarm Service

Connected Car Service Example

❖ Remote Door Control Function

- Utilizes existing “Door Control Service” provided by SoA Adaptor

Service Name	Service Interface	Argument	Direction	G/W Acts as	External Protocol
Door Control	Request & Response	Door Position (FL/FR/RL/RR) Target Status (Lock/Unlock)	Vehicle Termination	Service Consumer	MQTT

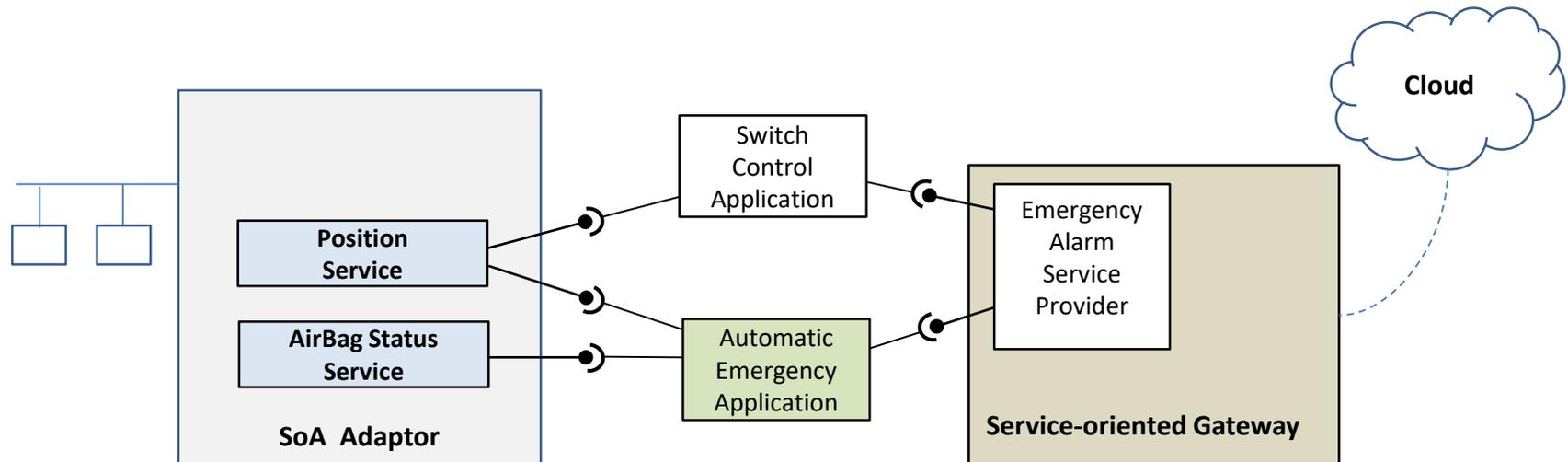


Connected Car Service Example

❖ Airbag Activation Alarm Function

- Utilizes existing “Emergency Alarm Service” provided by Service-oriented G/W

Service Name	Service Interface	Argument	Direction	G/W Acts as	External Protocol
Emergency Alarm	Request & Response	Current Position Alarm Reason	Vehicle Origination	Service Provider	HTTP



Concluding Remarks

- SoA can be **extended to End-to-End** from legacy ECUs to **Cloud**.
- **Service-oriented G/W** can be introduced for efficient SoA extension to Cloud.
- It enables in-vehicle S/W to interact with Cloud **in a service-oriented way**.
- It efficiently handles external-network related issues like availability, delay, cost, and security, by performing **protocol conversion, caching, filtering, network mapping, and access control**.
- Its operation can be **dynamically controlled** as defined in the policy from Cloud.
- With SoA Adaptor and Service-oriented G/W, **new connected car services** can be developed and deployed **with least time and effort**.