Use Case and Technology Evaluation Criteria - CPS Mobility Management Use Case Step 1

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1. Introduction

1.1. Vision

IOWN technologies achieve a communication platform that can handle very large volumes of data at high speed and low power consumption with an efficient data processing architecture. This enables large amounts of sensor data from roadside equipment such as cameras and radar to be processed with fewer servers and reduced power usage. As a result, road operators can decrease the number of processing nodes due to improved efficiency in data transmission, which helps lower operational costs such as maintenance labor and electricity expenses. In addition, the improvement in data processing efficiency removes the need to deploy many edge computing systems for the purpose of artificial intelligence analysis, which greatly reduces initial capital investments. By supporting real-time processing of large sensor data sets while keeping system resource requirements, energy consumption, and operational expenses low, IOWN contributes to faster detection of road anomalies, improved traffic safety, and reductions in downtime for road services.

1.2. Scope

This document refines the Mobility Management Use Case concept outlined in subsection 3.2 of the Cyber-Physical System Use Case document, which was published in 2021. To refine the use cases, it details selected reference cases and organizes key technical requirements.

The proposed use cases are examined in Step 1 and Step 2. The focus in Use Case Step 1, as shown in Figure 1, is on a road management system that processes sensor data obtained from roadside sensors at a remote data center. Use Case Step 2, as shown in Figure 2, includes sensor data from in-vehicle sensors in addition to Step 1. The sensor data collected from Roadside Units (RSUs) is transmitted to the remote data center, and the processed data is sent back to vehicles through RSUs, forming a driver assistance system. In both steps, IOWN's Open All-Photonic Network (APN) provides end-to-end optical paths between roadside areas and a data center, enabling high-performing and energy-efficient data transfer. The sensor data are processed on IOWN's Data-Centric Infrastructure (DCI), which aims to achieve high-performing and energy-efficient data processing, especially with hardware-acceleration technologies. This document focuses on Use Case Step 1.

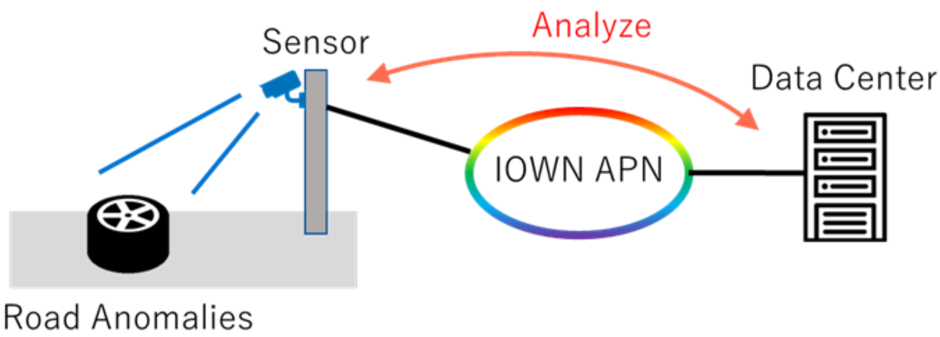

Figure 1: Configuration for Use Case Step 1

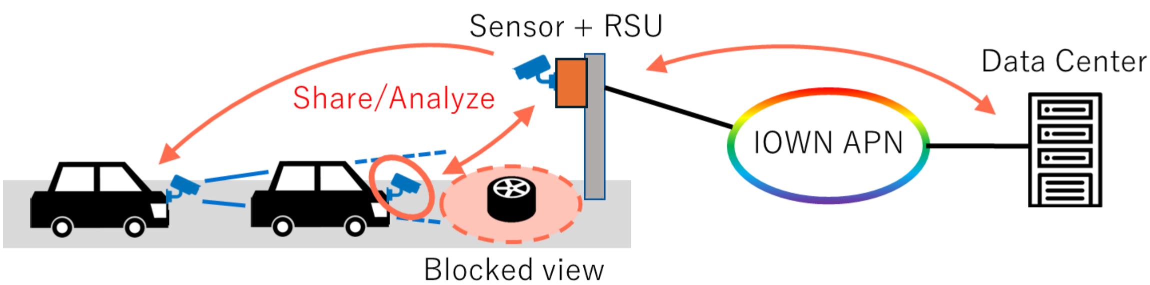

Figure 2: Configuration for Use Case Step 2

2. Industry Roadmap and Stakeholder Collaboration

For Step 1, collaboration with highway operators will drive infrastructure integration using roadside sensors, enabling advanced road monitoring and faster anomaly detection.

Additionally, partnerships with telecom and data center operators will strengthen end-to-end mechanisms from data collection to analysis and notification.

For Step 2, collaborations with Standards Developing Organizations (SDOs) for Vehicle-to-Everything (V2X) and adjacent technologies will help create an industry-wide ecosystem roadmap. For example, we aim to broaden the scope of use cases through collaborations with an SDO focusing on edge computing technologies and another SDO working on wireless communication technologies.

3. Use Cases - Road Condition Surveillance

This use case aims to significantly enhance road condition awareness and recovery efficiency by utilizing the APN and DCI technologies.

Sensor data from cameras, radars, and LiDAR sensors installed on roads is collected at remote data centers used by road operators. AI continuously analyzes the sensor data, detecting anomalies such as fallen objects and cracks, and automatically notifying the road operators.

The sensor data is transferred using Remote Direct Memory Access (RDMA) over APN, with RDMA-capable Network Interface Cards (RNICs) serving as the interface between roadside sensors and data center servers. This eliminates the need for edge AI, enabling centralized computing systems and improving economic efficiency. The sensor data is analyzed through a hardware-accelerated pipeline on the DCI, improving the energy efficiency of AI analysis. This use case achieves rapid lane restoration, reducing downtime of road services.

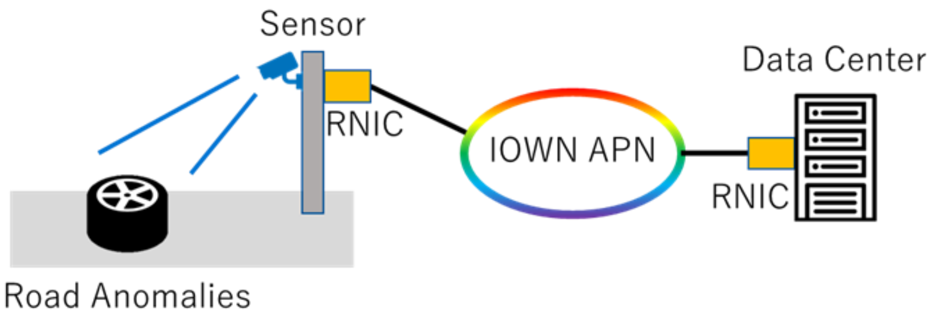

Figure 3: Use Case Configuration

4. Key Requirements - Road Condition Surveillance

This section presents the key requirements for implementing the proposed use case.

Table 1: Key Requirements

Item	Value	Note
Number of sensor devices accommodated	5,000 devices or more	To monitor the entire road, more than 5,000 units must be accommodated in a system. It assumes a 300-kilometer highway where sensors are installed every 200 meters, with three sensors at each location. Additional sensors are installed in curves and tunnels to ensure enhanced monitoring and safety.
Network Bandwidth	● HD/H.264: 25 Gbps ● Full-HD/MJPEG: Up to 300 Gbps	We assume the camera data has a spatial resolution of HD or Full HD and a frame rate of 15 fps with H.264 or Motion JPEG (MJPEG) compression. H.264 compression for HD video is estimated to require a bandwidth of about 5 Mbps per camera, while MJPEG compression for Full-HD video is expected to require a bandwidth of 45–60 Mbps per camera. Even higher bandwidth may be required for more advanced AI analysis.
Latency	Several hundred ms	This use case defines latency as the time from the reception of sensor data at the roadside to the completion of AI analysis at the data center. Low latency is essential for real-time information sharing.

5. Technology Evaluation Criteria

To evaluate the benefits of adopting IOWN technologies, reference cases and metrics are defined.

5.1. Reference Case for Road Condition Surveillance

Table 2: Benchmark Conditions

Item	Value	Note
Road length	300 km	A highway in one area
Distance between sensors	200 m	Average value for the entire monitored area
Monitoring time	24 hours	Continuous monitoring

5.2. Metrics

The following metrics will be measured to evaluate the developed system.

Table 3: Evaluation Conditions

Item	Description
Latency	End-to-end processing time from sensor data reception to AI analysis completion
Throughput	Volume of sensor data processed per unit time
Required system resources	The overall system resources and configuration, such as number of servers and network equipment
System energy consumption	Total energy consumption of the overall system, or at least the energy consumption of nodes for aggregation of sensor data and AI analysis
Estimated human resources	Number of operators required for road condition surveil-lance

6. Conclusion

This document proposes a new approach to road management by leveraging the IOWN APN and DCI to improve AI processing efficiency and reduce energy consumption, and lower both operational and deployment costs for road operators. This approach facilitates a transition from human-resource-dependent monitoring to sustainable and economically efficient operations.

Future steps include integration with vehicles in Step 2, enabling driver assistance through roadside and in-vehicle sensor integration, and ensuring interoperability through collaboration with SDOs for V2X and related technologies. Additionally, reference implementation models and proof-of-concept activities will comprehensively evaluate performance, cost, and environmental impact.

Ultimately, this initiative aims to contribute to solving social challenges such as improving traffic safety, reducing accidents, and lowering environmental impact.

History

Revision	Release Date	Summary of Changes
1	August 2026	Initial Release