NEEDS FOR ADVANCED CONNECTIVITY SERVICES FOR COMMERCIAL VEHICLES

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A STUDY WITHIN THE DRIVE SWEDEN PROJECT ”SYSTEMS AND SERVICES FOR MOBILITY, 2021”

1 Introduction

The overarching goal of the Drive Sweden project "Systems and Services for Mobility, 2021" is to provide Drive Sweden with a technology and service platform and related conditions to enable and drive the development, demonstration and innovation of automated transport and mobility services so that Sweden and Swedish actors can achieve Drive Sweden's goal of making Sweden a leader in the field. In 2021, there are specific goals regarding the continued development of Innovation Cloud and Traffic Tower and to support investments in digital twin, simulation, AI and specific functionality linked to freight transport and logistics.

This report focuses on the needs for advanced connectivity services for commercial vehicles, and trucks in particular. This is done by making a plan for how the advanced connectivity capabilities that are currently under development on the Scania test track in Södertälje (see section 3) can be better leveraged in different use cases by combining it with the Drive Sweden Innovation Cloud (see section 0). The primary objectives that Scania wants to fulfil are described in section 2. Thus this report addresses several topics that has been studied both under WP1, WP2, WP3 and WP4 of the related project.

2 Objectives

2.1 Main objectives

OBJECTIVE 1: TO READ advanced intersection and general traffic information from a network resource

OBJECTIVE 2: TO READ telco network QoS parameters based on data from base stations and possibly augmented with data from vehicles (use fleet as probes)

OBJECTIVE 3: TO SET the parameters that change QoS in a test telco network (with actual impact on the real network)

OBJECTIVE 4: TO RUN scenarios to see what the result is of different changes in telco network parameters, results illustrated in Innovation Cloud

2.2 Interesting functionality to explore

- A local breakout with an edge node as well as edge features and characteristics in a federated cloud network (Mobile Edge Compute).
- Service and Network Exposure Functions (NEF) and other APIs
- Network slicing ie creating multiple unique logical and virtualized networks over a common multi-domain infrastructure.
- Impact on use of NR frequency range 2 (24-71 GHz) (also known as mmWave)
- 5G and RTK positioning
- 5G ultra reliable low latency communications (URLLC)
- SIM applets and LPA for rules-based choice of network

3 Intended connectivity solution for Scania's test track in Södertälje

Scania is, in collaboration with Ericsson and Telia, in the process of equipping its test track in Södertälje with advanced connectivity capabilities in order to be able to test and develop state of the art connectivity solutions in fast iterations. The planned service includes:

1. a dedicated local private radio infrastructure using private/industrial spectrum
2. a customized radio infrastructure for Telia Public 4G and 5G coverage
3. a connection of the above radio infrastructure to the innovation platform, Telia Innovation Hub.
4. a connection of the public radio infrastructure to Telia Public Macro Network

Telia Innovation Hub is a new 5G platform targeted for customer centric innovation and development where Telia and Ericsson will offer state of the art functionality and technology before launched in the public network. In the first release basic functionality will be offered, but gradually more advanced 5G technology and functionality will be introduced based on customer needs and platform upgrades. The Telia Innovation Hub network is intended for data centric applications and will, at least initially, not include any voice and sms/mms services. This means that most smart phone type of devices which typically require a voice service won't be able to connect to this network. There are currently no plans to introduce voice and messaging services in Telia Innovation Hub, since it's a data centric platform.

Ericsson is providing a Digital Twin system inside Innovation cloud. Also an external sensor network is connected to the mobile wireless infrastructure and Innovation Cloud for real time data collection and visualization. To support positioning measurement (sub 10 cm) also a GNSS/RTK system is connected to support visualization and decision.

4 Use cases to explore

4.1 Advanced intersection information provision - Phase 1- Hidden Cyclist

This addresses *OBJECTIVE 1: TO READ advanced intersection and general traffic information from a network resource*

4.1.1 Use Case

To support the use case a 5G standalone network is used together with Innovation cloud. In addition external sensors are used to improve perception and security in for complex traffic environments, they supports complex obstacle detection support and collision avoidance. Prime focus is to study and test it at zebra crossings and at complex traffic situations in an intersection. This setup also has the possibility "seeing through obstacles", e.g. breaking in advance before directly sensing different moving objects on its path. This is realized through cameras with active object detection streaming to Innovation Cloud but also information sharing to connected trucks to get info about hidden objects.

4.1.2 Innovation cloud feature description

The information from multiple sources is fused and distilled in the Innovation Cloud into a real-time digital twin view, which is then distributed to the vehicle

4.1.3 Demo

Collect object info from connected vehicle as well as object info from other events identified during the vehicle route. Focus is to identify low speed objects e.g pedestrians and bicyclists. All object info is collected and visualised in real time in Innovation cloud.

4.1.4 Testing

Use developed digital twin functions in Innovation cloud that support information sharing with external sensors and connected vehicles. Test and verify that the vehicle can identify objects and also stop driving if obstacles are identified.

4.2 Advanced intersection information provision - Phase 2 - Vehicle in area with many obstacles

This addresses *OBJECTIVE 1: TO READ advanced intersection and general traffic information from a network resource*

4.2.1 Use Case

The configuration used in phase 1 is expanded with more functions to multiple vehicles. That gives the possibility to interact with more vehicles and to analyze complex obstacle detection support and collision avoidance. With more objects a zebra crossing with complex traffic situations at an intersection can be tested and analyzed.

4.2.2 Innovation cloud feature description

This use case is expanded with more connected vehicles and more pedestrians moving around in the cross sections in order to verify what happens when more real time objects are involved.

4.2.3 Demo

More objects are active and visible in Innovation cloud in this more advanced use case .

4.2.4 Testing

More objects are used and verified by Innovation cloud. Results are visible in Innovation cloud and info is sent back to the vehicle´s backend systems for analysis. Performance and latency in interaction with Innovation cloud is implemented and tested at the edge to verify bandwith performance and latency figures.

4.3 Prioritizing traffic, mitigating high load scenarios - Using "Dynamic QoS" API

This addresses *OBJECTIVE 3: TO SET the parameters that change QoS in a test telco network (with actual impact on the real network)*

4.3.1 Use case

An autonomous bus encounters an obstacle and is stopped for safety reasons; the connected vehicle requests the back-office (potentially supported by a human operator) to start remote operation. The back office requests sends a "Dynamic QoS" request to the *Innovation Cloud* API (via NEF API (N33)) to ensure uplink video quality and downlink control signalling latency even during high (cell) load situations.

4.3.2 Innovation cloud feature description

Innovation cloud exposes an API to an application that dynamically controls QoS over RAN via NEF API (N33) to receive improved QoS during high (cell) load situations, by applying RAN 'absolute scheduling priority' for the remote-control session.

4.3.3 Demo

1. Without Dynamic QoS and high cell load (need to simulate background load); too low video quality and bad latency for remote control signalling for safe driving is experienced, but not so bad that automatic safe stop occurs.
2. Activate Dynamic QoS from server application; UL video quality and DL latency significantly improved. Visualization of improved KPIs in control tower graphs

4.3.4 Testing

Iperf is a Ericsson development tool to inject different traffic patterns from simulating devices and traffic load into a Radio cell.

Use Iperf test tool to create background load for the network (simulate several user devices) and to simulate the remote-control operation. Measure the obtained bandwidth throughput and latency figures with and without QoS activated. Both for 'background' sessions and remote-operation session

- Measure the activation time; time it takes to reach the desired throughput and latency figures, i.e. from the time NEF receives the instruction on N33, until Devices performance start increasing and when reached the top value.

4.4 Prioritizing traffic, mitigating high load scenarios - Using Radio Resource Partitioning (RAN slice) in static scenario

This addresses *OBJECTIVE 3: TO SET the parameters that change QoS in a test telco network (with actual impact on the real network)*

4.4.1 Use case

Fixed external object detection sensors (fixed cameras) are placed in an intersection. Sensors transmits information about detected objects. Sensor devices is allocated to a 'RAN slice' using Ran Partioning (RRP)with a certain percentage of resources sufficient to maintain minimum publishing time even during high (cell) load situations.

4.4.2 Innovation cloud feature description

Allocating a percentage of the cell capacity using Radio Resource Partitioning (RRP) to ensure consistent performance for time critical applications even during high (cell) load situations

4.4.3 Demo

Without RRP activated, at high cell load (devices to generate background traffic needed), the publishing interval varies. After RRP activation, the publishing interval is stable on decided interval. Visualization likely needs to use control tower produced graphs.

4.4.4 Testing

Use Iperf test tool to create background load and to simulate the object publishing

- Run the 'publishing', observe the used percentage of resources, configure this percentage to the 'RAN slice'
- Load the cell, several active users may be needed to affect the publishing performance.
- Measure the performance (latency, throughput) for sensor object data with and without RRP activated. With RRP activated the publishing should be done at a stable interval. Measure the obtained throughput and latency figures for background users to make sure MBB quality is not impacted.

4.5 Using cellular network feedback for application rate adaptation, mitigating varying radio performance

This addresses *OBJECTIVE 2: TO READ telco network QoS parameters based on data from base stations and possibly augmented with data from vehicles (use fleet as probes)*

4.5.1 Use case

Remote control of autonomous vehicles. Using rate adaptation for UL video, triggered by Network exposed RAN buffer status (L4S).

4.5.2 Innovation cloud feature description

Rate adaptation by application for user plane traffic, based on RAN buffer status (L4S) exposed to application via a network exposure function

4.5.3 Demo

step 1: Mini race car application for UL rate adaptation (L4S) in Kista and Södertälje

- Reuse demo created by Ericsson Research in Luleå
- Implement into Kista 5G Connected Vehicle site (Kista Innovation Park), and later over to Scania's testtracks in Södertälje.
- Expose RAN buffer status via NetWork API proxy
- During driving, simulate varying radio performance with Iperf load. UL video from car should run smoothly with L4S turned on.

4.5.4 Testing

Basic testing in one of Scania's sub networks. Later if we are successful with practical setup also testing between Scania's mobile subnetworks in combination with mobility (HO) can be of interest to test, e.g. enter a loaded cell in a private or public network.

4.6 Prioritizing traffic, mitigating high load scenarios – Using Radio Resource Partitioning (RAN slice) in mobility scenario

This addresses *OBJECTIVE 3: TO SET the parameters that change QoS in a test telco network (with actual impact on the real network)*

4.6.1 Use case

An autonomous bus/car encounters an obstacle and is stopped for safety reasons; the control tower starts remote driving. Uplink video and downlink remote control messages is allocated to a 'RAN slice' using RRP with a certain percentage of resources sufficient to to ensure UL video quality and DL control signaling latency even during high (cell) load situations.

4.6.2 Innovation cloud feature description

Allocating a percentage of the cell capacity using Radio Resource Partitioning (RRP) to ensure consistent performance for time critical applications even during high (cell) load situations

4.6.3 Demo

Remote driving bus/car enters cell with high load.

- Without RRP and high cell load (need to simulate background load); too low video quality and bad latency for remote control signaling for safe driving is experienced, but not so bad that automatic safe stop occurs.
- With RRP; uplink video quality and downlink latency significantly improved. Visualization of improved KPIs in Innovation cloud .

4.6.4 Testing

Using Iperf test tool to create cell load and to simulate the vehicle being remote controlled

- Enter highly loaded cell after RRP activation, vehicle performance should be stable also in the loaded cell. Load the cell, several active users may be needed to affect the remote-control performance.
- Measure the obtained throughput and latency figures for background users and the 'simulated' vehicle in remote control/supervision. Measure the obtained throughput

and latency figures for background users to make sure Mobile broadband quality is not impacted.

4.7 Providing GNSS/RTK precise positioning data to Connected vehicle

This addresses *OBJECTIVE 1: TO READ advanced intersection and general traffic information from a network resource*

4.7.1 Use case

High positioning accuracy is important for many use cases and applications, e.g. to provide lane accuracy for vehicles, accuracy for sensors and subsequently for their detected objects including detected vulnerable road users.

4.7.2 Innovation cloud feature description

To improve GNSS positioning by applications running on the devices, RTK data is distributed to devices from the Ericsson NW Location (ENL) server. Long term, the RTK data will be broadcasted within the cellular NW. Short term, RTK data is distributed over unicast IP sessions on the Uu interface but using 3GPP standard procedures and formats. GNSS position can be corrected down to centimeter accuracy.

4.7.3 Demo

The accuracy is visualized in Innovation cloud (digital twin and map) by turning RTK on and off. A RTK enabled sensor could also be located together with a non-RTK sensor to show the difference in reported position for own sensor position and positioning error on reported object (e.g. using one external partner device. such as Scania bus or truck co-located with one RTK enabled device)

4.7.4 Testing

- Measure the difference in positioning accuracy for RTK enabled device and non-RTK enabled device, both sensor position and resulting position for detected objects.

- Test mobility in relation to RTK data from the NW, i.e. a Virtual Reference Station (VRS) for RTK data is associated with an area. The VRS at Testtrack is provided by an RTK correction provider. When the Vehicle move, ENL needs to select the VRS and RTK stream to forward to the client. How long time does it take until VRS change? Does this cause any disturbing interruption (positioning error)? Positioning info visualized at Innovation cloud. Based on KPI definition between Telia, Ericsson and Scania.

5 Conclusion

Innovation Cloud will be used as a connection broker and visualization tool to explore advanced connectivity features. It will be used to measure and visualize connections, But also create statistical findings on differences in traffic patterns when quality of service is in use or not. With all different prioritization mechanism like RAN Partioning and L4S bandwith and latency figures can be visible.