Title: Slice Negotiator and Service Continuity in X-Border Environment

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Abstract

This paper describes the ability of 5G networks to be the capable infrastructures to address the situations of connected and automated mobility (CAM). The cross border environments provide an additional challenge for the 5G technology but also for the service continuity and also for the quality of the service as a car crosses a border. This paper identifies two enablers that provide the means for an automated car to have a ubiquitous communication in cross border environments. The enablers provide the mechanisms for notifications on approaching passengers and freight and assignment of necessary resources in the destination network (proactive resource allocation) and the means for service continuity in cross border communications. In order to achieve this, it is important to leverage on heterogeneous inputs from vehicles, transferred goods and people and to propose prediction algorithms for predicting traffic in the destination network and plan accordingly the needed resources. Finally, it is important to include actions for setting-up and configuring the telecommunication network and any potential vertical aspects. Moreover, the multimodality aspect can be tackled where unloading of freight from e.g. trucks and loading to ships can take place in addition to passengers' movement. Therefore an automated checking of freight (towards zero-touch), conducting logistics operations and informing authorities can take place in a smooth way.

Use Case description

The use case that will be presented comes in two Phases. The first scenario focuses on the cross-border communication and provides mechanisms for notifications on approaching passengers and freight and assignment of necessary resources in the destination network (proactive resource allocation). In order to achieve this, it is important to leverage on heterogeneous inputs from vehicles, transferred goods and people and to propose prediction algorithms for predicting traffic in the destination network and plan accordingly the needed resources. Finally, it is important to include actions for setting-up and configuring the telecommunication network and any potential vertical aspects. Moreover, the second scenario referred as multimodality aspect can be tackled in the second phase where unloading of freight from e.g. trucks and loading to ships can take place in addition to passengers' movement. In this phase, there can be automated checking of freight (towards zero-touch), conducting logistics operations and informing authorities.

The ***key objectives*** of this use case are:

- To provide proactive and multimodal management of passengers and freight when crossing borders.
- To provide a pro-active resource allocation mechanism based on traffic predictions at the borders.
- To offer improved resource management capabilities at the border through customize predictive slicing & configuration
- To enable automated control and risk assessment on incoming passengers and freight, enhancing security and intelligence at the borders.

The main ***cross-border aspects*** of this use case are:

- Pro-active resource allocation takes place for the neighboring PLMN, before the vehicles/passengers have crossed the borders (employing inter-PLMN communication). In this way the capacity of the target network is taken into account, and the service delivered to vehicles/passengers doesn't degrade when crossing the borders.
- Automated border control for passengers and freight is key for smooth multi-modal logistics operations on an international level. This use case will provide mechanisms capable of delivering such functionality at the borders, irrespective of connectivity restrictions (i.e. inter-PLMN functionality).

Some key parts of this use case could not have been realized without the advanced capabilities offered by 5G networks. More specifically 5G enables this use case as follows:

- Slicing capability offering differentiated QoS simultaneously towards different types of users: Thanks to the versatility of 5G networks different end-users (passengers, ships, trains, vehicles, logistics operators, etc.) may be served at the same time from a single 5G network. Slicing also offers extreme customization capabilities for dynamically configuring each slice, hence offering the capability to adapt to live traffic and network conditions.
- eMBB capabilities of 5G are essential for this use case as it enables the HD live streaming and HD picture capturing from multiple border locations and/or vehicles/ships/trains, allowing the live monitoring and control functionality of this use case
- The uRLLC capabilities of 5G are a prerequisite for this use case, as it enables the ultra-fast transmission of information collected from a variety of sources (road side sensors, vehicles, etc.), which allow for dynamic -on the fly- resource allocation, slicing and configuration decisions. Ultra fast communication is needed as the inherent mobility of vehicles, trains and ships do not allow for long preparation windows before crossing the borders.
- The mMTC functionality of 5G is potentially the key aspect enabling this use case, as it is a prerequisite to collect a large amount of information from heterogeneous, fixed and mobile, sensors distributed along and across the borders. As more and more vehicles/ships/trains will be equipped with a multitude of sensors, while passengers also create multiple traffic streams (smart-phones, tablets, smartwatches, etc.), the ability to efficiently collect and transmit information becomes critical, especially in cross-border environments.

5G functionalities to be tested and demonstrated:

- Real time analysis and prediction of border conditions on two sides of the borders. The outcome of this analysis is the generation of requests for network slice establishment on both PLMNs to support the means of border control.
- Establishment of appropriate network slices on both PLMNs for the communication between the means of border control (cameras, sensors etc.) and the Customs servers
- Possible migration of selected custom services from Cloud to MEC in case of special situations or emergencies
- Establishment of inter-PLMN Network slice for the communication between the two border Customs.

KPIs to be demonstrated and validated:

- Low slice deployment time

- Increase of operational efficiency of customs/borders authorities
- Decrease of security incidents in cross-border data rate areas

Associated KPIs

The following KPIs are associated with the above described scenarios, and will be validated through the lab and field trials.

Scenario 1 specific KPIs

- QoS degradation < 5% during cross-border mobility
- Zero dropped sessions during cross-border mobility
- Low slice deployment time

Scenario 2 specific KPIs

- Low slice deployment time
- Increase of operational efficiency of customs/borders authorities
- Decrease of security incidents in cross-border areas

Overall Technical KPIs

- Throughput: 100 Mbps (DL/UL) per user
- E2E latency: < 100 ms
- Jitter: < 5 ms
- Mobility: < 200 km/h
- Reliability: 99.999% (RAN)
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