Multi-Connectivity for Livestock Transport in Rural Areas

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Multi-Connectivity for Livestock Transport in Rural Areas

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***Abstract*—The transport of livestock is an essential part of the supply chain of animal breeding for food production. The regulations imposed by the European Union to ensure animal welfare require constant monitoring and reporting of the animals' health status and conditions before, during, and after transportation. However, the poor coverage and connectivity performance in rural areas hinder compliance with the regulations and the optimization of the livestock trading process. In this article, we introduce the main connectivity challenges for the livestock transport sector and propose potential solutions to overcome them. We also discuss how further digitalization would help optimize the livestock trading process.**

I. Introduction

Every year, more than 1.6 billion live animals are transported across and beyond the European Union (EU) for trading purposes [1]. In order to ensure animal welfare during transport, the EU set a series of requirements, which are defined in [2]. These regulations include constant monitoring of the livestock conditions in both the loading/unloading locations and while the animals are being transported as well as reporting of livestock (truck) location during the journey. However, the poor coverage in rural areas and in certain parts of the main transport routes in Europe poses a challenge to meeting the livestock transport regulations, suggesting the need for enhanced connectivity solutions [3]. Additionally, digitalizing certain operations would increase logistic efficiency and optimize the livestock trading process. These observations indicate that this sector would strongly benefit from a service provided by the latest cellular technologies such as 5th Generation (5G) or Non-Terrestrial Networks (NTN), that would allow online, digital, and high-volume data transfers.

The mentioned connectivity issues will be addressed in the Horizon Europe (HE) COMMECT project[1], which aims at bridging the digital divide gap experienced by rural communities, and specifically within the Living Lab (LL) in Denmark: *Connected Livestock Transport*, one of five different LLs established in the project. This LL focuses on developing and testing connectivity solutions for the issues outlined above and for different operations within the livestock (pigs) transport sector. An overview of the Danish LL is shown in Fig. 1. The LL will allow us to validate the connectivity solutions proposed in this paper in a real-life setup, i.e., in farms, transport centers, and livestock transport trucks.

[1]www.horizoneurope-commect.eu

II. Use Cases

As it is depicted in Fig. 1, the Danish LL of the HE COMMECT project will investigate how to provide seamless and reliable connectivity for the whole livestock trading process: from the supplier premises until the customers' location, and during the journey. We distinguish between two use cases: connectivity in livestock loading/unloading locations and over-the-route seamless connectivity.

A. Connectivity in Livestock Loading/Unloading Locations

The lack of connectivity, the poor data rates, and the high latency provided by the existing technologies in rural areas impede an efficient logistic process for livestock trading. Digitalization of certain operations would optimize the process, e.g., sharing of electronic transport invoices after livestock transport is completed, cloud-based solutions for pigs counting in both source and destination locations, or authorized license plate recognition for trucks accessing the facilities. There are existing systems providing these services. However, interviews with the main livestock (pigs) suppliers in Denmark suggest that these operations are currently challenging due to the existing coverage in rural areas, and call for better connectivity solutions in the farms and assembly and resting stables.

B. Over-the-route Seamless Connectivity

According to regulations, livestock transporters carrying out long journeys within EU countries should ensure the monitoring of relevant information. This includes truck location along the journey, animal compartment temperature and backdoor status monitoring, and traveled distance and time, among others. Additionally, there are restrictions on the number of hours the trip should last, and truck drivers need fast route re-planning methods in case of unexpected traffic jams or road cuts, as well as a live stream of the traffic areas in the planned route. Access to an Intelligent Transport System (ITS) would increase the safety, efficiency, and sustainability of the livestock transport process.

However, interviews and surveys among end users (truck drivers, transport centers, etc.) conclude that the existing cellular coverage in the main transport routes of Europe does not support high enough data rates to comply with the regulations or meet the needs of the users. Therefore, better connectivity solutions that can provide high data rates seamlessly along the main transport routes of Europe are necessary.

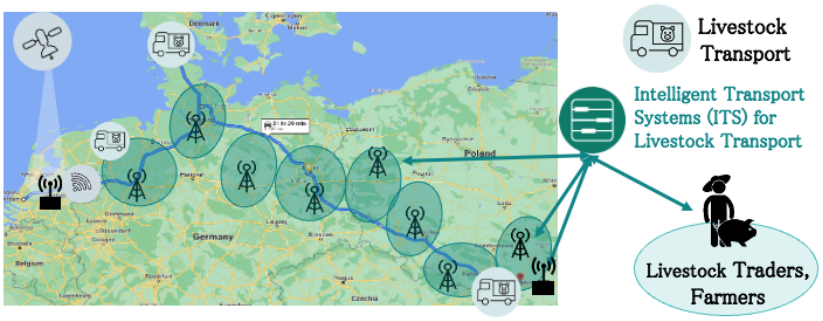

Fig. 1: COMMECT Livestock Transport Living Lab in Denmark.

III. Potential Connectivity Solutions

A. 5G Local Broadband Networks

The main connectivity concern at the livestock loading/unloading locations is the availability of an uplink (i.e., from the terminal to the network) broadband connection, which can (i) provide sufficiently high data rates for a video monitoring of the loading/unloading process (e.g., for livestock counting) as well as (ii) grant access to the livestock transportation trucks to these locations. Uplink broadband connection is especially challenging in rural areas since the poor coverage does not support the additional uplink data rate requirements. The COMMECT project we will address this challenge by investigating the creation of on-demand local 5G broadband networks in a cost-effective and sustainable way. The possible range of solutions could vary from creating such a 5G local broadband network by using only non-terrestrial-networks, or a combination of satellite links and a local 5G terrestrial infrastructure.

B. Satellite Connectivity

It is widely recognized that, in order to be successful and meet user demands, the 5G infrastructure will be an ecosystem of networked networks, utilizing different and complementary technologies. The satellites' role in the 5G ecosystem is proven on the basis of their benefits and their integration into the overall network. Often, satellite remains the only connectivity solution in areas where existing terrestrial infrastructure is insufficient. Satellite communications systems are easy to establish and use: not only they are portable and quickly deployable, but today's innovative end-to-end solutions also allow plug-and-play connectivity. For these reasons, in the COMMECT project, in areas with poor coverage, we will investigate the deployment of a local, temporal broadband network including the option to have satellite backhaul, dedicated for the provisioning of on-the-fly coverage during the loading/unloading of the animals.

C. Multi-Connectivity

When addressing over-the-route connectivity, the main issue is the lack of coverage from the most recent cellular technologies (i.e., 4G/5G), which are the ones able to provide higher rates and lower latency, compared to past generations. This is even more of an issue when considering rural areas.

To overcome this issue, we propose the use of multi-connectivity, as an effective solution to provide seamless connectivity, thereby enhancing data rates and decreasing latency. Multi-connectivity entails the presence of a main link to a 5G network whenever available, and a fallback link to a different available connectivity technology, such as other cellular or satellite technology. [4].

IV. Conclusion

In this paper, we identified two main use cases in the livestock transport sector that could benefit from enhanced connectivity solutions: over-the-route seamless connectivity and broadband connectivity in livestock loading/unloading locations. By deploying 5G networks with edge solutions we expect to provide low latency and high capacity connectivity. Additionally, seamless connectivity could be achieved on the road by using multi-connectivity between different Terrestrial Networkss (TNs) or between TNs and NTNs. We expect these solutions to allow improved and extended connectivity in rural scenarios, thereby fulfilling current user needs and potentially supporting new services for the livestock transport industry. Future work includes the deployment of the proposed connectivity solutions and their evaluation in the Living Lab.

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[2] Council Regulation (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No 1255/97.

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