5G for LEO
Technical Challenges and Initial Results

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ABSTRACT

In December 2019, 3GPP have for the 5G specification decided to separate the Narrowband IoT Non-Terrestrial Network (NB-IoT NTN) from the New Radio NTN. Due to this change, NB-IoT NTN becomes a very attractive candidate for LEO IoT satellite constellations.

The decision emphasises that there is a strong push for cellular standards into the space industry and that commercial utilizations in large scale is getting closer. However, it also entails significant technical challenges in terms of connectivity, backhaul integration and operational features. GateHouse Telecom currently work on an ARTES supported project (Narrowband IoT standard for small satellites). Based on the existing 3GPP terrestrial NB-IoT standard the purpose of this project is to identify areas of adaptations to utilize this from space. Further, the project will provide solutions to overcome the waveform challenges related to doppler, latency, timing, propagation loss etc.

This poster provides initial results from the project in terms of architecture, suggested adaptations and technical challenges related to architecture and implementation.

INTRODUCTION

The Space-based IoT and M2M market is in an early stage and the market is growing as the technologies matures. The annual growth is between 20% and 30% according to market analysis reports [1,2,3,4,5]. The smallsat industry will enable affordable satellite connectivity (IoT and M2M) in areas unserved by terrestrial networks. This will enable a wide range of new opportunities and applications for which acquisition of data is an important factor. Examples of this can be environmental and pollution monitoring which is critical in facing the global warming issue and for environmental protection.

Commercial considerations

For a company wanting to provide IoT services from space, the question arises: “make or buy?” and further the question arises “proprietary or standardized solution?”.

Implementing an IoT NTN solution for commercial use in a 24/7 operating constellation network is a significant effort both in terms of development and maintenance. Having each of the IoT service providers developing and maintaining their own individual solutions is not only very expensive it is not sustainable for the industry as a whole.

The advantages of using an independent supplier for this type of technology include:

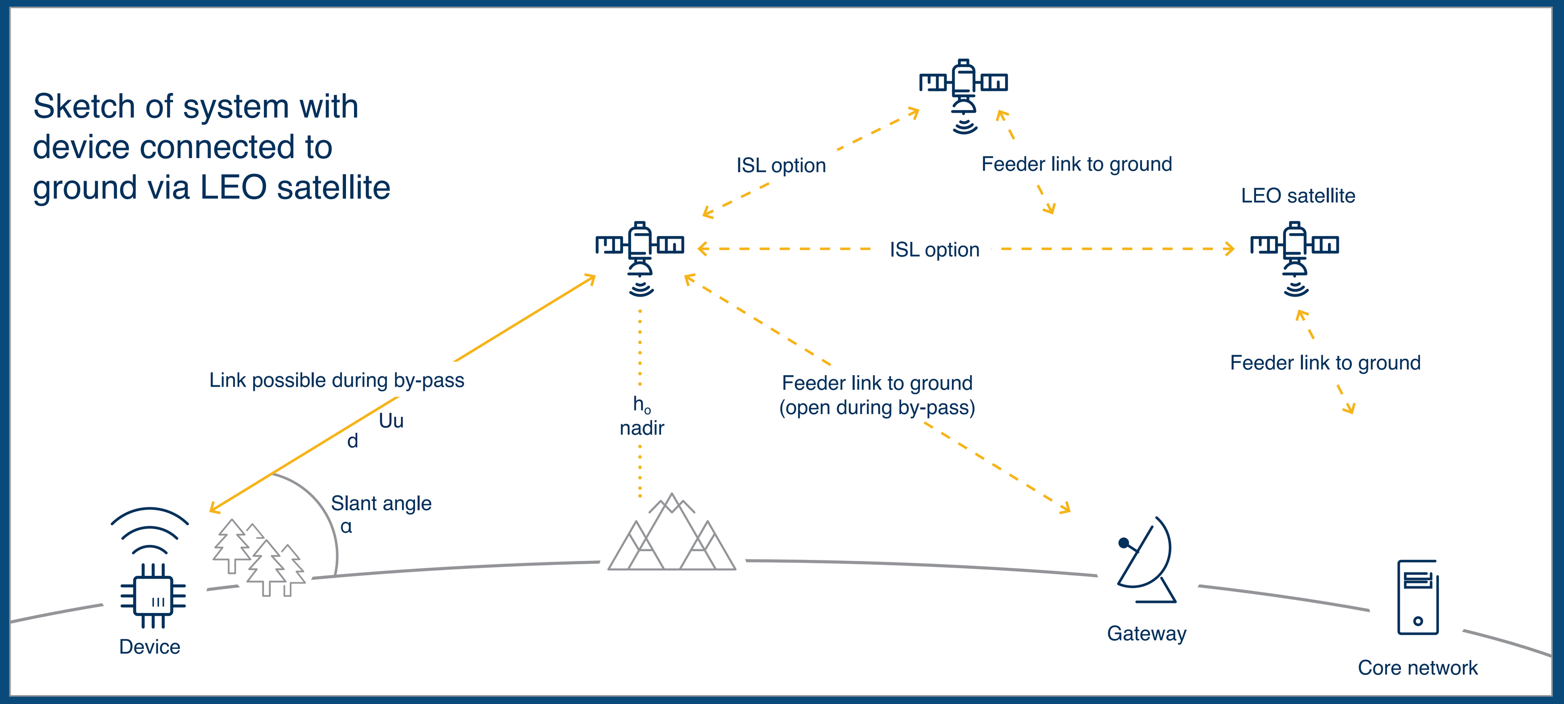
- Reduced time to market.
- Low cost level both OPEX and CAPEX and potentially a flexible price model.
- Be able to focus in delivering services – not spending time on technology.
- Agnostic in relation to satellite bus suppliers.
- Share maintenance cost between multiple users.
- SW is tested as part of many missions and therefore matured faster.

NB-IoT

The reason and motivation for selecting the 3GPP NB-IoT as the foundation for a space based IoT solution is that the NB-IoT has certain advantages compared to other technologies or standards.

The main advantages include but are not limited to:

- Terrestrial NB-IoT is widely deployed and there is a roadmap for NB-IoT NTN in 5G.
- Scalable and high uplink data-rates.
- Down link data rates similar to uplink data rates.
- Access scheme with contention resolutions provides for higher capacity.
- Low power consumption.
- Good link budget conditions which enables usages of small antennas.



TECHNICAL CHALLENGES

Adapting a communication system for non-terrestrial use which was designed towards terrestrial requirement is not without challenges. One of the first things noticed is that the signal path between the UE’s (device) and the network is much longer – affecting the power budget. The signal path is also more vertical than horizontal which is, most of the time, opposite to terrestrial systems – leading to different channel characteristics. Satellites will either be very far away (GEO and MEO) and stationary/semi-stationary relative to ground - or low (LEO) but moving with high speed - e.g. 7500m/s at 600 km height leading to significant Doppler shifts; This is a major difference compared to terrestrial systems - designed only for UE-movement and at much lower speeds.

The figure above shows an overview of a LEO-satellite based system. The satellite has a feeder link to the core network at ground via a gateway. The feeder link can only be maintained while there is visibility between satellite and gateway. The latter property implies that the connection to the core network must be handed over to another gateway to maintain continuous service as experienced in the terrestrial systems. To reduce the number of gateways it is possible to relay between satellites (ISL). ISL will increase the signal delay - especially if relaying through e.g. GEO satellites.

Areas of technical challenge:

- Channel impairments (doppler, timing, …)
- Link budget, including spotbeams and antenna considerations
- Back-hauling
- Scheduling of packets towards devices
- Power optimization

NEXT STEP AND PERSPECTIVE

As the 3GPP standardization of 5G NTN matures in release 17 the open standard approach could potentially be realized within the next few years and therefore become a strong candidate as a standardized solution for space based communication - for both broadband and IoT services. Looking at the perspective for space-based IoT solutions the following market perspective can be derived:

Upstream market: The global commercial smallsat market is expected to reach approximately 14 billion euro in 2030. Looking at the distribution between EO, communication etc. the communication represents ~50% equal to 7 billion euro in 2030. Of this, IoT is expected to represent 1/4 of the total communication market which is 1,8 billion euro in 2030. From multiple official numbers we see the range from 1 to 3,5 billion Euro for the IoT upstream market in 2030.

Downstream market: Few official numbers are available on the downstream market. However, 5 billion euro in 2025 representing user terminals and services together seems to be a common ground. The predictions of the number of terminals served by satellites seems to be very fluctuating. Official numbers show between about 10 million up to about 800 million devices connected via satellite over the next 5 to 10 years.

CONCLUSIONS

The availability of an independent NB-IoT NTN solution for LEO will be crucial to drive the time to market and cost down – not only the initial establishing cost but also the cost of maintenance and evolving the technology.

Establishment of a commercial quality solution is a comprehensive task involving several challenges related to physical layer, MAC layer and layers above in resolving the challenges presented in this paper. The definition phase project that GateHouse is currently performing will identify the major adaptation elements required for enabling terrestrial NB-IoT for LEO usages. Further, the project will implement and test performance of those identified adaptations.

As the project is still active, the conclusion on performance and methods is not yet finalized, but up to this point the outlook seems promising.

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