Satellite Communication in the Age of 5G

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Abstract

The next generation of mobile networks (5G) aims to revolutionize the world of communication. New technologies and use cases spawn new opportunities. Many of the promised performance characteristics of 5G require that terrestrial networks are augmented by communication satellites. This paper describes where an integration of satellite and 5G will benefit both technologies.

Keywords: Satellite Communication, GEO, LEO, ESA.

1 Introduction

The emerging 5G ecosystem promises a cornucopia of new services. Some are an expansion on the current 4G/LTE services, like enhanced mobile broadband (eMBB) with its gigabit speeds and the adjacent advantages for users – consumers and businesses alike. Some are not available with previous technology: a tremendous increase in connected devices incurred by the dawn of the internet of things (IoT) gives rise to massive machine type communication (mMTC) and the need for real time control over robots and sensors in Industry 4.0 demands ultra-reliable low-latency communication (URLLC). These developments entail a paradigm shifting new technology.

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Amidst the increasing buzz around this next generation of mobile networks appears a player that previously received little attention: communication satellites. To deliver on all the promises of 5G the use of communication satellites is inevitable.

2 5G and Its Challenges

5G promises to deliver a whole lot of everything:

- Data rates of up to 10 gigabits per second
- End-to-end round-trip delays of less than 1 millisecond
- Device density of up to one million subscribers per square kilometre
- Network reliability of 99.999 percent
- Support for battery life times of up to 15 years

The above characteristics are accompanied by the notion that they will be available anywhere and at any time. 5G begets that coverage issues are a thing of the past.

However, it is obvious that it is neither reasonable nor feasible to build a network that can deliver all of the above qualities at all times and in any location – and neither is it necessary. No single use case requires them to be available at once, at all times, in any location. Therefore a mix of technologies, a network of networks is required to deliver upon these promised characteristics in an appropriate fashion.

The three focal areas of 5G, eMBB, mMTC, and URLLC, all create different challenges for this new technology to overcome.

2.1 Challenges of eMBB

Scaling the mobile network to the demand of users can be challenging. An increasing amount of data is consumed on the move – high resolution streaming content is putting the capacity of current infrastructure to the test. In densely populated areas the demand is growing faster than the capacity of the network, while inhabitants of rural areas feel the negative effects of the growing digital divide. In scarcely populated areas, even in industrialized countries, connectivity itself cannot be guaranteed. Countries without legacy infrastructure face even bigger challenges. Lack of pre-existing backhaul infrastructure and geographically challenging environments make a tough business case to close for network operators – let alone locations without permanent human settlements, like mountain ranges, deserts, and the high seas. Ubiquitous and reliable connectivity that is often associated with 5G is one of the biggest obstacles to overcome.

2.2 Challenges of mMTC

The internet of things, for private users, mostly consists of smart refrigerators and remote controlled lightbulbs. But for commercial use, highly distributed sensors and control networks offer many new opportunities. Smart agriculture with its connected farming robots, soil sensors, and health monitors for livestock relies on connectivity even in the remotest of areas. Monitoring of energy networks or rail tracks require high availability and security of service. The orchestration of such vast networks of end-nodes meets their tight restrictions on energy consumption thus creating a challenging use case for 5G.

2.3 Challenges of URLLC

In the context of Industry 4.0 sub-millisecond latency in wireless networks is of utmost importance. For physical reasons, this real-time reaction can only be delivered if functionality is moved to the edge of the network. Providing this edge computing capacity with high reliability in a safe and secure manner is a core functionality of 5G. However, to minimize cost, energy consumption, and for deployment reasons, this edge computing capacity will be limited and thus needs to be flexibly and reliably connected to the core network. High demands on availability, flexibility, and connectivity together make a tough nut to crack with 5G.

3 The Potential Role of Communication Satellites

Satellite communication, in its role as a global supplier of reliable connectivity, offers solutions to many of the above mentioned challenges. Modern high-throughput satellites (HTS) in geostationary earth orbit (GEO) can deliver reliable, high data-rate, two-way broadband services in an instant. With the dawn of low earth orbit (LEO) satellite constellations [1], planned to become operational in the next years, additional capacity and flexibility will become available all around the globe. A key element of a modern communication network, to offer truly global connectivity, cannot be achieved economically with purely terrestrial technology.

The following use cases shall illustrate how communication satellites will play a vital role in the 5G ecosystem.

3.1 Communications on the Move

Mobile platforms, such as aeroplanes and maritime vessels, usually operate in areas without terrestrial network coverage. But even land mobile vehicles, like trains, trucks, and cars, and individual users often encounter white spots in the network.

Larger vehicles can easily be equipped with very small aperture terminals (VSAT) to benefit from ubiquitous, high speed connectivity – already today using GEO satellites. In the coming years, with the deployment of LEO satellite constellations and the accompanying development of low cost, electronically steered, phased-array antennas, even smaller vehicles like cars and drones can bridge gaps in the terrestrial networks using satellite links. In these cases the satellite connection is used as backhaul for local, moving 5G base stations.

Direct access to user equipment is also feasible for low data rate application, e.g. in the internet of things. Battery activated sensors or handheld devices, deployed in remote areas, can use satellite connectivity to transmit data. These low data rate applications can be achieved without special antenna technology – no modification to the equipment is necessary.

3.2 Backhauling and Tower Feed

Analogously to the case described above, satellites can be used to serve as backhaul and feeder connection to individual fixed cellular base stations. Already used today, this type of connectivity is ideally suited to expand network coverage in hard-to-reach locations. Satellites can be used as sole supplier of backhaul capacity to a given site or support an already existing connection to the core network in times of high load, e.g. sports events and festivals.

The satellite's natural broadcast ability can be used advantageously to simultaneously deliver identical content to the edges of the network, offloading from the core network.

3.3 Trunking and Head-end Feed

Campus networks will be a central use case for 5G technology. International companies that choose to deploy 5G campus solutions in their various company sites will want to connect those sites to their headquarters. Satellite offers highly secure and reliable broadband connectivity across the globe irrespective of distance and borders.

Other use cases, where satellite connectivity is already used today are emergency response, disaster relief, and mission critical communications.

4 Closing Remarks

There are many projects in Europe and all over the world that work towards a full integration of 5G and satellites. A very notable example is ALIX, a project funded by the European Space Agency (ESA) [2]. The consortium, comprising companies and research institutions from France, the Netherlands and Germany, works towards including non-terrestrial networks (NTN), such as satellites, into the 3GPP standards that define 5G [3]. Another ESA-funded project, SATis5, implements a testbed, allowing users to demonstrate and verify 5G use cases that include a satellite communication component [4].

5G promises to revolutionize the way humans and machines communicate. Its full potential can only be achieved, though, if communication satellites are a part of it.

References

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Biography

Marc Hofmann is a scientific staff member at the German Aerospace Center (DLR) Space Administration in the department for satellite communication. He graduated with a diploma in physics from the University of Bonn, Germany, in 2010. He received his Ph.D. in physics from the Technical University of Braunschweig, Germany, in 2014. After working as a post-doc researcher at the Max-Planck-Institute for Solar System Research in Göttingen, Germany, Hofmann joined DLR Space Administration in 2017. He went on to head the space agency's newly established 5G Taskforce, represents Germany at the European Space Agency's (ESA) 5G Advisory Committee to the Joint Board on Communication Satellite Programme, acts as national ambassador for ESA's Satellite for 5G Initiative, and serves as project officer for several development projects in the German national space programme and ESA's Advanced Research in Telecommunications Systems programme.