Role of Satellite Communications in 5G and Challenges

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ABSTRACT
The next generation of mobile radio communication systems are called 5G will provide some major changes to those generations to date. The ability to cope with huge increases in data traffic and improved quality of users experience to gather with major reduction in energy usage are big challenges. In addition future systems will need connections to billions of objects the so called Internet of Things (IoT) which raise new challenges. This chapter includes several potential roles for satellites in 5G including coverage extension, IoT, providing resilience, content caching and multicast, and the integrated architecture.

Keywords: Internet of things, communications, satellites,5G

INTRODUCTION

We are about to witness what a really "connected world" looks like in the modern day. In the near future, 30 billion gadgets, 50 billion machines, and 6 billion humans are expected to be online. That simply means that everything and everyone is connected, across all geographies, to serve every application, including mobile games, consumer internet, connected automobiles, global business networks, ships, and connected farms. The massive issue of supporting a connected world is one that the current telecom infrastructure is ill-prepared to tackle. The creation of the next 5G networking architecture is being driven by this fact. Massive scalability, exponentially higher efficiency, much lower costs for mobile and fixed networks, and ultra-low latency applications like connected cars are among the benefits of the 5G standard.

All access technologies must adhere to the standard network architecture that 5G defines. In order to achieve full teroperability within the end-to-end 5G network, 5G will significantly alter how satellites are integrated into society. The satellite business has historically had to play catch-up, devoting more time to finding ways to incorporate satellite technology into the prevailing standards and technologies. With 5G, the satellite network was designed from the start to function with other 5G devices. While allowing mobile and fiber operators to use satellite connectivity to expand their coverage areas and offload their networks through crucial functionalities like 5G, the satellite industry has the best chance to break out of its niche and for satellite service providers to offer a much wider range of services.

1.1 The Evolution to 5G

The fifth generation of mobile networks is known as 5G. Since the early 1990s, new capabilities and services have been delivered by each generation: 3G brought the mobile Internet and multimedia content, 2G gave digital voice communications, wider coverage, and text messaging, and 4G brought mobile broadband, high-speed data, and smartphones. Higher network performance, dependability, energy and cost reductions, as well as increased device connectivity, are the main goals of 5G. In addition to supporting new revenue-generating services by expanding into vertical industries like healthcare, manufacturing, transportation, public services, and the automotive industry, improved capabilities are required to keep up with the exponentially increasing amounts of mobile data traffic. Over the next five years, mobile data traffic is anticipated to increase annually at a rate of 31 percent, reaching 136 bytes per month.

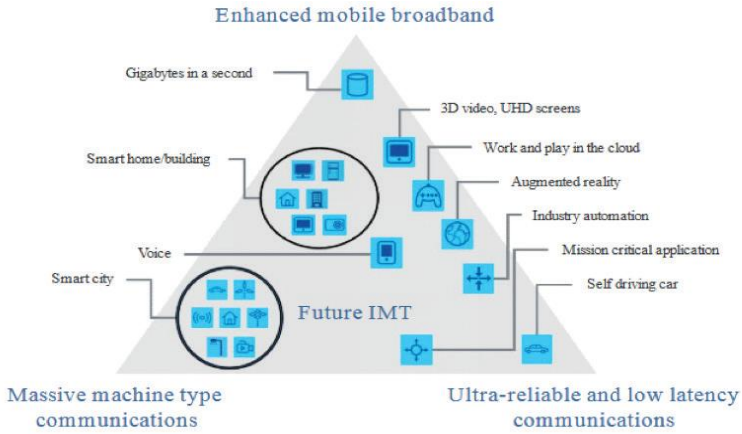
Fig: Evolution of 5G

1.2 5G INNOVATIONS

The communications sector needs to make a few crucial technological advancements if it is to establish the 5G future of ubiquitous connectivity. These developments center on utilizing EPC, orchestration, and a brand-new waveform termed 5G New Radio (5GNR) to significantly boost speeds, cut latency, and enable full network orchestration. Speed improvements are one of 5G's main promises. Two developments will be principally responsible for achieving this: the deployment of SDN capabilities and the functioning of the RAN using the waveform NR in higher frequency bands. Within a cellular network, SDN capabilities and NFV operate together to divide up EPC functions. By dividing traffic into the data plane and the control plane, they will be able to separate decision-making from traffic management. The network will be able to dynamically scale by virtualizing and slicing the functions. As a result, much more mini-base stations will be required to cover the same area than are needed now for traditional base stations. The economies that follow from moving essential 3GPP data and control plane activities to the network's edge will result in a more significant reduction in latency than the somewhat reduced latencies caused by ultra-high frequency transmission over short distances. Allowing many radio waveforms under one standard is another innovation in the development of the 5G standard. The objective of 5G designs is to deliver integrated services over numerous access networks, including satellite, small cells, and Wi-Fi. The creation of the 5GNR waveform is one of the most crucial elements of this. The 3GPP ratified 5GNR in June 2018.

1.3 5G APPLICATIONS & SATELLITE'S ROLE

Three key use cases—Enhanced Mobile Broadband (eMBB), Ultra-Reliable and Low-Latency Communications (URLLC), and Massive Machine-Type Communications (mMTC)—are anticipated to undergo significant change as a result of 5G's advanced communications. In each of these areas, satellite plays an essential function.



Enhanced Mobile Broadband (eMBB):
With 5G comes the chance to provide hotspots for mobile or fixed networks with significantly improved and faster internet access (for example, voice, video, and data). • 5G to Premises: Satellite will augment terrestrial networks and provide backup broadband access for enterprise sites or for homes or offices in underserved areas.
• 5G Fixed Backhaul: Only or best covered via satellite, 5G will deliver broadband coverage to isolated and rural locations where it is challenging to construct terrestrial connections.
• 5G Mobility Backhaul: Satellite-based broadband connectivity will be made available to remotes or UEs that are moving, such as those who are traveling by car, train, airplane, or boat.

Ultra-Reliable and Low-Latency Communications (URLLC):
The second group of 5G use cases focuses on URLLC applications, which are crucial for mission-critical and simulated real-time systems. Let's look at the situation of autonomous vehicles, where latency is crucial. Autonomous vehicles must be able to communicate with everything around them and with each other in milliseconds (also known as "vehicle-to-everything" or "V2X") in order to function properly. No network had been able to handle the enormous scale and low latency needed to make autonomous driving a reality prior to the launch of 5G. With its lightning-fast connections and intelligent routing, the 5G standard is set to alter that. V2X data, for instance, is delivered most quickly in this use case if it isn't routed to the core network and then sent back out.

Massive Machine-Type Communications (mMTC):
mMTC for M2M or IoT devices and sensors makes up the third group of use cases. The ability of SDN capability to service a given UE with significantly fewer resources will be crucial in this situation since it will allow numerous UEs to be serviced with the same amount of resources as a single 4G UE. This already demonstrates the anticipated scale of 5G. In order to link and backhaul data from the millions of smart gadgets and sensors that will soon be found within houses and urban infrastructure, or "smart Cities," the 5G architecture will need to rapidly scale. Despite being on a small scale, the sheer amount

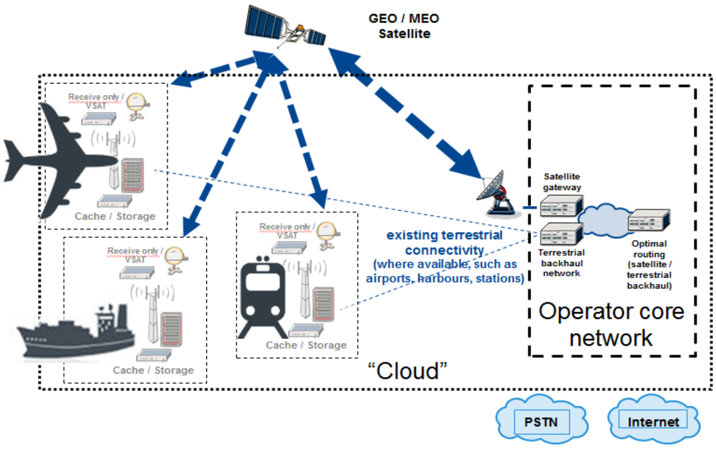
of M2M and IoT connectivity will significantly affect the network traffic. In Backhauling non-latency sensitive data from these devices, or more specifically, from the aggregation points back to the main network, can be one potential for satellite in order to offload 5G networks.

1.3 5G USES IN SATELLITE COMMUNICATIONS

Communications on the Move:Moving Communications: High-speed, multi-cast-enabled satellite links from geostationary or non-geostationary satellites that are direct to an aircraft, train, vehicle, or other vessel at speeds of up to 1 Gbps or more would allow:

• Multicasting of (video, HD/UHD TV, and non-video data) across backhaul when otherwise impractical

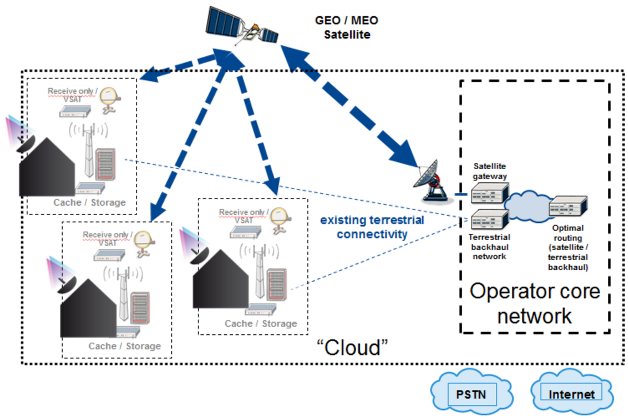
•Effective backhauling of gathered IoT traffic or direct connectivity



Hybrid Multiply:

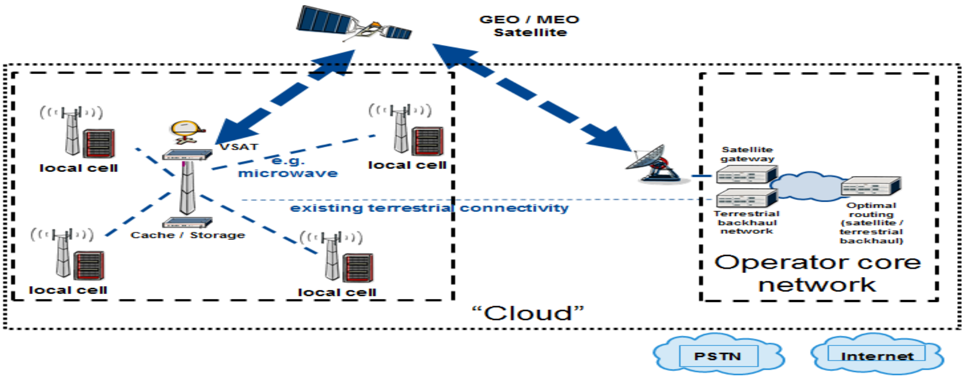
A very fast (up to 1 Gbps or more) satellite connection to each house or office with the capacity to multicast the same material (video/UHDTV and non-video data) over a wide coverage area (for example, local consumption or storage)

• Further in-home or in-office distribution through Wi-Fi or tiny 3G/4G/5G Nano-cells • The same capability enables effective broadband connectivity for aggregated IoT data

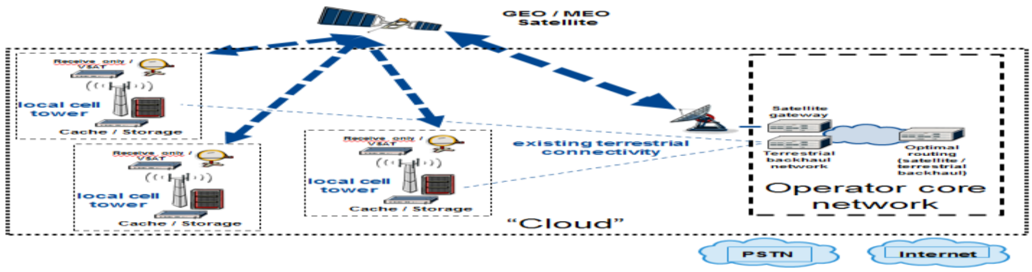


Trunking and Head-end Feed:

The following will be possible with the addition of a very fast satellite connection (up to 1 Gbps or more) from geostationary and/or non-geostationary satellites: •High speed trunking of video, IoT, and other data to a central site, with further terrestrial distribution to local cell sites (3G/4G/5G cellular), for example, nearby villages.



Backhauling and Tower Feed:
In addition to existing terrestrial connection, a very fast satellite link (up to 1 Gbps or more), direct from geostationary and/or non-geostationary satellites to base stations, would allow:
•Backhaul connectivity to each cell with the capacity to multicast the same material (such as video, HD/UHD TV, as well as non-visual data) over a wide coverage area.
•Effective backhauling of IoT traffic from many sites that has been collected



1.5 KEY AREAS WHERE SATELLITE CAN PLAY A PART IN 5G
The main applications for satellites in 5G are discussed below.

Coverage
In keeping with the ubiquitous coverage that 5G networks aim for, satellites can provide the vast coverage to complement and extend the dense terrestrial cells. They won't be able to match the 5G terrestrial's area spectral efficiency, but they can offer larger cells in a heterogeneous configuration that can also be used for critical and emergency services, and they might even be able to relieve the terrestrial cells of signaling and management tasks in a software defined network configuration.

Integration
The main area that provides many benefits is probably the integration of satellites with the terrestrial infrastructure. enhancing QoE by intelligently allocating traffic amongst the delivery platforms and caching large-scale video for subsequent terrestrial transmission. This is made possible by the built-in multicast and broadcast capabilities of satellite systems, while adaptive caching eliminates the problem of propagation latency. The ability to increase resilience and security by using the two networks provides the prospect of offloading traffic from the terrestrial system to conserve important terrestrial spectrum.
Backhaul

The increased demands on the backhaul caused by the extremely high number of tiny cells are one of the main problems with 5G, according to experts. Here, high throughput satellites can be utilized to supplement terrestrial delivery and offer backhaul in places where doing so terrestrially is challenging. Some network node activities may be included on board the satellite in a virtualized and SDN environment, reducing the need for physical locations on the ground.

Resilience, security and availability

They won't be able to offer the entire range of services, but they are essential for maintaining vital and life-saving ones. There will be an increase in the use of 5G for strategic services as it transitions from a nice-to-have feature to a necessary component of national infrastructures.

IoT

The Internet of Things (IoT) is particularly suited to satellite gathering and dissemination because it contains billions of sensors that all send at low data rates over vast distances. Once more, integrated systems are demonstrated with innovative network topologies that gather data from collections of sensors and backhaul it to fusion POPs using satellites. IoT economies of scale can be reached based on the extensive satellite coverage, and this will support workable business models for many bursty-low rate communications.

Spectrum

One of the main motivators for the 5G network architecture was thought to be the scarcity of spectrum. If more spectrum was made accessible, the requirements for network architecture may be lowered. If both sectors agree to the sharing rules, dynamic frequency sharing across mobile and satellite systems can result in significant spectrum expansions. Future systems could incorporate cognitive radio and data base approaches to enable such frequency sharing. An integrated strategy would benefit both industries and make this a win-win situation.

1.6 RESEARCH CHALLENGES

Although there are many issues that both satellite and terrestrial domains face, we have listed the main satellite issues below.

• Integration challenge: Cellular networks might use satellites to broaden their coverage and improve the efficiency, cost-effectiveness, and variety of their services while cutting terminal costs.

• The QoE challenge: Regardless of the user's location, ensure the user's experience in terms of throughput, latency, and cost per bit.

• Meet the latency requirements of new interactive and immersive services with a latency of less than 100ms.

• Spectrum challenge: Enabling satellite and terrestrial spectrum sharing in the millimeter and higher bands.

• The goal of the energy reduction challenge is to use 90% less energy than it does today by 2020 without sacrificing performance or raising costs.

• Localization challenge: To enable the Internet of Things, provide positioning capabilities down to the millimeter range in conjunction with terrestrial networks.

• The resilience challenge: Develop a comprehensive, integrated 5G network that is trusted by strategic authorities and is inherently resistant to attacks from both man-made and natural causes.
• Multi-service challenge: Establish a general network architecture that can effectively support M2M rate services, high-speed video services, and all other types of services.

1.7 CONCLUSION

The main areas where satellite can contribute to the 5G network have been covered in this chapter. The potential topics that were looked at were spectrum utilization, content multicast and caching, resilience and overspill, coverage, enormous machine type communications, integrated networks, resilience and overspill, and ultra-reliable communications.

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