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A Survey and Investigation of Medical Electronics

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Abstract:

Satellite communications (SatComs) have seen a spike in interest recently, spurred by technological breakthroughs and bolstered by private sector investment and companies. The purpose of this survey is to chronicle the current state of the art in SatComs while simultaneously highlighting the most promising areas for future research. The main innovation drivers are covered first, including innovative constellation types, on-board computing capabilities, nonterrestrial systems, and space-based data collection and processing. The second portion covers the most potential application, like 5G integration, satellite links, Earth monitoring, aircraft and marine monitoring and transmission. After that, a thorough literature review is carried out along 5 axes: I system features, ii air interface, iii access to media, iv connectivity, and v testbeds & prototypes.

Keywords: *nonterrestrial, transmission, processing*

INTRODUCTION

SatComs have been used for a variety of purposes since their introduction, namely media transmission, backhauling, and news gathering. SatComs are currently through a transition stage, focussing the systems integration on mobile networks, notably broadband SatComs, as a result of the rise of Internet-based applications. The key drivers are: a) the fast acceptance of media streaming over linear media transmission, and b) the pressing need to expand broadband connectivity to underserved areas. Moreover, the combination and merging of various wireless network technologies was a significant milestone in the 5th generation of communication networks (5G). SatComs, in this respect, pave the path for easy integration aimed at specific use cases that might benefit from their distinct characteristics. Private initiatives, on the other hand, have fueled the growth of a slew of new businesses. New Space has inspired a slew of cutting-edge broadband and environmental sensing missions, all of which necessitate advancements in SatCom systems.

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MOTIVATION

Constellation Types

GEO satellites have typically been utilised for SatComs because they allow for large coverage with a single satellite and eliminate quick motion between the endpoints and the satellite receiver. Multibeam spacecraft systems, like their land cellular equivalents, were specifically designed to provide effective frequency recycling and elevated broadband speeds across the service region. However, enhanced communication technology and lower launch costs are driving the development of new, more grandiose cluster types. Large LEO arrays that can supply high-throughput internet services at low delay have recently sparked a lot of interest in this sector. Since Teledesic first suggested it 25 years ago, this cluster type was the golden standard of SatComs [1].Several firms, notably Amazon, SpaceX, TeleSAT, and OneWeb, already have announced huge LEO plans involving thousands of spacecraft, with some even launching demonstration satellites. SpaceX has launched 241 spacecraft to establish its Starlink network as of January 2020, with a target of roughly 10000 spacecraft by 2020 [2]. In addition, we shift our attention to Medium Earth Orbit (MEO), where a cluster of 20 spacecraft (O3B) was already positioned in a circular orbit over the equatorial at an elevation of 8063 kilometres. Each satellite has twelve manually steerable antennae that allow for terminal monitoring and transfer. The next series of O3B satellites will feature an active antenna capable of generating hundreds of beams, as well as a digital visible computer on board.This constellation kind is special in that it achieves a good balance of constellation volume and lag. Finally, the emergence of new formation types has resulted in hybrid formations, which integrate assets from various orbits. The integration of GEO and MEO connection, for example, allows terminals to easily switch between the 2 orbits [3]. Backhauling of LEO satellite measurements via higher orbit spacecraft is yet another instance [4], [5.

Capabilities onboard

Typically, advanced SatCom techniques were constrained by on-board processing capacity. To begin with, most satellites serve as a relay, converting, amplifying, and forwarding data, hence on-board processing must be waveform agnostic. Second, there's really usually a significant route loss to fight and a restricted power source, both of which are directly proportional to the satellite weight and flight cost. Third, because there is very little likelihood of repairing or replacing the property after it is sent into orbit, the on-board parts and technologies used must be super duper and resilient. Nonetheless, recent advancements in power production efficiency, and also the fuel efficiency of radio waves and digital signal processing elements, have enabled improved on-board computing, that can enable novel solutions.Additionally, space-hardened way to capture radios may enable on-board wavelet processing that can be improved throughout the course of the satellite's lifetime. Lastly, low launch costs and conveyor-belt production enable more risky/innovative ways to be deployed while simultaneously maintaining with telecommunication evolutions. Non-Terrestrial Networks The word NTN was established as part of the 5G standardisation process to describe communication systems such as satellites, UAVs, and HAPs.

The major goal of this programme is to examine the architectural and air interface characteristics of these resources in order to smoothly incorporate them into 5G networks. More significantly, the stakeholders involved want to capitalise on NTNs' distinctive features, such as their vast coverage, multicast capabilities, and compatibility with local grounded equipment. Moreover, by utilising 5G chipsets/systems and leveraging economy of scale, the cost of deployment can be significantly reduced. A range of potential use applications have been proposed in this direction.

New Space

New Space does not relate to a specific technological advancement, but rather to a new attitude about space. It arose from three primary factors: Space privatisation, satellite shrinking, and novel companies that rely on space data are all possibilities. In contrast to the usual institutional method, privatisation refers to the fabrication and, in particular, the launch of spacecraft by private businesses like Rocket Lab and SpaceX. Simultaneously, satellite and element simplification enabled simple space travel by multiplexing several cubical into a single launch. By combining the two first features, the latter has been achieved, providing for speedy and relatively low-cost access to space. A plethora of data gathering constellations have been launched in this regard, covering a wide range of applications.Returning our attention to connectivity, New Space has sparked new possibilities for gathering data from base stations immediately via satellites, a phenomenon known as the Satellite Web of Things. Hundreds of private enterprises are currently working on prototypes in order to develop a successful commercial service. Almost all of these endeavours rely on low earth orbits, which adds to the difficulty of quickly downlinking the acquired data to the ground for analysis. Traditionally, each of these ventures would necessitate a large network of earth stations to ensure high uptime.

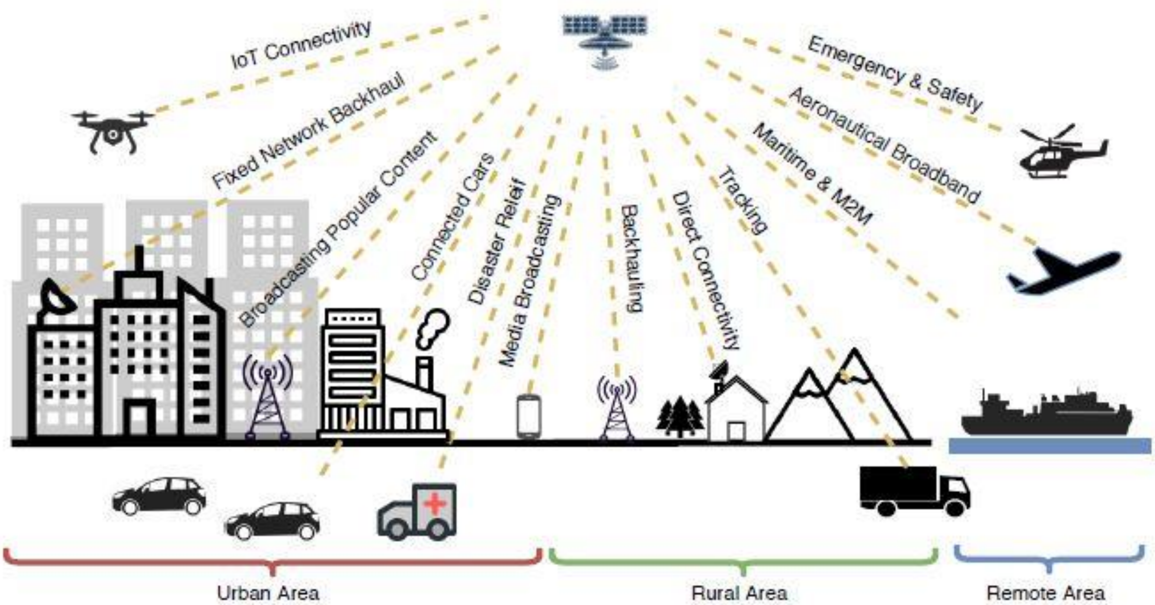

Fig. 2. Satellites' function in the 5G ecosystem

APPLICATIONS AND USE CASE STUDIES

The purpose of this section is to summarise and quickly describe some of the most important applications and use scenarios in which SatComs can be useful. A. 5G Non-Terrestrial Network 5G would be more than a continuation of past standards, encompassing a broad new variety of applications to meet future segments of the market like automobile and transport, entertainment and media, e-Health, Industry 4.0, and etc, . ITU-R defines three primary groups of 5G use applications for IMT in 2020 and beyond [8]: eMBB, mMTC, and uRLLC. The critical role that satellites can serve in the 5G ecosystem has long been acknowledged.In March 2017, the 3GPP launched new initiatives to investigate the role of satellites in 5G, and two research items (SI) were already completed. After a two-year study period, it has been decided that NTN will be a new major element of 5G, with a work item (WI) beginning in January 2020 [11]. The 3GPP [12] has established three broad kinds of use applications for NTN 5G networks. For starters, NTN can greatly improve 5G reliability of the network by assuring service continuity in situations where a single or combo of terrestrial systems cannot provide it. This is particularly true when it comes to mobile devices and mission-critical interactions.

Second, NTN can ensure the availability of 5G services in neglected or unserved places where a terrestrial net does not present or is too difficult/expensive to reach. Last but not least, because to the satellites' efficiency in multihoming or distributing over a large area, NTN can provide 5G service scaling. By streaming popular material to the network's edge or straight to users, it can be a very effective way to unload the conventional network. Below was a more comprehensive list of satellite use scenarios for every 5G service group.• BATF: In this use case, the satellite plays a supporting function by backhauling data from the network's edge or beaming popular content to the network's edge, allowing the 5G internet infrastructure to run more efficiently.

• THEF: In remote places where terrestrial equipment is challenging or hard to build, the satellite provides direct 5G access.

• HYMP: The satellite provides 5G service into underdeveloped communities via hybrid aerial broadband links, allowing for 5G service in homes and offices.

• COOM : The satellite offers immediate or supplementary connectivity to enable 5G connectivity on initiatives including planes, ships, and trains. 2) Satellite mMTC application cases: Massive machine-to-machine communication, often known as the IoT, is based on low-cost, minimal devices (sensor systems) that can produce and exchange data. The data produced by these IoT devices, despite its small size, will have a substantial impact on network load. As a result, satellites can assist in offloading the domestic IoT network via backhauling, or to provide continuity of service in circumstances where a domestic network is unavailable. Due to the type of application, this set of use instances can be divided into two smaller sections.

• Wide-area IoT systems: This use case involves applications that are based on a collection of IoT devices that are dispersed across a large region and report data to or are managed by a central computer. The satellite can be used in a variety of purposes, including: - Energy: Monitoring of petroleum infrastructure is critical (e.g. pipeline status) - Transportation: Ship control, object tracking, banner advertising, and remote road warnings are just a few of the services available. - Agriculture: animal husbandry and farming

• Local area IoT services: These apps employ IoT devices to gather local record and information it to a centralized computer. A microgrid sub-system or offerings to on-board mobile platforms are examples of typical uses.Self driving, telemedicine, and manufacturing automation are just a few examples of common applications. Due to the increasing latency in the communication channel, it is evident that the spacecraft, irrespective of orbit height, is unable to directly offer these operations. However, in some circumstances, taking a secondary role can be vital. Content transmitted over a large region and wisely cached locally is a good example of minimal "perceived" delay at the user's end.

In addition, due of its transmission over a vast area capability, satellites can be particularly beneficial for car software upgrades, traffic updates, and other autonomous driving use cases. Figure 3: Communication architecture with multiple layers. SatCom-assisted VLEO and VLEO Networks in the Air Thanks to technological advancements in aerial and smaller satellite platforms, transmission medium of communications networks between terrestrial and classic satellite sections have evolved in recent years. These new systems can be classed based on their operating altitude, regardless of their purpose. VLEO spacecraft, HAPs, and LAPs are the three major categories. With the introduction of these new platforms, a new multi-layer connectivity design [16] is now possible, with many inter-layer links capable of overcoming even the most difficult conditions. This new multi-layer communications paradigm is depicted schematically in Fig. 3. The opportunities and drawbacks of LAPs, HAPs, and VLEO satellites are summarised in the subsections below. 1) Very Low - earth orbit Orbit: VLEO satellites circle the Globe at a lower altitude than LEO satellites. As a result, they can be simpler, smaller, and hence less expensive [14]. However, at such lower elevations, the atmosphere is denser, resulting in greater aerodynamics. This could be construed as a challenge.Furthermore, higher drag reduces orbital lifespan, but it also implies more regular fleet renewal with smaller, less expensive spacecraft, making the fleet more sensitive to technological and market developments.

ENABLERS & TOPICS FOR MEDIUM ACCESS CONTROL

The purpose of this section is to discuss some essential components of a satcom system's MAC layer. This layer is in charge of managing the channel access technologies that help several endpoints or networking devices to interact in a network.

1) Forward Link Scheduling: In order to fully leverage the new capabilities of the DVB-S2 standard (created in 2003), forward packet planning has been explored since its inception. The air interface proposed in DVB-S2 is capable of adapting the ACM to channel models in

order to enhance spectrum efficiency. This is accomplished by presenting each client with the most appropriate ModCod value based on the SINR measured. As a result, the DVB-S2 standard allows for the management of several services while maintaining a certain level of QoS. Because they may play with the dimension of time to divide satellite resources across different projectors and recipients depending on the input circumstances and QoS demands, packet scheduling techniques play a significant role in ensuring efficient resource management.

• Prioritization of packets: Lesser priority packets may be delayed (or even discarded) in favour of higher priority packets. Emergency real-time packets, such as medical emergency communications, emergency, and disaster management services, must, for example, be given first priority. • Quality of Service (QoS) criteria: Prioritize packets with strong QoS needs. • Buffer invasion: Load balancing algorithms are inextricably linked to the problem of buffer management. Prioritize packets that are allocated to severely overloaded queues.

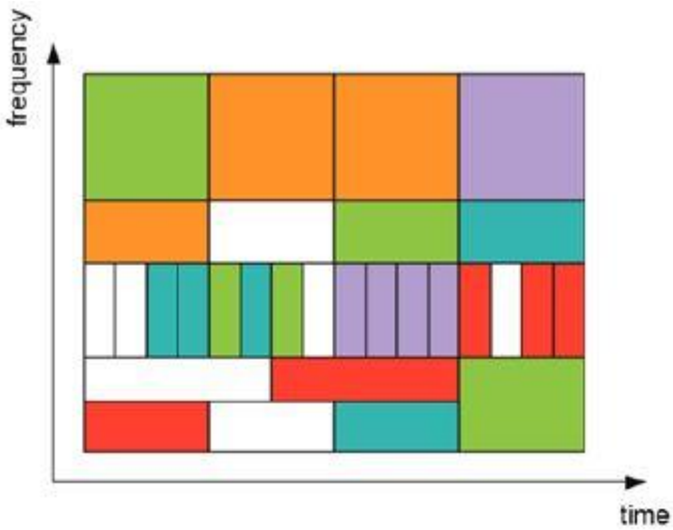

Fig. 17. In satellite uplink, the MF-TDMA technique is employed.

CA is a critical component of today's LTE satellite services. The satellite communications industry has been paying close attention to its capacity to increase peak data rates, efficiently utilise increasingly limited available spectrum, and meet the need for data-hungry apps. The use of CA in satellite technology has piqued curiosity, with numerous possible scenarios being debated and examined on the basis of market, economic, and technological feasibility. In Figure 17, the CA design is depicted.

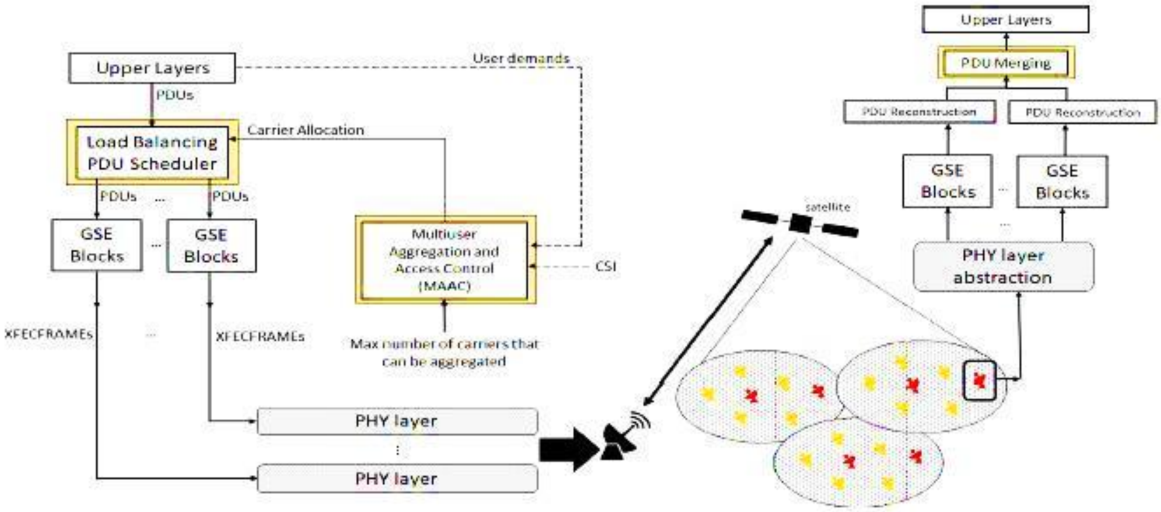

Fig. 18. Architecture of CA

PROTOTYPING & TESTBEDS

This section refers to communication functional prototypes that have been constructed for various communication levels in order to showcase some advanced SatCom ideas in a practical setting. Based From sensing to computers to radios appropriate for use in spaceship applications, the technology industry's spectacular advancements drive a trend towards ever compact, faster, faster, and more powerful equipment. Their availability has sparked a revolution in tiny and medium-sized spacecraft, as well as consumer electronics on the ground. The community is aiming for re-configurable SDR SoC ground receivers, as well as satellite-on-a-chip at its most extreme. In the previous decade, SDR technologies have gained popularity, with numerous demos for terrestrial communication systems.It is characterised by the fact that the majority of signal processing is carried out in the digital domain by a suitable GPUs make up an SDR platform. All of the transmitter and receiver features can be changed by simply changing the computer code of the DSP chips on these platforms, making them extremely versatile.

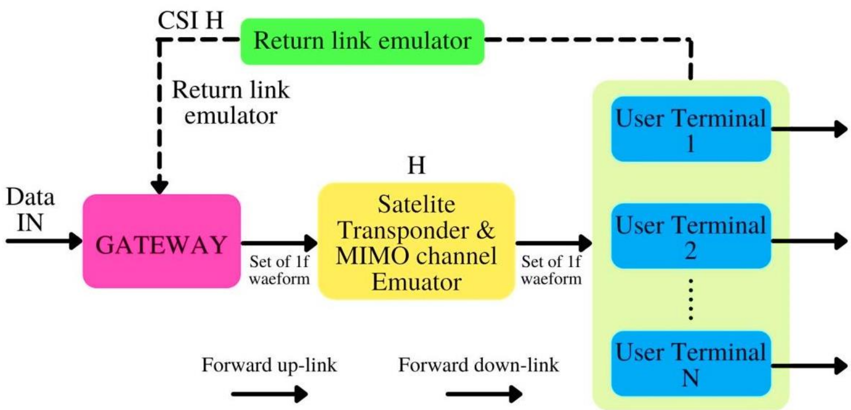

Fig. 19. The end-to-end satellite forward connection hardware testbed is depicted in this diagram.

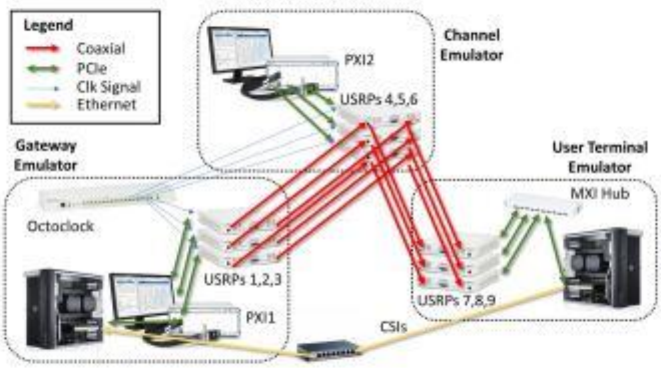

Fig. 20. End-to-end satellite forward connection hardware testbed with SDR infrastructure

Because satellite systems are hard to access and expensive, tools like satellite system simulation games, which play a central role in the growth of PoCs/testbeds, have become increasingly important in satellite technology research. In this regard, proof-of-concepts/testbeds can play a critical role in conducting protests and rigorous evaluations of viability, achievement, controllability, and other factors for new frameworks, techniques, protocols, methodologies, and other technologies using low-cost strategies and believable and repeatable network situations. The precision of the replicated models and the subsystems to be assessed is one of the most important characteristics of a simulation.

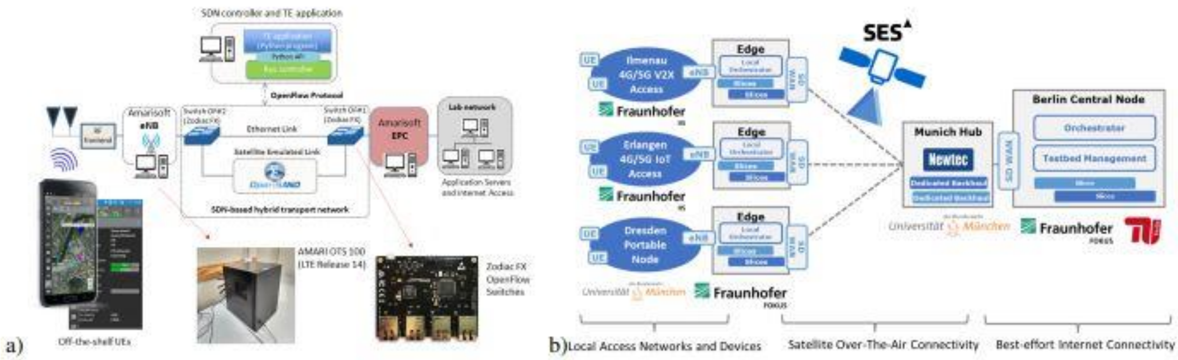

Fig. 22. Aerial picture of the components of the prototype test bed a) A traffic engineering solution based on SDN P

Conclusions:

The massive growth of various Internet-based apps and companies has resulted in an ever-increasing demand for ultra-high-speed, varied, ultra-reliable, and low-bandwidth links, and satellite technology have recently entered a vital stage of their development. Due to their unique attributes and technological achievements in the industry, satellites may be a foundation in satisfying this demand, as either a stand-alone option or as part of integrated satellite system. To summarise, this research looked into the most current industrial, scientific, and standardisation breakthroughs in satellite communications. The most significant prospective benefits and use cases, which are now the emphasis of SatCom study, have been highlighted.The communication testbeds that were built to demonstrate some of the most recent SatCom ideas in a realistic way are on display. Finally, certain key future challenges, as well as their corresponding open research topics, have been recognised.

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