SATELLITE AND SPACE COMMUNICATIONS **SSC**
http://committees.comsoc.org/ssc/

IEEE COMMUNICATIONS SOCIETY

SSC Newsletter **Vol. 29, No. 2, Dec 2019**

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The Satellite and Space Communications (SSC) Committee is a volunteer group actively involved in advancing satellite and space communication technologies within the IEEE. This committee is approved by the IEEE Communications Society and is governed by the constitution and bylaws of the IEEE as well as the other twenty-three Technical Committees in the Society. The committee belongs to the Technical Committee Clusters of Communication/Signal Processing (C/SP).

SATELLITE & SPACE

- JOIN US -

All conference attendees are welcome to join us in the SSC Committee meeting.

Location: GC'19, Waikoloa, USA
Room: Paniolo III
Marriott Waikoloa
Date: Wednesday, Dec. 11, 2019
Time: 12:30-14:00

Future SSC Meetings
June 2020, Dublin, Ireland
December 2020, Taipei, Taiwan

GC 2019 SSC Committee Activities:

Symposium on Selected Areas in Communications:

Tuesday, Dec. 10, 14:00 - 15:30, Room: Queen's 4
SAC SSC1: Satellite Systems
Chair: Ulrich Speidel (University of Auckland, New Zealand)

Tuesday, Dec. 10,16:00 - 17:45, Room: Kohala 4
SAC SSC2: Satellite Networking
Chair: Alaa Sabbagh (Florence Darlington Technical College, United States)

Wednesday, Dec. 11, 8:45 - 10:30, Room: Kohala 4
SAC SSC3: Satellite Communications
Chair: Jules M. Moualeu (University of the Witwatersrand, South Africa)

Thursday, Dec. 12, 17:00 - 17:45, Room: Grand Promenade
MPS3: Merged Poster Session3
Chair: Qichao Xu (Shanghai University, P.R. China)

HOW TO JOIN SSC COMMITTEE AND MAILING LIST

If you like to join SSC Technical Committee: Please send your name and e-mail address to the SSC Secretary, optionally include your mail address, telephone and fax numbers.
If you like to join SSC Mailing List: Instructions on how to subscribe/unsubscribe are available at https://comsoc-listserv.ieee.org/cgi-bin/wa?A0=ssc.

SSC COMMITTEE OFFICERS

MESSAGE FROM THE CHAIR

Dr. Tomaso de Cola

As pointed out in the messages provided in the previous SSC newsletter, the objective of this TC is to now maintain the visibility and stability achieved in the last years, by further consolidating the number of submitted papers and strengthening the presence of SatCom in highly-ranked IEEE journals and magazines. To this end, new opportunities are being sought in terms of special issues to be hosted in journals or magazine, giving priority to ComSoc publications but not just limited to this society but also considering other IEEE prestigious society such as Signal Processing and Vehicular Technology. As reported in the paragraphs below, the objective of achieving a special issue on IEEE JSAC on satellite-5G topics could not be fulfilled although the received reviews were quite positive. Nevertheless, the TC is enthusiastically committed to find new opportunities, by taking also advantage of the new hype of satellite communications, especially in terms of the so-called non-terrestrial networks which have been receiving quite some consensus in 3GPP in the ongoing 5G standardization process.

Last but not the least, my term as chair is going to conclude (Spring 2020) so that elections for the new officers (chair, vice-chair, and secretary) will start in early 2020 in order to have the new officers announced before ICC'20 and then start the activities right afterwards.

The rest of this message then contains important notes about the most relevant activities regularly carried out by the TC.

Participation to TC Meetings. The SSC TC last meetings shown a good trend in the number of attendees, confirming the number already recorded in the previous meetings held in 2018. In particular, the trend is to always have about 30-40 attendees participating to the SSC meeting, hence testifying the increasing interest in the TC activities and also confirming the stability of our TC. Nevertheless, we have to continue to publicize our meeting and to invite members, past and new, to attend.

Operative Policies and Procedures (OP&P). Upon discussion during the last meeting, the charter is expected to be update so as to include also topics related to UAV and more in general new space, which are going to become more and more important in the context of SatCom in a broad sense. A new version of the charter will be likely submitted to the TC board for validation and approval in early 2020. The policies and procedures has also undergone some important modifications to reflect the recommendations provided by the TC board P&P, especially in terms of the TC objectives and the duties of chair, vice-chair and secretary. Moreover, specific definition of members and associates have been introduced to keep compliancy to the TC board P&P, with particular attention on the fact that TC members must be IEEE/ComSoc members.

Membership Management. The approach started a few years ago to continuously attract more people is achieving quite good results, also in relation to the large audience of each SSC meeting. Moreover, the editorial initiatives around SatCom have increased the worldwide visibility of SSC hence possibly increasing the attention towards the TC and eventually getting new members.

Extended Cooperation. It consists of strict cooperation with Industries, research institutes, standardization institutes (e.g., CCSDS, ETSI, DVB), and space agencies of several countries (e.g., NASA, JAXA, ESA, DLR). The success of this task is further strengthened by the presence of industry and academia in many of the editorial initiatives promoted by the TC, counting on satellite operators and vendors. Moreover, most of the last perspective articles

present in the newsletter are coming from industry-driven projects, hence showing the great interest from industry and space agencies about the work being done in the TC.

SSC Website and Mailing List. Maintenance and periodic update of mailinglist and website are performed by the committee secretary, in order to guarantee up-to-date material and possibly attract new members interested in SatCom-related topics.

Current Journals/Magazines. After the publication of the IEEE Network and IEEE Wireless Communication Magazines, an initiative to promote a special issue on integrated satellite-5G networks has started on IEEE JSAC. In spite of the good reviews received by the editorial board, the proposal has been however not enough mature for JSAC and therefore rejected. Other opportunities are being considered especially with respect to the role of SatCom in 6G and also the use case of satellite IoT systems.

Conference Activities (ICC/GC and others). In ICC/GC is consolidated the SSC Track. In the recent years the SSC track has been quite successful. The SSC track of past GC editions and the current ICC'19 showed a very good number of submissions, being approximately 70 and 60 respectively. The present edition of GC'19 also maintains this trend with a considerable number of accepted paper, though slightly less than the previous editions. Concerning other conferences, the SSC TC has endorsed SPECTS, WiSee, and which are being held in the second and fourth quarter of 2019, and ASMS/SPSC for year 2020 (third quarter).

Standardization Activities. Since the meeting in Atlanta (IEEE GC'13), we have appointed the Standard Liaison, Dr. Henry Suthon, Principal Senior Engineer at Boeing (h.suthon@ieee.org), who has recently confirmed his commitment in this role. Additionally, a dedicated board (formerly conceived as WG) is being under formation so as to put even more effort and visibility on the standardization activities performed around satellite and space communications. In this respect, it is worth noting that the contribution of this group to the standardization context is also confirmed the perspective article present at the end of this newsletter, where the effort paid by the satellite community in 3GPP to promote the inclusion of non-terrestrial networks (including SatCom) is highlighted. Moreover, liaison with IEEE standardization groups are being formed in the exercise of providing inputs to the IEEE 5G initiative where the dedicated SatCom WG has already compiled a report about the technology roadmap until 2030.

Dr. Tomaso de Cola, Chair
Satellite and Space Communications TC

SCANNING THE WORLD

Song Guo

In the passing 2019, there have been 87 orbital launches including 5 failures so far. The second half of 2019 has witnessed a lot of news on satellite technologies and space probing activities. Some representative news is summarized below.

From July 11 till July 18, Galileo, the European satellite navigation system, experienced a major outage. The system's status page listed all 22 of its satellites as either "Not Usable" or "Testing". The cause of the incident originated by an equipment malfunction in the Galileo ground infrastructure, which affected the calculation of time and orbit predictions. Galileo, which is owned by the European Union and operated by the European Space Agency, was first launched in December 2016 as an alternative to GPS. The system consists of 22 operational satellites, with two more in testing and 12 yet to launch, and is scheduled to be fully operational by 2020.

On October 9, a Russian Proton rocket launched the company's MEV 1 spacecraft, the first mission to test out satellite servicing capabilities while in space. This spacecraft has a very specific task: latch on to a satellite already in orbit and extend its life. The vehicle's target called Intelsat 901 is running low on propellant and ground operators won't be able to control the spacecraft for much longer. MEV 1 will try to use a device to pull the two satellites close so that they're practically right on top of each other. With the two satellites acting as one, MEV 1 will then ignite its own engine and place Intelsat 901 in a new orbit so that the satellite can continue working.

On October 10, NASA launched a satellite Thursday to explore the ionosphere, the frontier of the Earth and space, where energy from above and below combines to affect everything from astronaut missions to radio and GPS communication. The satellite shot into orbit from a plane flying over the Atlantic Ocean off the coast of the US state of Florida. According to NASA, the ionosphere is a fluctuating layer of electrons and charged atoms and molecules ranging from 48 kilometers (30 miles) above the Earth's surface to 965 kilometers (600 miles) above the ground at the edge of space.

On November 11, SpaceX launched a second group of 60 satellites at once in 2019, sending them into orbit on a veteran rocket that's already seen space four times. This is a big step forward for the company's space internet ambitions. The satellites are part of SpaceX's Starlink project — a group of satellites that the company hopes will eventually provide stunningly fast internet nearly anywhere in the world. SpaceX President Gwynne Shotwell has said they hope to begin offering services to customers as early as mid-2020.

Prof. Song Guo, Vice Chair
Satellite and Space Communications TC

FORTHCOMING GLOBECOM AND ICC CONFERENCES

ICC 2020

June 7-11, 2020, Dublin, Ireland

http://icc2020.ieee-icc.org/

The International Conference on Communications (ICC) is one of the two flagship conferences of the IEEE Communications Society, together with IEEE GLOBECOM. Each year the ICC conference attracts about 2-3000 submitted scientific papers, a technical program committee involving about 1500 experts provides more than 10000 reviews, the conference being finally attended by 1500 - 2000 professionals from all around the world. IEEE ICC is therefore one of the most significant scientific events of the networking and communications community, a must-attend forum for both industrials and academics working in this area. IEEE ICC 2020 - Featuring the latest developments in telecommunications from a technical perspective. Subjects include Communications Theory, Wireless Communications, Wireless Networking, Optical Networking, Next Generation Networks for Universal Services, Multimedia Communication and Home Networking, Signal Processing for Communications, Communications QoS, Reliability and Performance Modeling.

GLOBECOM 2020

December 7-11, 2020, Taipei City, Taiwan

http://globecom2020.ieee-globecom.org/

IEEE GLOBECOM 2020 - IEEE Global Communications Conference (GLOBECOM) is one of the IEEE Communications Society's two flagship conferences dedicated to driving innovation in nearly every aspect of communications. Each year, more than 2,900 scientific researchers and their management submit proposals for program sessions to be held at the annual conference. After extensive peer review, the best of the proposals are selected for the conference program, which includes technical papers, tutorials, workshops and industry sessions designed specifically to advance technologies, systems and infrastructure that are continuing to reshape the world and provide all users with access to an unprecedented spectrum of high-speed, seamless and cost-effective global telecommunications services.

COSPONSORING / RELATED CONFERENCES AND WORKSHOPS

CONFERENCES CALENDAR

CONFERENCE	DATE & LOCATION	INFORMATION
SPECTS 2020 International Symposium on Performance Evaluation of Computer and Telecommunication Systems	TBD	http://atc.udg.edu/SPECTS2020/
ITC 2020 32rd International Teletraffic Congress	22-24 September 2020 Osaka, Japan	http://itc32.org/
ICTS 2020 International Conference on Computer, Information and Telecommunication Systems	5-7 May 2020 Hangzhou, China	http://atc.udg.edu/CITS2020/
ICL-GNSS 2020 International Conference on Localization and GNSS	2-4 June 2020 Tampere, Finland	http://www.icl-gnss.org/2020/
PIMRC 2020 IEEE International Symposium on Personal, Indoor and Mobile Radio Communications	31 August – 3 September 2020 London, UK	http://pimrc2020.ieee-pimrc.org/
Ka-Band/ICSSC 2020 The 26th Ka and Broadband Communications Conference and the 38th International Communications Satellite Systems Conference (ICSSC)	TBD	http://www.kaconf.org/
VTC-Spring 2020 2020 IEEE 91st Vehicular Technology Conference (VTC-Fall)	25-28 May 2020, Antwerp, Germany	http://www.ieeevtc.org/vtc2020spring/
ASMS/SPSC 2020 10th Advanced Satellite Multimedia Systems Conference (ASMS) and 16th Signal Processing for Space Communications Workshop (SPSC)	7-10 September 2020, Graz, Austria	https://www.asmsconference.org/

To all SSC members: If your postal address, telephone or fax numbers have changed, please update them with the committee secretary. You can review our current records on our web page at http://committees.comsoc.org/ssc/.

PERSPECTIVE ARTICLE *December 2019*

On the Use of AI for Satellite Communications

Miguel Ángel Vázquez[1], Pol Henarejos[1], Ana I. Pérez-Neira[1,2], Elena Grechi[3], Andreas Voight[3], Juan Carlos Gil[4], Irene Pappalardo[5], Federico Di Credico[5], Rocco Michele Lancellotti[5]
Centre Tecnològic de Telecomunicacions de Catalunya, Castelldefels (Spain) [1].
Universitat Politècnica de Catalunya, Barcelona (Spain) [2].
Eutelsat, Paris (France) [3].
GMV Aerospace and Defense, Tres Cantos (Spain) [4].
Reply, Turin (Italy) [5].

***Abstract* —This document presents an initial approach to the investigation and development of artificial intelligence (AI) mechanisms in satellite communication (SatCom) systems. We first introduce the nowadays SatCom operations which are strongly dependent on the human intervention. Along with those use cases, we present an initial way of automatizing some of those tasks and we show the key AI tools capable of dealing with those challenges. Finally, the long term AI developments in the SatCom sector is discussed.**

INTRODUCTION

It may come as a surprise to realize that nowadays satellite communications still heavily depend on human expertise and manual operations. Satellite operator's teleports require strong human involvement, leading to a high operational expenditures (OPEX) and a reduced client quality of service. Indeed, ticketing processing of incidents in the radiofrequency (RF) plane require the intervention of human experts in order to provide a technical solution.

Moreover, with the forthcoming deployment of flexible payloads, satellites are meant to reconfigure their transmission budgets on a millisecond basis. This requires radio resource management algorithms with a very short response time, able to design time, frequency, power and beamforming in order to meet the clients service level agreements. Furthermore, the advent of satellite megaconstellations only add complexity to the picture, imposing the need to coordinate space networks of hundreds if not thousands of satellites.

In this context, it is forecasted that automation algorithms will be incorporated to the daily satellite operations in the next few years. The use of deep learning may play an important role in this problem due to its capability of mimicking any nonlinear function.

In this work we introduce four use cases; namely anomaly detection in telemetry data, flexible payload optimization, interference detection and classification and beam congestion prediction, which we consider that AI may have a substantial impact on. All of them are part of nowadays and near future satellite communications daily operations. AI tools capable of dealing with the described use cases are introduced. In addition, other ideas on how AI can support long term satellite communications are also presented.

PROMISING USE CASES

A. *Anomaly Detection in Telemetry data*

Conventional telemetry usage very often refers to comparison between the instantaneous readings and static thresholds. Given the large amount of data downlinked from the satellites, it is often difficult to analyse trends or detect anomalies if readings do not exceed these thresholds. The introduction of AI and a new approach including data labelling would bring considerable benefits to the industry to better identify anomalies including not only failures but patterns deviating from nominal behaviours. By labelling data referring to a specific event as an anomaly, specific future failures could be prevented in a timely manner potentially avoiding heavy on board reconfigurations, but acting in a more proactive approach. At industry level, anomaly early detection could allow, for instance, spare on board equipment saving such as traveling-wave tube amplifiers (TWTAs) or could even trigger a better ground service customer management and TWTA gains configuration according to telemetry trends.

This use case can be described as the generic ML problem of anomaly detection in multivariate temporal data series. Despite it being a topic which has received considerable attention in the last 10 years [1], its applicability to real systems is subject to investigation in current innovation labs within companies and academic groups.

There is a myriad of options for addressing the problem of anomaly detection in multidimensional time series. One case is based on robust principal component analysis by Netflix [2] on payment transactions. Yet another case is the usage of predictive statistical methods for detecting DDoS attacks as reported in [3].

B. Flexible Payload Optimization

Flexible payloads will become mainstream in the near future and will revolutionize the conventional idea of a satellite communications mission [4]. On top of the new perspective of reconfigurable payload, AI shall be integrated in the end-to-end service delivered in order to achieve a smart interference management system. A fully reconfigurable payload operated in a conventional approach with regards to interference management could not bring any substantial differentiator to the industry neither to customers, who on the other hand are expected to pay for more expensive capacity. Instead, the winning combination of flexible payload with smart interference avoidance system is definitely a must that can not only deliver the benefits of the previously mentioned use cases but also increase customer satisfaction and stickiness.

The main idea of this use case is to develop a mechanism able to provide a satellite payload configuration in terms of power allocation per feed element, bandwidth allocation and beamforming design, given a sudden change in the interference power level of a certain coverage area. The new payload configuration shall be provided in a very short time lapse; thus, it follows that the mechanism shall manifest a reduced computational complexity.

Existing techniques use parallel processing or other high performance computation means to explore every possibility. During the deployment, the applications require significant engineering effort to configure the software to match specific payloads. For this use, we expect to revisit the recent activities of deep learning applications to operations research [5], where deep neural networks are used for either reducing the optimization search space or providing initial efficient configurations.

Using a learning system we would expect the following gains: i)Less engineering effort would be needed to define payload configuration, therefore less effort to set up each instance. ii)Faster computation with no need to assess every possible solution. As payloads get more complex this factor becomes more and more relevant and may enable automated reconfiguration. iii)Can include factors that need to be separately programmed into a mass computation system (e.g. routing restrictions or "do not touch" components)

B. *Interference Detection and Classification*

Unfortunately, interferences in satellite communications are usually frequent. Interference detection is typically a task performed on a reactive mode instead of proactive. Given that in most of the cases satellites simply rely signals coming from the Earth, interfering signals are present to a large extent in all frequency bands. The possibility to offload a purely human task such as Power Spectrum Density check to an automated system, able to detect the presence of unwanted signals, is an exciting perspective in terms of improved spectral management and customer incident avoidance.

Most of the interferences present today are caused by human errors – either due to mispointed antenna (cross-polarization or adjacent satellite) or misconfigured equipment (noise introduction, intermodulation, etc.). These parameters cover 70-80% of all interference cases and are not related terrestrial networks. If there are carrier overlaps, it implies a digital video subscriber (DVB) carrier overlapping another DVB carrier or a satellite modem transmission, including very small aperture terminal (VSAT) traffic in time division multiple access (TDMA), for instance.

In order to mitigate them, there are several techniques that may help to reduce the levels of interferences. However, in many occasions, it is still difficult to cope with them. Currently, the only way to manage interference is by human intervention and performing an exhaustive analysis, that may take several days to solve the incidence. In other words, there are qualified personnel dedicated to detect interferences by inspecting figures, such as the spectrum, abnormal error rates increase or degraded user experience.

Here we propose an automated system capable to detect interferences and reduce the human intervention in order to generate alarms when interferences are occurring to perform operations in an automated fashion. The proposed system implements latest improvements on AI algorithms that are able to detect deviations of the signal's statistics, altered by unwanted interferences [6]. At the end, the system throws an alarm if the deviation trespasses a fixed threshold.

C. Congestion Prediction

The load prediction problem is a widely analyzed

topic. However, to the best of our knowledge, the application of machine learning algorithms to improve congestion prediction has yet to appear because of the difficult challenge in characterizing the satellite communication signals. This is especially useful for detecting anomalous behaviors and predicting not recurrent patterns in a strong non-linear scenario.

The most common approach to the satellite system congestion consists in two phases: performance prediction and application of mitigation techniques.

As of today, the performance prediction is in general based on trend curves of the previous days. This does not allow neither long term predictions nor management of anomalous behaviors. By considering several additional factors (e.g. traffic type in terms of services and download/upload bandwith), machine learning techniques can both extend the time frame on which the analysis is done and identify in quasi-real time irregular traffic patterns that unexpectedly affect the performance (e.g. release of os update or live events). A long time frame prediction is particularly useful for marketing purposes like identifying seasonal trends and simulating future scenarios characterized by a different number of users.

On the other hand, mitigation techniques are commonly based on human decisions and therefore they show scalability issues as well as a limited view on the effect of the applied actions. Also, in this phase, machine learning techniques can boost the effectiveness of the countermeasures, implementing automatic and real-time mechanisms to cope with congestion impairments.

Note that meaningful predictions can only be made considering homogenous populations, which can be obtained through clustering algorithms. These are unsupervised algorithms that should pre-process the input data to the learning network in order to recognize hidden patterns in the data. Different existing techniques, hierarchical clustering, K-Means, Density-Based Spatial Clustering of Applications with Noise (DBSCAN), affinity propagation, and spectral clustering (especially suitable when the hidden structure does not obey to convex sets) are explored and results compared. Moreover, within arising clusters, forecasting and regression techniques (such as SARIMA, LSTM and XGBoost [7]) are used to predict future traffic levels.

OTHER PROMISING USE CASES

5G satellite-terrestrial interoperability and IoT (Internet of Things) services can also benefit from AI techniques that can cope with big volumes of very diverse data (e.g. telemetry, communication, weather, earth observation, …), which present uncertainty due to data inconsistency and incompleteness, ambiguities, latency, model approximations, structured, unstructured text, multimedia,... In general, AI is becoming one of the main enablers for new services and to optimize industrial processes, reduce cost of available telecommunication technologies and systems, still pursuing performance increase in data rate and flexibility.

Last but not least, mega-constellation systems offering capacity to mobile users such as vessels and airplanes have to tackle a two-level dynamic environment: the satellite and the user terminals. This varying system has to be able to deal with potential hotspots beams (i.e. a coverage area which a high demand) that change over time and satellite. Although a classical data fusion between satellite and user terminals trajectories may help in detecting these hotspots, demands and motion present a stochastic nature which could be tackled via data-driven algorithms. In other words, the past detection of hotspots may support the inference of future ones.

ACKNOWLEDGEMENT

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