SATELLITE AND SPACE COMMUNICATIONS **SSC**

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IEEE COMMUNICATIONS SOCIETY

SSC Newsletter **Vol. 28, No. 2, December 2018**

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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'18, Abu Dhabi, UAE
Room: Capital Suite 7
ADNEC
Date: Tuesday December 11, 2018
Time: 12:30-14:00

Future SSC Meetings
May 2019, Shanghai, China
December 2019, Waikoloa, USA

ICC 2018 SSC Committee Activities:

Symposium on Selected Areas in Communications:

Monday, December 10, 8:00 - 9:30
Room: Conference Hall B: Part D
SAC-SSC. 1: Satellite Communications I
Chair: Andreas Knopp (Bundeswehr University Munich, Germany)

Monday, December 10, 15:30 - 17:00
Room: Conference Hall B: Part D
SAC-SSC.2: Satellite Networking I
Chair: Kaoru Ota (Muroran Institute of Technology, Japan)

Tuesday, December 11, 8:30 - 10:00
Room: Conference Hall B: Part D
SAC-SSC.3: Satellite Communications II
Chair: Claudio Sacchi (University of Trento, Italy)

Tuesday, December 11, 13:30 - 15:00
Room: Conference Hall B: Part D
SAC-SSC.4: Satellite Networking II
Chair: Fabio Patrone (University of Genoa, Italy)

Wednesday, December 12, 13:30 - 15:00
Room: Conference Hall B: Part D
SAC-SSC.5: Satellite & Terrestrial System Integration
Chair: Tomaso De Cola (DLR, Germany)

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.

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MESSAGE FROM THE CHAIR

Dr. Tomaso de Cola

This message comes at the first meeting after my reconfirmation as SSC, chair, whose previous term was completed in June 2018. Following the roadmap that was initially drawn some years ago by my predecessor (Prof. Igor Bisio) and taking as reference the initial activities carried out in my first term, my plan for the coming two years is to keep high the interest of IEE/ComSoc audience on the SSC activities, by enriching them with new initiatives in terms of editorial proposals as well as contribution at IEEE level. As to the former, these are quite well detailed in the following paragraphs. As to the latter, the reference goes to the IEEE 5G initiative where there is a working group dedicated to SatCom, which is led by Dr. Sastri Kota and Prof. Giovanni Giambene that are long-standing SSC members. I expect that these activities along with upcoming new initiatives will help increase even further the success of SSC TC, with respect to the submission to the flagged SAC-SSC track as well as the participation to the SSC meetings. Moreover, in order to carry out the plan of implementing working groups, the TC will likely soon implement boards (a similar concept to working groups), aimed at putting some more emphasis on the research and standardization activities directly performed by the SSC itself (i.e., in terms of editorial initiatives or reported in the SSC newsletter) or by its members (i.e., not directly endorsed by the SSC TC but subsequently reported in the context of SSC-related activities.

Participation to TC Meetings. The SSC TC last meetings have a quite satisfactory number of attendees. In the past ICC and GC conferences since 2017, we had about 30-40 attendees, 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). After the modification introduced during 2017 about a new award (technical recognition) already assigned during ICC'18, the OP&P document is now in a stable version and available on the website. Further modifications concerning the charter with respect to new topics and the composition of work packages as anticipated in the past will be further addressed during the GC'18 SSC meeting.

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), and space agencies of several countries (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. 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. The IEEE Network special issue on integrated 5G satellite networks has been eventually published in September. Moreover, the special issue about space information network organized on the IEEE Wireless Communication Magazine is completing the second review round, so that its publication is planned within the first half of 2019. Finally, the TC is discussing the possibility of proposing a new special issue on IEEE JSAC; to this end, a call for volunteers for serving in the editorial board has been circulated.

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 ICC and GC editions showed a promising number of submissions ranging between 40 and 60, with some relevant achievements as in the case of the forthcoming GC'18, where approximately 70 submissions were recorded. Concerning other conferences, the SSC TC has endorsed SPECTS, WiSee, and ASMS/SPSC conferences, which are being held in the second quarter of 2018.

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.

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

SCANNING THE WORLD

Song Guo

The second half of 2018 has witnessed a lot of spaceflight activities that enlarge the space probing scope of human beings. These attempts reflect the development of the satellite and space technologies, such as the communication relay. Some representative activities are summarized as follows.

On November 16, NASA's Parker Solar Probe reports its well operating conditions since its first solar encounter. In addition to the challenge that keeping its cool, another issue with protecting it is to figure out how to communicate with it. Since Parker Solar Probe will travel alone for most of the time, and it takes eight minutes for light to reach the Earth. This means that if the engineers have to control the spacecraft from the Earth, it would be too late when something goes wrong. Parker Solar Probe is deigned to autonomously keep its safe and on track to the Sun by utilizing several sensors without any human intervention.

On November 26, NASA InSight lander successfully touched down on the surface of Mars after about seven-month, 300-million-mile journey from Earth. It captures the images of Mars and transmits them to Earth. InSight uses the NASA's Deep Space Network (DSN), an international network of antennas that provides communication links between planetary exploration spacecraft and their mission teams on Earth. DSN consist of three deep-space communications complexes placed approximately 120 degrees apart around the world. The strategic placement permits constant links to distant spacecraft even as the Earth rotates on its own axis. The Insight mission relies on Mars-orbiting spacecraft to relay data from the spacecraft to the antennas of the DSN.

In the same month, the Defense Advanced Research Projects Agency (DARPA) has awarded satellite operator Telesat a contract to study the use of commercial buses in the agency's experimental low-Earth-orbit constellation program known as Blackjack. Telesat of Ottawa, Canada, is the third company to receive a study contract for Blackjack, a DARPA demonstration mission that envisions deploying 20 satellites — each carrying one or more payloads. The DARPA study includes evaluating the use of intersatellite links on Blackjack satellites that would enable them to connect with Telesat's constellation, which will also have intersatellite links for in-space communications.

In December 3, SpaceX successfully launched Spacefight SSO-A: SmallSat Express to a SmallSat Express to a low Earth orbit from Space Launch Complex 4E (SLC-4E) at Vandenberg Air Force Base, California. The mission represented the largest single rideshare mission from a U.S.-based launch vehicle to date because it carries 64 payloads. A series of six deployments occurred approximately 13 to 43 minutes after liftoff, after which Spaceflight began to command its own deployment sequences. Spaceflight's deployments are expected to occur over a period of six hours. This mission also served as the first time SpaceX launched the same booster a third time.

In the same month, China plans to launch Chang'e 4 lunar probe by the Long March III B carrier rocket at the Xichang Satellite Launch Center. The highlight of this mission is that China will achieve the first soft landing and patrol exploration on the back of the moon in the world, which is considered as a leap and innovation in both engineering technology and space science. Because of the occlusion of the moon, the engineers cannot communicate with and control the probe when it is on the back of the moon. To this end, China launched the "Queqiao" relay satellite in May 2018. It currently works in the L2 mission orbit of Lagrange, which is about 65,000 kilometers from the moon. It will provide the Earth-Moon relay TT&C and data transmission services for the Chang'e-4 lunar probe landing on the back of the moon.

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

FORTHCOMING GLOBECOM AND ICC CONFERENCES

COSPONSORING / RELATED CONFERENCES AND WORKSHOPS

ICC 2019
May 20-24, 2019, Shanghai, China
http://icc2019.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. The vibrant city of Shanghai, China is proud to host the 53rd IEEE International Conference on Communications (ICC 2019). Themed “Empowering Intelligent Communications,” this flagship conference of the IEEE Communications Society will offer five full days of original paper presentations, tutorials, workshops, keynotes, demonstrations, industry panels and social events designed to further career opportunities and the in-depth understanding of the latest communications advancements worldwide.

GLOBECOM 2019
December 9-13, 2019, Waikoloa, HI, USA
http://globecom2019.ieee-globecom.org/
IEEE GLOBECOM is one of two flagship conferences of the IEEE Communications Society (ComSoc), together with IEEE ICC. Each year the conference attracts about 3000 submitted scientific papers and dozens of proposals for industry events. A technical program committee of more than 1,500 experts provides more than 10,000 reviews, and from this a small fraction of the submitted papers are accepted for publication and presentation at the conference. The conference attracts roughly 2000 leading scientists, researchers and industry practitioners from all around the world. IEEE GLOBECOM is therefore one of the most significant scientific events of the networking and communications community, a must-attend event for scientists, researchers and networking practitioners from industry and academia. IEEE GLOBECOM is a five-day event. Two days are dedicated to tutorials and workshops, while the remaining three days are dedicated to the IF&E program and the technical symposia. The program of the technical symposia includes oral or poster presentations of about 1000 scientific papers, grouped into 13 thematic symposia, and more than 15 parallel sessions. Themed " Revolutionizing Communications," GLOBECOM 2019 will offer five full days of original paper presentations, tutorials, workshops, keynotes, demonstrations, industry sessions and social events designed to further career opportunities and the in-depth understanding of the latest communications advancements worldwide.

CONFERENCES CALENDAR

CONFERENCE	DATE & LOCATION	INFORMATION
SPECTS 2019 International Symposium on Performance Evaluation of Computer and Telecommunication Systems	July 22-24, 2019 Berlin, Germany	http://atc.udg.edu/SPECTS2019/
ITC 2019 31st International Teletraffic Congress	September 27-29, 2019 Budapest, Hungary	http://itc31.org/
ICTS 2019 International Conference on Computer, Information and Telecommunication Systems	August 28-31, 2019 Beijing, China	http://atc.udg.edu/CITS2019/
ICL-GNSS 2019 International Conference on Localization and GNSS	June 4-6, 2019 Nuremberg, Germany	http://www.icl-gnss.org/2019/
PIMRC 2019 IEEE International Symposium on Personal, Indoor and Mobile Radio Communications	September 8-11, 2019 Istanbul, Turkey	http://pimrc2019.ieee-pimrc.org/
Ka-Band/ICSSC 2019 The 25th Ka and Broadband Communications Conference and the 37th International Communications Satellite Systems Conference (ICSSC)	October 29 - November 1, 2019 Okinawa, Japan	http://www.kaconf.org/
VTC-Spring 2019 2019 IEEE 89th Vehicular Technology Conference (VTC-Spring)	April 28 - May 1, 2019 Kuala Lumpur, Malaysia	http://www.ieeevtc.org/vtc2019spring/
IEEE BlackSeaCom IEEE International Black Sea Conference on Communications and Networking	June, 3-6, 2019 Sochi, Russia	http://blackseacom2019.ieee-blackseacom.org/

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Information-Centric Networking for Future Deep Space Explorations

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***Abstract* —With the advent of manned deep space explorations, future deep space networks will develop into fully distributed information networks of human and things, which involves i) Machine-to-Machine, ii) Machine-to-Human and iii) Human-to-Human communications. Although Delay/Disruption Tolerant Networking (DTN) is still the most practical architecture for deep space internetworking (DSI), inspired by Information-Centric Networking (ICN) for Internet of Things (IoT) on the earth, we try to explore the possibility of ICN for future DSI. A possible architecture of ICN for DSI is proposed in this article and the advantages and open issues are also discussed.**

INTRODUCTION

With advanced onboard processing capabilities and inter satellite link technologies, deep space probes and satellites can cooperate through space internetworking for better connections, more communication opportunities and broader bandwidth. Meanwhile, there have been more and more manned or human-machine cooperative exploration missions planned for the near future, especially in Lunar and Mars explorations. With human onboard or landed on other planetary body, there will be a novel transition in future deep space internetworking (DSI), from a traditional earth-centered data acquisition network with Tracking, Telemetry and Command (TT&C) capabilities to a fully distributed information network of human and things, which involves i) Machine-to-Machine (M2M), ii) Machine-to-Human (M2H) and iii) Human-to-Human (H2H) communications.

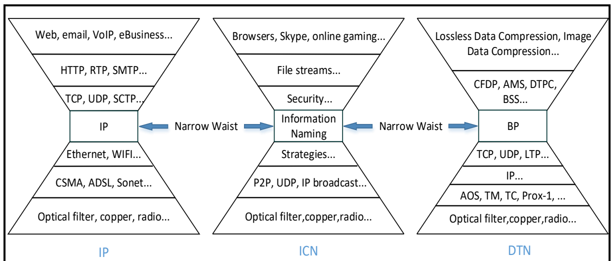

Fig. 1 Comparison among TCP/IP, DTN and ICN network architectures

There are basically two effective standardized network architectures for space internetworking [1], i.e. TCP/IP (IP over CCSDS) and Delay-Tolerant Networking (DTN), as shown in Fig. 1. Designed for terrestrial networks, TCP/IP has been widely adopted in near-earth networking, in which the link conditions (delays, error rates, channel asymmetry, etc.) are similar or close to those on the earth. While DTN is currently the only protocol suite practical for deep space applications.

In the past decade, research in terrestrial networks introduced new architectures for Future Internet, such as Information Centric Networking (ICN), also shown in Fig. 1. Various ICN architectures, clean slate, underlay or overlay, have been proposed and verified in many research projects. ICN standardization are also going on in different standard-developing organizations (SDO), such as ITU-T. Similar to DTN, ICN also utilize persistent storage as one of its key features. The similarity and the difference of DTN and ICN have already been discussed in the community [2], but few works have been done to further evaluate and improve ICN as a candidate network architecture for DSI. Although after more than 20 years of research, development, demonstration and application, currently DTN is still the most promising architecture for DSI, ICN's inherent tolerance of delay/disruptions and other advantages revealed in terrestrial networks are still attractive and inspiring for further study of ICN for deep space applications.

ICN ARCHITECTURE FOR FUTURE DSI

A. ICN and Its Advantages

Table 1 ICN Advantages in Terrestrial Netwroks and Its Supporting Features

Advantage	ICN Supporting Features
Scalability	Naming, In-Networking Caching, Content-based Security
Mobility	Naming and Name Resolution, Publish/Subscribe, Location Independence
Security	Naming, Location Independence, Content-based Security
Heterogeneity	Naming and Name Resolution, Strategy Layer
Data Availability	In-Network Caching
Energy Efficiency	In-Network Caching, Naming

As an ongoing research field, ICN represents a bunch of similar network architectures for Future Internet, such as CCN, NDN, 4WARD, PSIRP/PURSUIT, SAIL [3].

Different from the host-centric end-to-end TCP/IP architecture, ICN usually employs content/information naming, name-based routing, publish/subscribe paradigm, in-network caching and content-based security to achieve advantages over TCP/IP in terrestrial networks such as Internet, Internet of Things, 5G Cellular networks, etc.

Through data naming and name-based routing, ICN decouples information from its location, which facilitates mobility. In-network caching and name-based routing support multi-homing and ICN also employs in-network caching to serve potential data request, which improves data availability and network efficiency. Some advantages of ICN in terrestrial networks and the supporting features are listed in Table 1. The details of the benefits and the mechanisms of ICN can be further explored in many reviews of ICN [3][4]. It should also be noted that different ICN proposals might focus on different features and advantages.

B. *Related Works in Satellite Communications and Space Internetworking*

The techniques adopted in ICN and its advantages are definitely attractive. There have been direct applications of ICN in satellite communications and similar paradigms proposed for space internetworking, some even earlier than ICN.

1)ICN for Satellite Communications

Satellite communications have always been an irreplaceable supplement for terrestrial Internet to access rural, aerial and marine areas. Direct applications of ICN in satellite networks have been proposed for Internet backhauling [5] or emergency communications [6]. Caching-enabled satellite terminals can improve data availability and reduce content delivery delays for local users with interests in cached content. In-network caching also reliefs the traffic on bottleneck satellite links by reducing duplicate content transmissions.

What should be noted is that, current satellite networks are mostly based on Geostationary Earth Orbit (GEO) bent-pipe communication satellites. The storage and networking facilities are all on the ground, so usually there is no consideration on resource constraints as in space. And the network topology is basically static for fixed services.

2)Delay-Tolerant Networking

Designed for deep space communications and networking, DTN exploits storage to overcome long link delays and disruptions in deep space environment. The similarity and the difference between ICN and DTN have been discussed in [2][7]. It has also been proposed to integrate ICN and DTN for enhanced capabilities, either ICN as an overlay[8] or underlay[9].

The major differences between ICN and DTN are as follows, first, ICN is information-centric and running name-based routing while DTN is still host-centric; second, ICN's in-network caching is designed for content caching and replication while DTN's storage is used as store-and-forward buffer; third, DTN provides push-based communications services while ICN is either pull-based or pull and push both enabled, depends on different ICN proposals.

3)Asynchronous Message Service

Asynchronous Message Service (AMS) [10] is a CCSDS standardized protocol to provide general-purpose short messages exchange service for deep space mission operations. It is similar to ICN because it is also based on publish/subscribe paradigm.

The difference between AMS and ICN is that AMS focus on message distribution, so there are no caching or name-based routing features as in ICN. In other words, AMS is an application layer protocol based on publish/subscribe paradigm, while ICN is a complete network architecture with publish/subscribe features.

C. *New Challenges for Future DSI*

Since 2015, NASA has sequentially announced its manned exploration projects in Lunar orbit, on the Moon and to Mars in the next two decades. SpaceX has also announced its manned Mars colonization project for 2020. With human involved in future deep space explorations, the architecture of the deep space networks is facing some new challenges besides long delay/disruption, dynamic topology, and resource constraints, etc.

1)Scalability

For 2020 window alone, there have been 7 planned missions with 13 nodes for Mars exploration, which will triple the current number of nodes on Mars. Considering manned explorations in 2030 and 2045, the number of the nodes and crews for Mars and other planets will grow much larger and huge volume of data would be generated in various missions, while the capacity of the communication links in deep space is still very limited (hopefully several hundred Mbps for trunk links). Network architectures should be scalable to content access with efficiency.

2)New Infrastructure

In current robotic remote sensing explorations, all the data would be transmitted back in the traditional earth-centered bent-pipe deep space networks (DSN). Considering crews on other planets, a distributed network infrastructure with extraterrestrial mission control center and data center is necessary.

3)New Services for Manned Exploration

New services, such as multimedia communications, web services, information on demand, in place teleoperations, etc., must be provided to support manned or human-machine hybrid explorations.

Basically, various communication services, including M2M, M2H and H2H, should be supported by a distributed network in deep space, which to some extent resembles the Internet of Things (IoT) on the earth.

D. *ICN Architecture for DSI*

For future DSI, we propose to follow the ICN architecture currently under discussion at the Information-Centric Networking Research Group (ICNRG) in IRTF, which will be unified with two similar ICN proposals, i.e. Content Centric Networking (CCN) and Named Data Networking (NDN).

CCN/NDN have both been proposed and studied for more than a decade. There have been practical applications over CCN/NDN for Internet and 5G applications which are useful for future human exploration, such as video streaming [11]. More importantly, the feasibility of CCN has also been verified for IoT [12] recently. Most of the challenges in IoT are similar to those in deep space explorations, such as constrained hardware and computation resources, limited power supply, mobility, hop-by-hop link situation, push and pull type communications, interoperability and heterogeneity. It will be beneficial and economical for the development and the maintenance if the network architecture of future deep space explorations could be unified by ICN for IoT on earth.

A possible architecture of ICN for DSI is shown in Fig. 2. Content store (CS), pending interest table (PIT) and forwarding information base (FIB) are three major components in ICN forwarding engine on a ICN node [13]. The difference between ICN for DSI and ICN for IoT is mainly in that, for stack simplicity, ICN for IoT is designed as clean-slate which works directly on medium access layer [12], while ICN for DSI works in overlay mode over a convergence layer adapter (CLA) to accommodate heterogeneity. With dedicated CLA, ICN can work on Bundle Protocol (BP) or directly on Licklider Transmission Protocol (LTP).

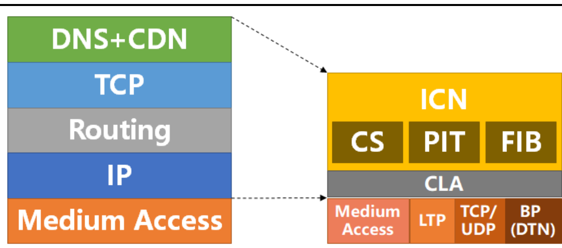

Fig. 2 CCN architecture for DSI and its comparison to TCP/IP stack

E. Some Open Issues

1)Caching Management

Caching management is a topic under research even in terrestrial ICN. For DSI, caching not only provide content replication for delivery efficiency but also provide the tolerance to delay and disruption, which makes the caching strategy more complicated for limited onboard storage.

2)Routing

DTN's contact graph routing algorithm employs global predictive contact information for efficient and optimum routing, while current practice in ICN utilizes the information recorded in FIB. It is still a problem how to take advantage of predictive contact information in name-based routing.

3)Delivery Efficiency

In current ICN, there is no efficient transmission mechanisms for deep space environment. An easy solution is to run ICN over LTP. It would also be interesting to combine ICN with Forward Error Correction (FEC) coding to improve its transmission efficiency.

CONCLUSIONS

In this article, we propose ICN as a candidate network architecture for future DSI. ICN not only provides networking advantages such as better support for scalability, mobility, security, data availability, tolerance of delay/disruption and human-machine interoperability, with a unified architecture as IoT on the earth, it will also be beneficial and economical for the development and the maintenance of future deep space applications. Despite the advantages, there are still challenges and open issues in ICN for future DSI, for which further evaluation and study are necessary.

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