SATELLITE AND SPACE COMMUNICATIONS **SSC**

http://www.comsoc.org/socstr/org/operation/techcom/ssc/index.html

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SSC Newsletter **Vol. 19, No. 2, Nov. – Dec. 2009**

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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: Tower Kailia, Room Hibiscus 1&2

Date: Tue, December 1st, 2009

Time: 17:00 - 19:00

Future SSC Meetings

May 2010, Capetown, South Africa
Dec. 2010, Miami, FL, U.S.A.
June 2011, Kyoto, Japan

GC2009 SSC Committee Activities

Symposium on Selected Areas in Communications:

SAC(SSC)-01: Transmission and coding techniques for satellite and space communications
Chair: Giovanni Corazza (University of Bologna, Italy)
Tuesday, 1 December 2009
10:15 - 12:15
Location: Kahili 2

SAC(SSC)-02: Technologies for next-generation satellite and space networking
Chair: Tarik Taleb (NEC, Germany)
Tuesday, 1 December 2009
14:00 - 16:00
Location: Kahili 2

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 http://lists.scnl.dist.unige.it/listinfo/ssc.

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MESSAGE FROM THE CHAIR

Prof. Takaya Yamazato

Welcome to the nineteenth issue of the Satellite and Space Communications newsletter. The goal of the Satellite and Space Communication (SSC) Technical Committee (TC) is to develop, organize and distribute technical information in the area of the satellite and space communications. The engineers and professionals from universities, government and research originations throughout the Globe participate as members and officers of this committee. At the moment, we have about 220 members and the number is growing with respect to previous years. All conference attendees are welcome to attend and those who are attending the SSC TC meeting for the first time will automatically become a member of the TC. Please join us to discuss mutual topics of interest in this important field in communications technology. The meeting agenda and other information about SSC TC activities and operation can be found at the TC web site (http://www.comsoc.org/socstr/techcom/ssc/).

I would like to thank our Vice Chair, Dr. Tarik Taleb, and our Secretary, Dr. Igor Bisio, for editing the SSC newsletter. I would like to thank again to Dr. Igor for SSC web page and membership information updates, and the meeting material preparation.

Concerning the technical activities, our member Dr. Claudio Sacchi, who is Track Chair of Satellite and Space Communications, Symposium on Selected Areas in Communications, Globecom2009, has successfully organized the sessions “SAC(SSC)-01: Transmission and Coding Techniques for Satellite and Space Communications” and “SAC(SSC)-02: Technologies for Next-Generation Satellite and Space Networking.” SSC Vice Chair Dr. Tarik Taleb is serving as Symposium Co-Chair of Selected Areas in Communications Symposium of ICC2010 (23-27 May 2010, Cape town, South Africa). SSC Secretary Dr. Igor Bisio is serving as Symposium Co-Chair of Selected Areas in Communications Symposium of Globecom2010 (5-10 Dec. 2010, Miami, Florida, USA). I will be a TC representative for ICC2011 (5 -

9 June 2011, Kyoto, Japan) and TC representative for Globecom2011 will be decided at the meeting held during Globecom2009.

SSC has technically endorsed many conferences not only to promote satellite and space communication research but also to recruit new members. Please see the following pages or our web site for details.

The committee has also been actively promoting satellite communications systems and technology via professional journals, transactions, and magazine publications. Members Dr. Riccardo De Gaudenzi, Dr. Hung Henry Nguyen and Dr. Fotini-Niovi Pavlidou together with SSC Secretary Dr. Igor Bisio and I will sponsor JCN special issue on "Recent Advances in Satellite and Space Communications," expected to publish in December 2010.

To promote research and development activities in the area of satellite communications within the industry and academia research community, the committee establishes "Satellite Communications Distinguished Service Award." The award is established as part of the SSC activities in involvement in the new and revolutionary developments taking place in the field. The award also aims to motivate the increase in number of research and publications in the field as well as number of researchers in this field and the TC membership. This year, the selection committee consisting of SSC TC officers (Chair, Vice-Chair, Secretary) has decided to give this award to Professor Giovanni E. Corazza. Please join us to congratulate the winner. For more information about eligibility criteria and how to apply for this award, please visit the SSC TC web.

The field of satellite communications continues to grow rapidly and remains interesting and exciting. I encourage all who are interested in this field to join our committee. Visit our web site (http://www.comsoc.org/socstr/techcom/ssc/) where you can get information on events and upcoming meetings, and interact with committee officers and members.

Prof. Takaya Yamazato, Chair
Satellite and Space Communications
Technical Committee

SCANNING THE WORLD

Dr. Tarik Taleb

In May 2009, Eutelsat launched its satellite-based residential Internet service, called Tooway, which provides bi-directional broadband Internet to home, particularly to areas that are poorly covered by terrestrial communications technology. With a Tooway satellite dish and a modem, users are capable to receive data at up to 2Mbps. Plans to increase the rate to 10Mbps are there. The service is currently provided to entire UK but the used satellite is able to cover the whole Europe, from Turkey in the East to Ireland in the West. More information about the service can be found at the official website of the company http://www.eutelsat.com/.

Dr. Tarik Taleb, Vice Chair
Satellite and Space Communications
Technical Committee

FORTHCOMING GLOBECOM AND ICC CONFERENCES

COSPONSORING / RELATED CONFERENCES AND WORKSHOPS

ICC 2010
May 23-27, 2010, Capetown, South Africa.
http://www.comsoc.org/confs/icc/2010/index.html
The IEEE Communications Society will, in 2010 being holding its flagship International Communications Conference (ICC) in Cape Town, South Africa. This will be the first time that ICC has been held in Africa and with Cape Town being voted one of the most beautiful cities in the World, this promises to be an exceptional conference.
Conference participants will have a wide range of exciting options to add to their conference tour: hikes up the famous Table Mountain; whale watching; tours of the Cape Winelands, Robben Island and even CapePoint where two oceans meet. The FIFA World Cup Soccer tournament, held all around South Africa starts just after the conference ends.

MILCOM 2010
October 31-November 03, 2010, San Jose, CA, USA
http://www.milcom.org/
The theme for the MILCOM 2010 conference is "Next Decade of Military Communications". MILCOM is the premier international conference for military communications and attracts a very impressive array of participants with high-level attendance from government, military, industry and academia. MILCOM 2010 gives industry the opportunity to promote communications to all branches of the armed forces, Department of Defense, federal government, and the heads of multi-national forces from around the globe.

In 2010, MILCOM will take place at the San Jose Convention Center in San Jose, California. It's been said that San Jose feels like a "campus." This sensation may be influenced by the proximity of the hotels, restaurants, and attractions including museums and performing arts venues. All are within walking area, and our conference hotel, the Fairmont is practically next door.
The conference is being hosted by Lockheed Martin Corporation and The Aerospace Corporation.

GLOBECOM 2010
December 6-10, 2010, Miami, FL, USA
http://www.ieee-globecom.org/confs/2010
The Premier Telecommunications Event for Industry Professionals and Academics from Companies, Governmental Agencies, and Universities around the World
Themed "MIAMI: Moving Into the Age of Mobile Interactivity," IEEE GLOBECOM 2010 covers the entire range of communications technologies, offering in-depth information on the latest developments in voice, data, image, and multimedia.

CONFERENCES CALENDAR

CONFERENCE	DATE & LOCATION	INFORMATION
SPECTS 2010 International Symposium on Performance Evaluation of Computer and Telecommunication Systems	July 11-14, 2010, Ottawa, Canada	http://atc.udg.edu/SPECTS2010/
SPACOMM 2010 The Second International Conference on Advances in Satellite and Space Communications	June 13-19, 2010, Athens, Greece	http://www.iaria.org/conferences2010/SPACOMM10.html
Ka and Broadband Communications Conference	To be defined	http://www.kaconf.org/
WCNC 2010 IEEE Wireless Communications & Networking Conference	April 18-21, 2010 Sydney, Australia	http://www.ieee-wcnc.org/
PSATS 2010 2nd International Conference on Personal Satellite Services	Feb 4-6, 2010 Rome, Italy	http://www.psats.eu/
WCSP 2010 International Conference on Wireless Communications and Signal Processing	November 13-15, 2009 Nanjing, China	www.ic-wcsp.org
Array 2010 IEEE International Symposium on Phased Array Systems & Technology	October 12-15, 2010 Boston, MA, USA	www.array2010.org
ICT 2010 17th International Conference on Telecommunications	April 4-7, 2010 Doha, Qatar	www.qu.edu.qa/ict2010
ICSOS 2011 International Conference on Space Optical Systems and Applications	May 2011 Los Angeles, CA, USA	Web Site not yet available

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://www.comsoc.org/~ssc/.

Delay- and Disruption-Tolerant Networking for Satellite and Space Communications

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***Abstract*—Delay- and Disruption-Tolerant Networking (DTN) is a field of networking research that have grown out of efforts, starting about a decade ago, to define an Interplanetary Internet. In this article, we give a very brief overview of DTN, consider how the technology might be of use not just in deep space networking, but also in Earth orbiting satellites. We also list areas where further research is required in order to make DTN really useful in such networks.**

***Index Terms*—DTN, CCSDS, Satellite networking, space communications.**

I. INTRODUCTION

Delay- and Disruption-Tolerant Networking (DTN) [1] began life as a space communications architecture for an Interplanetary Internet

Today, most open research on DTN is coordinated via the Internet Research Task Force's DTN Research Group. [2] In Europe, the FP7 N4C project [3] is a major current DTN activity, e.g. N4C currently maintains the most commonly-used open-source DTN stack: DTN2. In the USA, DARPA have funded two major DTN programmes since 2003, investing something of the order of US$20M [4]. In the broader networking research community, DTN has been the subject of two Dagstuhl workshops [5] and special issues of the IEEE Journal on Selected Areas in Communications, [6] and Elsevier Computer Communications. [7] The former special issue contained an "architectural retrospective" [8] paper describing how the DTN architecture has evolved since over the last decade.

Aside from space communications other application areas where DTN has been considered include military tactical networking, [9] sparse sensor-networks, [10] and as a core technology for communications challenged communities. [3] Routing in DTNs has been the subject of many studies [11,12,13] and there have also been a number of assessments of DTN for satellite communications. [14,15]

The "bundle protocol" (BP) [16] today forms the basis for many DTN experiments and deployments. Since there are various open-source implementations of the BP available on a wide range of platforms, it provides the basis for quickly and efficiently planning and starting networking experiments. There are also a number of extensions to the BP, addressing for example, in-line security mechanisms [17] and addressing ways to manage meta-data [18] in the BP. Using the BP also allows researchers and developers to quickly design and carry out experiments where diverse sets of nodes can interoperate and, in principle, be connected to one another – in fact, there is already a so-called "dtnbone" which is a network of DTN nodes deployed on the Internet to which experiments can be connected. [19]

The BP is an overlay protocol that can run over heterogeneous lower layers (termed "convergence layers" in DTN parlance), and provides end-to-end reliability via its co-called "custody" feature, where an intermediate DTN node can take responsibility for any re-transmissions required. And with the BP, all of this is designed to work in the face of either link disruptions or very high latencies. In the BP, so-called "bundles" contain both the application layer payload and may any required meta-data (e.g. for routing) and standard header fields can be used for various features considered useful in DTNs, e.g., delivery reporting, or custody signaling.

Sources and destinations in the BP each have endpoint identifiers (EIDs) which are syntactically URIs. There is a "dtn:" URI scheme registered for use with the BP, though to date most deployments have invented their own ways of using this scheme, work is now under way in the DTNRG to get broader agreement on name forms for DTN nodes.

There are a number of open- and closed-source implementations of the BP, with the main "reference" implementation being DTN2 and the main space-related implementation being ION, originally developed by NASA JPL and now maintained by the University of Ohio.

In addition to the BP, the DTNRG have also developed a delay-tolerant point-to-point protocol for use on high-delay links as might be found in deep-space communications. This is called the Licklider Transmission Protocol (LTP) [20] and provides reliability on high-delay links but without the need for initial round-trips, such as is required with more common transport protocols. ION includes an LTP implementation and there is also another implementation available from TCD that is planned to be integrated into the DTN2 reference implementation.

Links to all of the implementations mentioned above may be found from the DTNRG web site. [2] Finally, as DTNRG is an open research group, interested researchers can, and are encouraged to, subscribe to the mailing list and take part.

DTN protocols are currently under consideration as standards for future space missions, [21], which has a DTN working group currently examining whether the BP and LTP can meet the mission requirements of the space agencies that contribute to the work of CCSDS.

II. DTN in Deep-Space Communications

DTN was originally designed for deep space communications, where the "poster-child" DTN network involves the ground segment, Mars orbiters and Mars landers with DTN protocols offering the ability to routinely use the orbiters as relays for the landers. In this case, the BP is envisaged to be used end-to-end, with LTP being used for the Earth-Mars long-haul links.

DTN protocols have already been flown in space experiments, with the current distance-record (and first involving a "full" DTN stack) being the DINET experiment conducted by JPL on board the EPOXI or Deep Impact spacecraft. [22] In that experiment, bundles were sent from JPL over 25 million km to the spacecraft and then returned to JPL in an emulation of the type of Mars network mentioned above. The results were positive, with the DTN stack demonstrating dynamic routing and successfully handling a number of disrupted contacts with the spacecraft. As a result of DINET, the implementation used (essentially ION), is now claimed to be at technology readiness level 8 (TRL8). DINET is part of a broader NASA program that has the goal of ensuring that DTN protocols are ready for use in real missions by the end of 2011.

ESA are also addressing the use of DTN in space missions, for example with ongoing studies into the use of DTN in the ground segment in support of planned science missions. [23] For this study, a prototype is being built which will emulate the ESA space and ground segments for specific planned missions (or generalizations thereof) and the BP and LTP will be tested against other CCSDS protocol suites (e.g., CFDP) [24] to determine how each might perform for the missions of interest.

The vision for the use of DTN in deep-space missions is clear, the technology has clearly been designed for this use-case, and there is ongoing work to make the use of DTN in such space-missions a reality, so one would expect that future deep-space missions with any relaying requirements are quite likely to actually use DTN protocols. The main issues that remain to be addressed in this context are probably more organizational rather than technical networking issues, for example, the use of networking for deep-space missions involves an inherent conflict with the primacy of the science mission – with networking, one has to accept that sometimes, packets (or bundles) will be dropped in order to make the overall network more efficient, and demonstrating to science and mission operations that this is worthwhile remains a challenge, though one that experiments like DINET, and follow-on experiments with the EPOXI spacecraft, are aiming to address.

III.DTN for Satellites

In contrast to the use of DTN in deep-space networks, there has been less work on the use of this technology for Earth orbiting satellites, whether in LEO or GEO, and it is certainly the case that DTN is further from the mainstream for such networks. However, Caini et al. [15] have done compared the use of DTN protocols against those more typically used in satellite networking and found that the DTN protocols compare reasonably well in terms of end-to-end performance to even the best current approaches to satellite networking, but that the DTN protocols are, as one would expect, much better at dealing with link disruptions when compared to the other approaches studied (TCP-Hybla or PEPs).

In what was the first example of the use of DTN protocols in space, an experiment was performed in which the UK-DMC satellite used a partial implementation of the BP (on the space segment) to send very large files (modeling large images) back to the ground over multiple passes. [25] In the tests performed, a single file would require at least 3 passes to be transferred back to the ground, and the fact that the BP supports fragmentation across multiple contacts enabled the transfer to succeed while still treating the file as a single unit at the application layer. In fact, in the tests performed, reassembly of fragments took place at the final destination of the bundle fragments, which was an additional "DTN-hop" from the ground station. The ground segment DTN-hops in this case used the DTN2 reference implementation demonstrating the benefits for experimenters in using protocols defined in Internet RFCs such as the BP (and of course the benefits of the existence of open-source implementations of those protocols).

The two examples already given of the use of DTN in satellite networking only made use of the BP, since TCP (or TCP-variants like TCP-Hybla) can work as a convergence layer for the BP in such cases. However, a study by Osterman and Ramadas [26] indicates that LTP might outperform TCP once a light-trip time (LTT) of more than about 50-100ms is involved. Given that the delays inherent in Geostationary satellites are of the order of 120ms LTT (and typically about 500ms RTT due to queuing and other delays), there may be a case to be made for using LTP for such links. Having said, that there has not, to the authors knowledge, been any serious consideration given to the use of LTP for Earth-orbiting satellites. However, one of the strengths of DTN is that the BP allows for the use of different convergence layers on different links, and in fact in the UK-DMC case cited above, a file transfer protocol called Saratoga [27] was used as the convergence layer between the satellite and the ground. There is therefore plenty of scope for research into the development of convergence layer protocols tailored for use in DTNs for both GEO and LEO satellites.

Finally, NASA have recently carried out some DTN experiments on the International Space Station (ISS). [28] The ISS's first DTN node is a BioServe Space Technologies combined computer/Commercial Generic Bioprocessing Apparatus package, which returns images of crystals formed by metal salts in free-fall to ground controllers. According to the principal investigator this has has "already speeded up the transfer of data back to Earth by about four times". [29]

Perhaps the biggest challenge to the use of DTN in satellite communications is the same as in other terrestrial applications of DTN: deployment. Compared to the use of split-TCP or similar approaches, DTN protocols require the endpoints to run a "special" DTN stack, and such stacks are not usually present on the end-systems concerned. As in other contexts, this can be addressed to an extent via the use of application layer gateways or proxies, (such as has been done for web and email for use by nomadic people in the arctic in the N4C project [3]), or eventually, through the adoption of the currently experimental DTN protocols as full Internet standards. (IRTF research groups generally only produce experimental, and not standards-track protocol specifications.) Initial discussions within the DTNRG have indicated that there may be sufficient interest in doing this that, in future, DTN stacks may be sufficiently standard to make use of in satellite communications. Alternatively, the DTN standardization work within CCSDS may also enable satellite standards development organizations to adopt the BP and/or LTP for use in Earth orbiting satellite networks.

IV. Conclusions

In conclusion, DTN is a maturing technology with clear applicability to both terrestrial challenged networks and deep-space networking, that is being developed in an open forum with open-source code already available, along with a supporting community, that allows investigators to quickly setup and carry out sophisticated networking experiments. Assuming that the BP and LTP are standardized by CCSDS, then a number of high-TRL commercial implementations can be expected to be developed, leading to the use of these protocols in other environments such as networking for Earth orbiting satellites. However, further research and experiments, in particular related to tailored convergence layers would probably required before DTN could be considered "mainstream" for satellite networks.

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