SPICE
SPACE INTERNETWORKING CENTER

SPICE update

A tri-annual newsletter

May 2012

Volume 3 Issue 1

SPICE Project Coordinator

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In this issue

CAPACITIES

Funded by the European Union Seventh Framework Programme [FP7/2007-2013] under grant agreement no 264226 [Project Title: Space Internetworking Center – SPICE]. The project is approved as a "Coordination and Support Action" under the "Research Potential" scheme (Grant Agreement Number 264226).

SPICE progress per Work Package

The project is conducted in four separate work packages.

Work Package 1:

Project Management

As part of the project management procedures, a Steering Committee meeting took place during the first days of March. During this meeting, members of the Steering Committee discussed on the progress of SPICE project so far and defined a plan for future actions.

Work Package 2:

Exchange of know-how and recruitment of researchers and administrative staff

During the past months, Dr Eli Katsiri joined the research team of Space Internetworking Center, while on late April Dr Artemios Voyiagis joined SPICE as a visiting researcher for the time period of one month.

On March 26th 2012, a lecture from distinguished researcher Ioannis Paschos was given at the premises of SPICE. Being a digital evidence examiner and having gained experience at several laboratories, Mr Paschos gave an insight on satellite cardsharing forensics.

Moreover a regular colloquium was organized among researchers at SPICE, focusing on diverse research topics. For details see:

http://www.spice-center.org/distinguished-speaker-series/

Work Package 3:

Infrastructure update and state-of-the-art DTN testbed

The main activity of SPICE researchers within WP3 was to incorporate the newly purchased equipment within the existing DTN testbed, developing new mechanisms and convergence layer

Moreover, Bundle Streaming Service (BSS), a joint effort of SPICE and NASA was released as a part of the ION v3.0 software. Bundle Streaming Service (BSS) is a framework, specifically designed for Delay Tolerant Networks, that supports the delivery of streaming media in DTN bundles, allowing for reliable delay-tolerant streaming while improving the reception and storage of data streams. For more details on BSS refer to:

www.spice-center.org/bss/

Work Package 4:

Exploitation and dissemination

This Work Package (WP4) includes all dissemination activities of the project. In this context, we have:

- published research papers in a variety of conferences and journals
- presented our research achievements so far and actively participated in the definition of future space communication standards during Spring 2012 CCSDS meeting, which was held between 16 and 20 April 2012 in Darmstadt, Germany
- planned a "Disruption- and Delay- Tolerant Networks (DTNs)" workshop in parallel to the 10th International Conference on Wired/Wireless Internet Communications, which will be held on the 7th and 8th of June 2012, on the island of Santorini, Greece. The workshop consists of:
  - a keynote speech by Prof. Jorg Ott
  - a panel discussion on Delay- and Disruption-Tolerant Networks (DTNs): Challenges, Limitations and Application Scenarios
  - a session on DTN scenarios, applications and protocols and
  - a session on Delay-Tolerant and opportunistic networks.

The majority of the events will also be broadcasted live over the Internet.

More information on the schedule of the workshop can be found here:

http://www.spice-center.org/dtns-workshop/

Dr Eli Katsiri
New researcher at SPICE

Dr. Eli Katsiri is Scientific Collaborator at the Institute for Management Information Systems at Research and Innovation Centre in Information, Communication and Knowledge Technologies, "ATHENA" specializing on middleware for ubiquitous computing systems and sensor networks. From October 2007 to October 2010 she was a lecturer in Computer Science at the Department of Computer Science and Information Systems, at Birkbeck College, University of London, where she supervised several MSc and BSc students including one PhD student. From 2005 to 2007 she worked as a postdoctoral researcher at Imperial College London in distributed Software Engineering. Eli has a PhD from Cambridge University's Engineering Department (2005) and she has done research in Cambridge University's Computer Laboratory working on Pervasive Computing (2000-2004). Eli has an MEng in Computer Engineering and Informatics from the University of Patras, Greece (1998). From 1998 to 2000 she worked as a systems analyst in Procter&Gamble, in Belgium. She has also worked as a programmer for Velti dR Ltd in London and Cetrus Inc in CA, USA, as well as a consultant in e-Government for the Hellenic Deputy Minister of Education, Religious Affairs and Lifelong Learning, Prof I Panaretos. Her research is broadly concerned with programming abstractions and models for real-time, efficient management of sensor data.

Selected publications

Journals

- E. Katsiri and S. Helmer. Energy-efficient routing in sensor networks: Directed Nearest Neighbour Trees. Submitted to Information Systems.
- E. Katsiri. Policy-based management for Implantable Body Sensor Networks. Submitted to Pervasive and Mobile Computing.

Conferences

- E. Katsiri. Cirrus: A Delay-Tolerant Cloud. In Proceedings of the 10th International Conference on Wired/Wireless Internet Communications (WWIC2012), Santorini, Greece, June, 2012

Bundle Streaming Service (BSS)

by Sotirios-Angelos Lenas

After several years of systematic research in various aspects of Delay/Disruptive Tolerant Networking (DTN) such as routing, transport protocols and convergence layers, DTN technology has reached a higher level of maturity. The development of a reliable set of working solutions and associated standards under the auspices of the Consultative Committee for Space Data Systems (CCSDS) and the Internet Research Task Force's DTN research group (DTNRG) has boosted the applicability of DTN architectures, which now present themselves as prominent solutions for global internetworking. Based on that progress, several studies promote the benefits of DTN architectures and highly suggest their use in disruptive environments through the Bundle protocol, which encodes most functionalities that an overlay network requires.

Our work deals with a relevant topic that has not yet seen much progress, despite its potential applicability: *data streaming over DTNs*. Data (and especially live) streaming in delay/disruptive tolerant environments becomes a particularly challenging task since the presence of high delays, frequent disruptions and variable bandwidth acts inevitably against the basic application principles of data streaming that call for mechanisms that guarantee smooth viewing experience of end-users.

In this context, we propose the **Bundle Streaming Service (BSS)** as a practical approach that addresses most of the networking challenges related to streaming over DTNs. BSS is a framework that enables "streaming" data to be conveyed via DTN "bundles" in a manner that supports in-order stream processing with minimal latency while still ensuring reliable delivery of all data to enable ad-hoc "playback" review of recently received information. Potential examples of real-time applications that could exploit the capabilities provided by this framework are one-way voice, video or continuous telemetry streaming.

The key concept behind BSS is to employ in the forwarding process of each DTN node both a best effort along with a reliable transfer protocol, in order to achieve minimal latency but also ensure reliable delivery of the whole stream. An additional advantage of our approach is that it does not confine future deployments of other sophisticated mechanisms on top of BSS, but instead, it grafts flexibility that further enhances synergistic application mechanisms.

BSS consists of two basic components: a *forwarder daemon* and a *library* for building streaming-oriented applications. Figure 1 depicts the architecture of BSS.

BSS framework was developed as an extra module in JPL's Interplanetary Overlay Network (ION) software

Bundle Streaming Service (BSS)

by Sotirios-Angelos Lenas

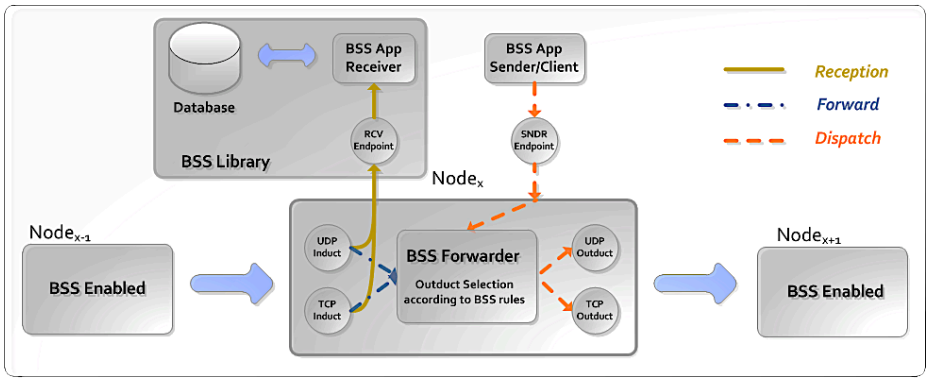

Figure 1.
BSS architecture

distribution that implements the DTN architecture. Following implementation, we conducted a preliminary experimental evaluation which aimed to establish the baseline performance characteristics of BSS over a simple streaming session under various network conditions, including variable propagation delays (PD) and high packet error rates (PER). The time needed for the complete reception of a stream consisting of 5000 frames was evaluated by using two basic sets of transport protocols in combination with BSS in order to evaluate its performance under terrestrial and Space environments.

The results obtained so far (Figure 2) show that the suggested framework has the potential to improve stream reception in both terrestrial and Space environments, since it manages to reduce the total requested time of receiving 5000 frames by almost 80% in the worst case, when terrestrial protocols are in use while, in Space environments, where LTP "red" transmission is used in place of TCP, BSS achieves better results in cases where the error rate of the channel is above 10%.

As future work, we plan to extend this preliminary evaluation by conducting more tests and employing several other metrics, such as out-of-order delivered packet ratio, packet loss ratio, frame loss ratio and peak signal-to-noise ratio, in order to accurately assess the efficacy of BSS and evaluate the impact of frame size, hop count and mobility on its performance.

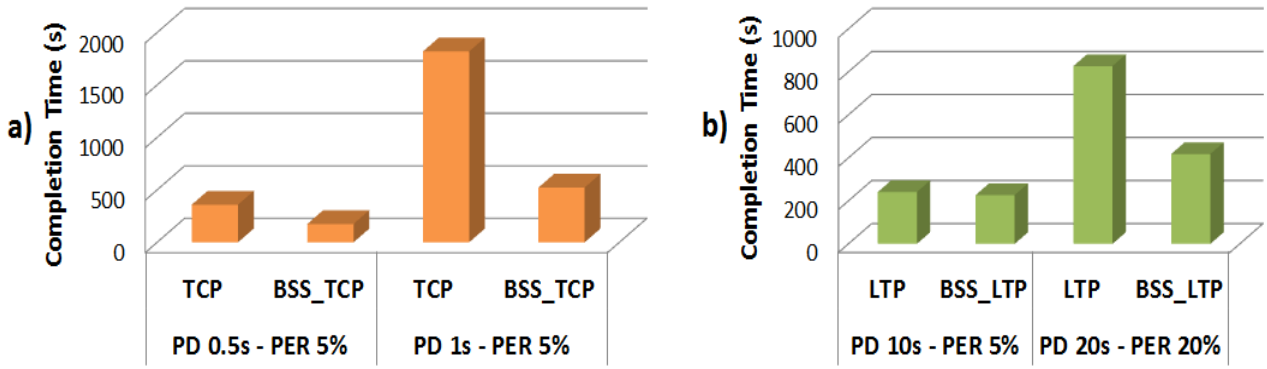

Figure 2. Completion Time for increasing Propagation Delays and PER using (a) TCP and (b) LTP as convergence layer protocols

On the performance of Erasure Coding over Space DTNs

by Giorgos Papastergiou

Space communication channels are characterized by significant shadowing and fading events, which strongly reduce signal-to-noise ratio and thus introduce bit errors within link frames. In addition, adverse weather conditions can cause long fading events or even link disconnections. In such cases, typical data-link recovery fails, resulting in bursty frame losses, occasionally in the order of tens to thousands of lost frames. Link layer failures are reflected on the upper protocol layers as packet erasures, i.e., missing packets that need to be retransmitted; however, long propagation delays and disruptions render Automatic Repeat reQuest (ARQ) solutions inefficient, since retransmission latency degrades network performance and extends communication (and thus data delivery) time significantly.

Delay Tolerant Networking (DTN) incorporates two significant reliability enhancements, that is, *custody transfer* and *storage capability*; their combined impact allows for retransmissions with reduced delay, since the source shifts data and responsibility gradually to intermediate nodes, towards the destination. Hence, lost data will be retransmitted faster, from nodes closer to destination. Inherently, therefore, DTN appears as a natural solution to improve reliability in space. However, shifting data custody towards the destination and thus gradually reducing retransmission delay is not sufficient solution in its own right.

Erasure coding has attracted the attention of space research community due to its potential to present an alternative or complementary solution to ARQ schemes, employing Forward Error Correction (FEC) strategies at higher layers with a clear-cut goal to reduce the number of retransmission rounds. Typically, erasure coding can enhance reliability and decrease delivery latency when long delays render ARQ-based solutions inefficient. Erasure coding imposes by definition a tradeoff between efficient bandwidth exploitation and faster delivery; however, the question "*when and to what extent does extra and redundant transmission effort translate into better application throughput*" has not yet been adequately addressed. This issue becomes vital in space, where a false strategy to exploit the tradeoff may cause minutes or hours of waiting. Given that erasure coding is a packet-level FEC technique, it can be incorporated within any protocol of the CCSDS DTN protocol stack that deals with data units (i.e., packets, frames, etc.).

In this context, we investigated mechanisms to explore erasure coding techniques in space communications without:

On the performance of Erasure Coding over Space DTNs

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(i) expending unnecessarily significant bandwidth for error correction overhead that cannot have return in application throughput and

(ii) over-investing in ARQ techniques when long delays dominate communication performance.

Hence, we focused on mechanisms and experiments that may promote our knowledge on how to dynamically administer the tradeoff between bandwidth and delay in space, with a minimal risk. Given the inherent advantage and significant standardization progress of DTN in space communications, we explored this tradeoff within the space DTN framework.

In order to explore the benefits of erasure coding for file transfers over space DNTs, a novel generic end-to-end transport protocol built on top of Bundle Protocol (i.e., placed architecturally between the application and the BP), was implemented and deployed into the DTN testbed, established in Space Internetworking Center. This experimental protocol incorporates erasure coding operating on a per-packet basis, based on block Low Density Parity Check (LDPC) codes, and also packet-oriented retransmission of encoding packets whenever decoding is unsuccessful. Our results revealed significant insights on the tradeoff among efficient bandwidth exploitation and delivery latency, and scenario-independent conclusions about when and to what extent erasure coding is beneficial in such environments were drawn. In particular, we quantified but also qualified the imposed tradeoffs in the context of:

(a) the optimal gain of erasure coding for file transferring

(b) the impact of over- / under-estimation of channel packet erasure rate (PER) on file delivery time and the associated waste of bandwidth resources

(c) the capability of an end-to-end "transport layer" erasure coding service to administer QoS in terms of delivery latency, by properly tuning the code rate

"We focus on mechanisms and experiments that may promote our knowledge on how to dynamically administer the tradeoff between bandwidth and delay in space, with a minimal risk.

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List of publications

- Giorgos Papastergiou, Christos V. Samaras and Vassilis Tsaoussidis, **"Where Does Transport Layer Fit into Space DTN Architecture?"**, 5th Advance Satellite Multimedia Systems Conference and 11th Signal Processing for Space Communications Workshop, ASMS-SPSC 2010, 13-15 September 2010, Cagliari, Italy

- Nikolaos Bezirgiannidis and Vassilis Tsaoussidis, **"Packet size and DTN transport service: Evaluation on a DTN Testbed"**, International Congress on Ultra Modern Telecommunications and Control Systems 2010, Moscow, October 2010

- Avi Arampatzis, Pavlos Efraimidis and George Drosatos, "**Enhancing Deniability against Query-Logs**", The 33rd European Conference on Infromation Retrieval, ECIR 2011, LNCS 6611, pp.117-128, Dublin, Ireland, 2011

- S. Lenas, S. Dimitriou, T. Tsapeli and V. Tsaoussidis, "**Queue-Management Architecture for Delay Tolerant Networking**", WWIC 2011, Vilanova i la Geltrú, Barcelona, Spain, on June 15-17, 2011

- D. Vardalis and V. Tsaoussidis, "**Energy-efficient Internetworking with DTN**", WWIC 2011, Vilanova i la Geltrú, Barcelona, Spain, on June 15-17, 2011

- E. Koutsogiannis, L. Mamatas and I. Psaras, **"Storage-enabled Access Points for Improved Mobile Performance: An evaluation study",** WWIC 2011, Vilanova i la Geltrú, Barcelona, Spain, on June 15-17, 2011

- T. Spyridopoulos and V. Katos, **"Towards a forensically ready cloud storage service"**, 6th International Annual Workshop on Digital Forensics and Incident Analysis (WDFIA 2011), London, UK, July 7-8 2011

- Remous-Aris Koutsiamanis, Pavlos S. Efraimidis, **"A heaviest hitters limiting mechanism with O(1) time complexity for sliding-window data streams"**, 2011 FTRA World Conference (FTRA WCC 2011), Jeju, Korea, December 12-15, 2011

- L. Mamatas, A. Papadopoulou and V. Tsaoussidis, **"Semi Markov modeling for User Mobility in Urban Areas"**, 2nd Stochastic Modeling Techniques and Data Analysis International Conference (SMTDA 2012), Chania, Greece, June 5-8, 2012

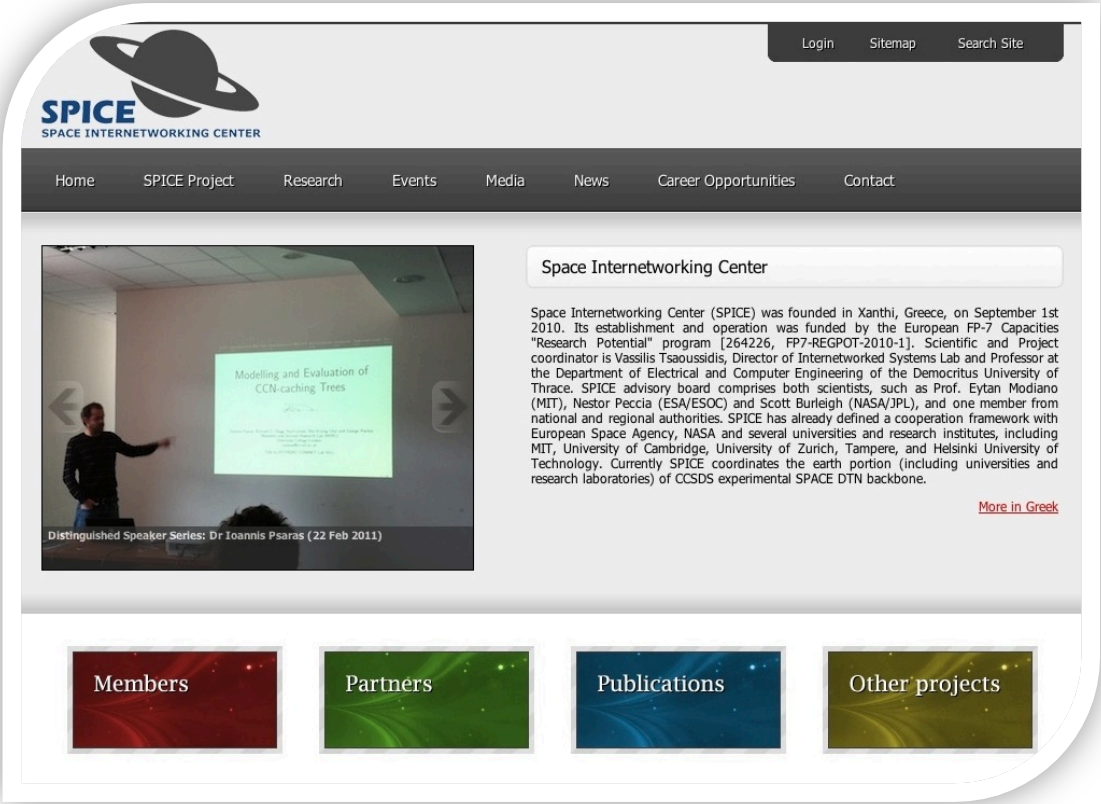
SPICE Newsletter and Website

Space Internetworking Center (SPICE) website can be found at:

www.spice-center.org

Here you will find:

- Previous issues of SPICE Update newsletter
- A comprehensive overview of the project, including details about partners and the various work packages
- Information on Space Internetworking Center, research interests and members
- Event information – a complete list of lectures, colloquia and relative events
- Publications



Upcoming Events

Journal of Internet Engineering (JIE)

Special Issue on "Future Network Architectures"

Panel discussion on DTNs:
Challenges, Limitations and Application Scenarios
Santorini, Greece

Workshop sessions on
1. DTN scenarios, applications and protocols
2. Delay-Tolerant and opportunistic networks
Santorini, Greece

Carlos Anastasiades, visiting researcher @ SPICE

University of Bern, Switzerland

Space Internetworking Center can host eight researchers for a time period of one month top. During that period incoming researchers will work together with researchers from SPICE on various networking topics.

Join us!

Space Internetworking Center

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SPICE UPDATE is published three times per year by the Space Internetworking Center to inform its members and friends of activities and new developments in the Center. For additional copies, call the SPICE office at 0030.25410.79.554

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SPICE update is edited and produced by Space Internetworking Center (SPICE), Greece. SPICE project is sponsored by the European Commission. SPICE UPDATE reflects only the authors' views and the European Union is not liable for any use that may be made of the information contained.