



SPICE update

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SPICE website

www.spice-center.org

→ SPICE Partners
→ SPICE Collaborators

Europe



USA

SPICE

progress per Work Package

The project is conducted in four separate work packages.

Work Package 2:

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

Dr Roman Dunaytsev has been hired as a new member of SPICE (senior researcher). Roman has long expertise in TCP performance evaluation.

In June 2011, SPICE staff member Sotirios-Angelos Lenas visited NASA's Jet Propulsion Laboratory (JPL) in Pasadena, CA, USA for 2,5 months. His visit was part of SPICE active collaboration with JPL on ION DTN implementation. ION is the most popular DTN implementation for

space communications. During his stay, Sotirios worked close with Scott Burleigh, main developer of ION platform, in incorporating a novel Bundle Streaming Service (BSS) within ION.

During the past months, three lectures from distinguished scientists were organised at the premises of SPICE. In particular,

- **Dr Ioannis Psaras** from Networks and Services Research Lab, University College London (UCL) presented part of his work on caching Network Named Content .

(NNC) as a new paradigm to realise Content Centric Networks (CCNs);

- **Ioannis Daglis**, director of the Institute for Space Applications and Remote Sensing provided an overview of space exploration for monitoring, forecasting and control, in the case of energetic charged particles;

- **Dr Darry Croke** from the Australian National University described in detail the development of a database of intensively monitored groundwater systems in Australia.





Apart from the Work Packages described in this section, Project Management is included as Work Package 1.

Moreover a colloquium among researchers at SPICE, focused on diverse research topics, was organised every week. 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 architecture of the DTN testbed. Several SPICE researchers worked on Satellite Toolkit Software, in order to provide kinematics scenarios as an input to the DTN testbed.

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 both Space

Internetworking Center and our research achievements so far to bodies, such as Massachusetts Institute of Technology (MIT) and National Aeronautics and Space Administration (NASA);

- participated in the DTN group of the spring CCSDS meeting 2011 held in Berlin, which is responsible for developing future standards for space communications;
- organised a session on Space Internetworking on June 16th-17th in Vilanova i la Geltru, Barcelona, Spain, in parallel to the 9th International Conference on Wired/Wireless Internet Communications (WWIC 2011). The session included two keynotes speeches from:

- o **Nestor Peccia (ESA)** and
- o **Scott Burleigh (NASA)**

and a panel between them on Space Internetworking. Prof. Tsoussidis was the moderator of the panel session. More information on the panel session are provided later on this issue;

- constantly updated SPICE website.

Roman Dunaytsev

New researcher at SPICE



Roman Dunaytsev received his M.Sc. and Cand.Sc. (licentiate) degrees from St. Petersburg State University of Telecommunications (Russia) in 1999 and 2005, respectively. From 1999 to 2003 he worked as an engineer in St. Petersburg R&D Institute of Telecommunications (LONIIS), where he was responsible for development of standards and other normative documents on local telecommunication networks. In 2003, he joined the Networks and Protocols Group at Tampere University of Technology, Finland, as a researcher and Ph.D. student under the supervision of Prof. Jarmo Harju. He received a Ph.D. degree in March 2010, with his Ph.D. thesis entitled "TCP Performance Evaluation over Wired and Wired-cum-Wireless Networks". From July 2010 until April 2011, he was a research fellow in the Advanced Networking Group, led by Prof. Yevgeni Koucheryavy, at Tampere University of Technology (Finland). His current research interests include space internetworking and delay-tolerant networking, P2P traffic management and optimization, TCP performance evaluation and modeling.

Selected publications

Journals

- R. Dunaytsev, D. Moltchanov, Y. Koucheryavy, J. Harju. "Modeling TCP SACK performance over wireless channels with completely reliable ARQ/FEC". Accepted for publication in the *International Journal of Communication Systems*
- D. Moltchanov, R. Dunaytsev. "Modeling TCP SACK performance over wireless channels with semi-reliable ARQ/FEC". *Wireless Networks*, volume 16, number 7, October 2010, pp. 1837-1863.

Conferences

- D. Moltchanov, R. Dunaytsev. "Modeling TCP performance over wireless channels with a semi-reliable data link layer". In Proc. of IEEE ICCS 2008, Guangzhou, China, November 2008, pp. 912-918.
- D. Moltchanov, R. Dunaytsev. "Modeling TCP performance over wireless channels using fixed-point approximation". In Proc. of ICT 2008, Saint Petersburg, Russia, June 2008.

Energy efficient internetworking with DTN

by Dimitrios Vardalis

As modern mobile devices are equipped with increasingly more powerful CPUs, larger memory capacities and faster wireless network adapters, their requirement for energy is also increasing. However, advances in battery technology have not been able to keep up with the increased energy demand, thus, calling for more efficient energy management. The wireless subsystem has been identified as a main contributor to the overall energy consumption of a mobile system, causing a great deal of effort to be invested in devising algorithms for energy conserving protocols. Most of these algorithms seek to buffer incoming traffic in order to allow the mobile host network card to switch to sleep mode for longer time intervals. However, we argue that DTN inherently provides the tools needed for shaping internetwork traffic at the base station, allowing mobile devices to balance their energy expenditure with minimal cost on throughput. More specifically, we have demonstrated the potential of DTN in mitigating energy consumption by exploiting two major DTN properties:

- i) retaining in-transit data on intermediate nodes for as long as it is necessary,
- ii) enhancing edge nodes with functionality to wait for sufficient amount of data to arrive, prior to forwarding it in bulk to the end node.

In order to test our hypothesis we developed scenarios and ran

extensive simulation experiments in ns-2, reflecting potential variations in traffic characteristics and error probabilities. The experiments revealed that energy expenditure can be reduced drastically and that DTN appears as an appropriate tool for constructing an overlay, requiring only minimal deployment on top of IP.

The DTN architecture leaves room for a number of future improvements on the original buffering algorithm. For example, a lightweight transport protocol could be used as the convergence layer for the wireless hop making better bandwidth use in the absence of IP layer congestion. Also, a passive bandwidth estimation mechanism at the base station can be of assistance both for congestion control as well as for central transmission scheduling at the DTN layer.

In conclusion, we have shown that DTN can provide the necessary framework for employing energy conservation mechanisms in a natural manner and within this framework we have set the foundations for designing a complete solution.

"DTN inherently provides the tools needed for shaping internetwork traffic at the base station, allowing mobile devices to balance their energy expenditure with minimal cost on throughput"

Bundle Layer End-to-End Retransmission Mechanism

by Efthymios Koutsogiannis

Delay Tolerant Networking (DTN) architecture is specifically designed to be operational under extreme delay/disruption conditions. Establishing an end-to-end path in such challenging environments may be impossible, therefore data delivery is achieved due to “store and forward” approach. Custody transfer is DTN’s reliability scheme and is based on reliable hop-by-hop communication and data storage until the final recipient in order to cover the whole path. However, hop-by-hop reliability cannot guarantee application reliability. The latter has attracted major attention from the internet community and has resulted in the well-known “end-to-end argument”, which claimed that end-to-end monitoring allows for more complete administrative approaches than the administration of intermediate hops.

The custody feature of DTN is rather restrictive in certain cases, since there is a single custodian node. For example, a bundle of data may be delivered with custody transfer to an intermediate node, which becomes isolated prior to forwarding it to another node. Especially in space, nodes may shut down unexpectedly in order to charge with solar panels, thus data will be unavailable. Given a single custodian per bundle, data transmission freezes in such cases, even when there are alternative routes from source to destination. In this context, scenarios focused on space communications evinced that the Bundle Protocol (BP) does not really provide end-to-end service. Furthermore, in order to enhance BP

by providing the missing end-to-end reliability, we proposed a new mechanism namely “Bundle Layer End-to-end Retransmission Mechanism” (BLER).

Focusing on NASA’s JPL DTN implementation for space, BLER extends ION’s implementation of BP to offer “guaranteed” transfer of critical data. It ensures that critical bundles will reach their final destination, provided that the initial sender is operational and a route to destination will finally be available. We have enhanced custody transfer’s point-to-point reliability by adding end-to-end functionality at the BP layer in order to allow the initial sender to monitor the transfer of critical data and detect failures.

We have evaluated the proposed mechanism for space communication scenarios and highlighted its efficiency in several cases where current DTN mechanisms fail. In addition, BLER mechanism can also be applied to terrestrial networks and allows for end-to-end reliability at BP layer. We plan to design a dynamically adjustable retransmission timer that will adapt in correspondence to network properties. This feature will allow for increased responsiveness and performance in general. We intend to further improve the mechanism using redundancy and load balancing techniques, in order to achieve higher reliability while minimizing delivery delay.

Session on Space Internetworking

Vilanova i la Geltrú, Barcelona, Spain, on June 15-17, 2011

Space Internetworking Center (SPICE) organised a session on Space Internetworking in parallel with the 9th International Conference on Wired/Wireless Internet Communications (WWIC) in Vilanova i la Geltrú, Barcelona, Spain on June 16-17, 2011. The session included two keynote presentations by invited speakers:

- **Mr Scott Burleigh**, senior researcher at Jet Propulsion Laboratory (NASA) and
- **Mr Nestor Peccia**, head of the Data Systems Infrastructure Division, Ground Engineering Department (ESA),

as well as a panel between them. Moderator of the panel session was Prof. Vassilis Tsaoussidis. The total duration of the session was four hours and approximately 50 researchers attended it.

The first keynote presentation by Mr Scott Burleigh took place on June 16, 2011 and its main goal was to familiarise audience with the emerging technology of DTN in space and terrestrial communications. The presentation was entitled "Tortoise and Hare: Ways of thinking about mission communication" and focused on different communication technologies for Space.

The next part of the session was the panel on future Space Internetworking.

At the beginning, Prof. Tsaoussidis presented the two invited speakers and made a short introduction on space internetworking, in order to highlight why space internetworking is needed. In the main part of the panel discussion, Prof. Tsaoussidis asked five questions on space internetworking and speakers were called to answer in the form of a debate. In particular, Mr Burleigh and Mr Peccia discussed on:

- (Why) Is DTN an appropriate technology for Space?
- How can DTN become a technology of choice for space?
- What are the issues to solve until DTN becomes a Space technology?
- What are the plans of each agency on Space Internetworking?
- Open issues (including funding opportunities)?

On June 17, 2011 the session on Space Internetworking was concluded with a keynote presentation from Mr Nestor Peccia entitled "ESA roadmap for a full DTN based Space Internetwork System". Since the audience had already been informed on DTN technology and the main space internetworking strategy of both ESA and NASA, the representative of ESA focused on ESA's plans to move from static to dynamic communication procedures.

- 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 Information 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



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

The screenshot shows the SPICE website homepage. At the top, there is a header with the SPICE logo and a navigation bar with links for Home, SPICE Project, Research, Events, Media, News, Career Opportunities, and Contact. Below the header, there is a large image of a man giving a presentation in front of a whiteboard. The whiteboard has the text "Modelling and Evaluation of CCN-caching Trees". To the right of the image, there is a box titled "Space Internetworking Center" containing text about the project's history and partners. At the bottom, there are four buttons labeled "Members", "Partners", "Publications", and "Other projects".

Upcoming Events

SPICE External Advisory Board meeting

Xanthi, Greece

Workshop on “Terrestrial and Space DTN”

Xanthi, Greece

Presentation at Aalto University

Helsinki, Finland

SPICE member as a visiting researcher at Aalto University

Helsinki, Finland

CCSDS Fall 2011 Meeting,

Colorado, USA

Presentation at Tampere University of Technology

Tampere, Finland

**New call for the recruitment of
senior researchers at SPICE**

Journal of Internet Engineering (JIE)

Special Issue on “Future Network Architectures”

Space Internetworking Center

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Prof. Vassilis Tsoussidis



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