SPICE update

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In this issue

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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

Within the framework of WP2, Prof. Vassilis Tsaoussidis and a SPICE Researcher, namely Nikos Bezirgiannidis, visited two collaborating European research institutes for a period of up to three months. In particular:

- **Prof. Tsaoussidis** completed the last two phases of his research visit to the Computer Lab of University of Cambridge, UK. In the second phase of the visit, collaboration focused on energy saving issues and potential application of DTN to the scientific area of smart energy grids. Moreover, Prof. Tsaoussidis prepared the outline of a potential joint proposal in the upcoming FP7 calls. At the third phase, the idea of providing Free Internet to all was shaped in the context of integration of terrestrial and satellite networks. A research proposal was prepared and submitted to the FP7 ICT call.

- On February 1st, 2013, SPICE researcher **Nikos Bezirgiannidis** visited European Space Agency's European Space Operations Centre (ESA/ESOC) in Darmstadt, Germany, for three months. Mr Bezirgiannidis worked on the METERON project and, in particular, he designed and implemented an Application Programming Interface to unify the Web Services

that were used as a communication means between network nodes, with the ION DTN software. After the implementation of the new interface, Bundle Protocol (BP), which is designed to overcome the limitations and challenges of space links (e.g. high error rates, disruptions, low and asymmetric data rates, etc.), provides an alternative communication option for METERON Web Services.

Moreover, two lectures from distinguished researchers were given at the premises of SPICE, as part of the Distinguished Speaker Series. In particular:

- Prof. Ferdinando Villa from the Basque Center for Climate Change gave a presentation on bridging scales and paradigms in natural system modeling, and
- Dr. Iphigenia Keramitsoglou from the National Observatory of Athens presented observations of the urban thermal environment from Space.

For details see:

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

Work Package 3:

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

Within the framework of WP3, SPICE researchers continued research on the integration of SIMSAT (*Simulation infrastructure for the Modeling of SATellites*) and the GSTV (*Ground Systems Test and Validation*) into the DTN testbed.

Work Package 4:

Exploitation and dissemination

This Work Package (WP4) includes all dissemination activities of the project. During these past months:

- SPICE researchers have published research papers in a variety of conferences and journals;
- SPICE staff member Fani Tsapeli presented part of SPICE work at the Computer Science Department of University of Birmingham;
- SPICE researcher Ioannis Komnios visited University of Cambridge in order to work on the novel research concept of providing Universal Internet Access.

Assisting Robotic Operations from ISS

Space Internetworking Center maintains a continuous communication with other projects and scientists within the related scientific areas. In this context, one of the most well-known and active Delay-Tolerant Networking (DTN) projects is **METERON (Multipurpose End-To-End Robotic Operations Network)**, with a consortium that includes ESA, NASA, ROSKOSMOS, ESOC, Vega Telespazio, CU-Boulder and BUSOC.

The overall goal of METERON is to set up a simulation environment to allow ground controllers in a Control Centre or astronauts on ISS to be able to simulate robotic exploration scenarios tele-operating a robot located on the ground through the ISS environment. European Space Operations Centre (ESOC), the main mission control centre for the European Space Agency (ESA), is the partner responsible for the development of the applications and services for the METERON project. ESOC, however, lacks expertise in the development and use of DTN platforms, an area in which SPICE has long-term experience and significant contribution. Therefore, ESOC and SPICE initiated a collaboration agreement; to this end, SPICE researcher Mr. Bezirgiannidis, an engineer with long-term experience in ION-DTN platform, visited ESOC during the period of February-April 2013 and cooperated with the METERON project team.

The main target of this cooperation was the design and implementation of an Application Programming Interface, namely JDTN API, to interface the METERON Services with the ION DTN implementation. JDTN API receives input messages from the METERON Web Services, creates bundles (Protocol Data Units of the Bundle Protocol), and transfers them over Bundle Protocol to the destination node. At the receiver site, JDTN is responsible to deliver the message to the corresponding Web Service. In case the Web Service needs to send a response to the message creator, a similar transmission will be created from the receiver to the initial sender.

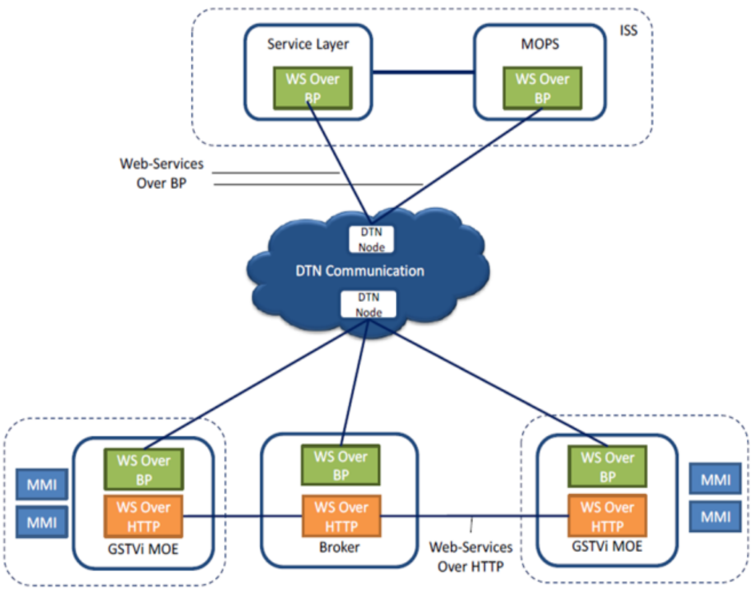


Fig. 1 Meteron Communications Architecture

Assisting Robotic Operations from ISS

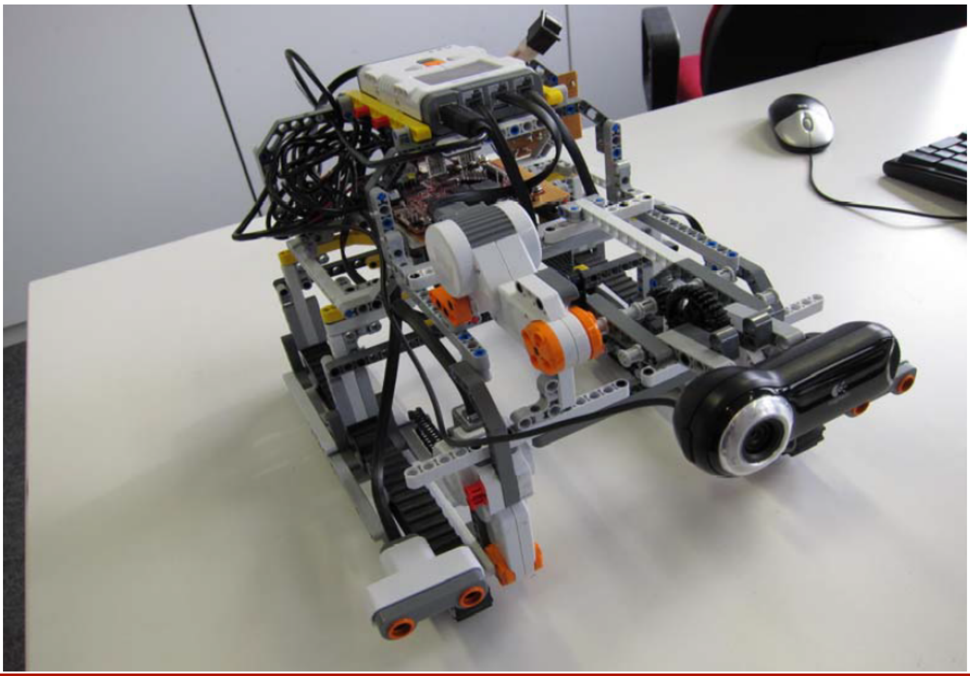
After its successful implementation, JDTN was integrated into the overall architecture of METERON, in order to interface Web Services with DTN for the space links, in parallel to the Web-Services-over-HTTP framework used for the terrestrial links (Fig. 1). The proper setup of the JDTN interface in the METERON architecture required the installation of ION-DTN implementation on the network nodes and their proper configuration. This task was among the contributions of Mr. Bezirgiannidis to the project.

Finally, the overall architecture, with the incorporation of JDTN, was tested in “SMILE room” at ESOC premises, in a demonstration that took place on 19/04/2013. The conducted experiments included several services that required data transmissions over DTN from and to a simple “MOCUP” rover (Fig. 2).

In this final demonstration, the services tested with the use of JDTN were:

- **Telemetry Data Transmission**
- **Set Initial Rover Position**
- **GO TO**
- **Take Image**
- **Fetch Image**
- **Rotate**
- **Set Movement Speed**
- **Set Rotate Speed**

The final result showed that JDTN worked effectively; all the aforementioned services successfully used the developed API to transmit telemetry, commands, and other data over the underlying DTN architecture in a transparent way.



In conclusion, the collaboration between ESOC and SPICE had a successful result, with a great contribution to the communications architecture of the METERON project.

Fig. 2 “MOCUP” Rover

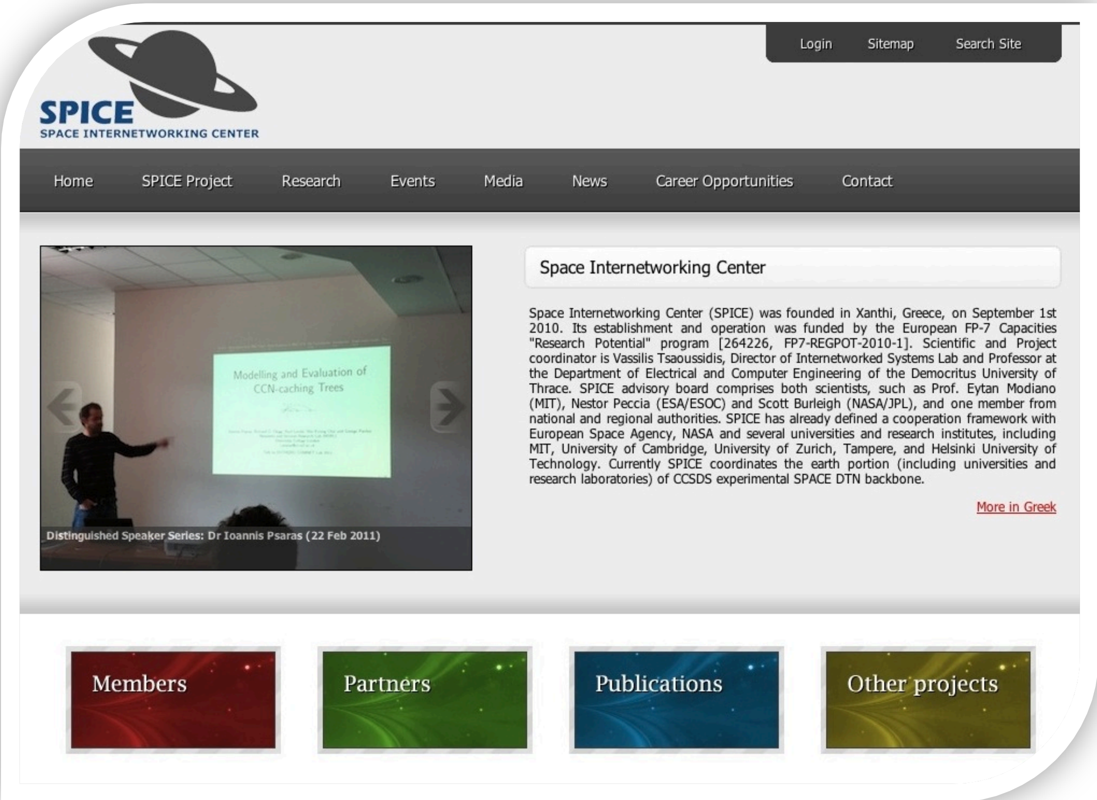
SPICE Newsletter and Website

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



Delay Tolerant Payload Conditioning

The DTN architecture and the accompanying Bundle Protocol (BP) specification propose a means for data communication on potentially heterogeneous networks characterized by high propagation delays, frequent link disruptions and disconnections. Examples of such networks include deep-space networks, sensor-based networks, terrestrial wireless networks that cannot ordinarily maintain end-to-end connectivity, satellite networks with moderate delays and periodic connectivity, and underwater acoustic networks with moderate delays and frequent interruptions due to environmental factors.

Practically, BP constitutes a network layer responsible for source to destination bundle delivery, possibly over heterogeneous networks, which resides directly below applications. Thus, unlike the traditional terrestrial protocol stack model, current DTN architecture does not include a transport layer for providing end-to-end services. Such services are left to the application. For example, in recognition of the potentially disconnected nature of DTNs, where an end-to-end closed-loop retransmission tactic is in most cases inefficient, retransmission of lost or corrupted data in the DTN architecture is performed only on a hop-by-hop basis, by the BP optional custody transfer mechanism, or convergence layer protocols.

As a result, applications requiring typical end-to-end reliability must implement their own end-to-end message reliability mechanisms.

Even in these challenged environments where an end-to-end path may never exist, it is both possible and desirable to provide end-to-end transport services. In that context, the Delay Tolerant Payload Conditioning (DTPC) protocol was introduced. DTPC is a novel protocol that extends DTN architecture in a fashion that accords with the end-to-end principle. Being an end-to-end protocol, DTPC protocol needs to operate only at the endpoints of the communication system. DTPC protocol is an expandable, connectionless, reliable, sequenced transport protocol designed to be used on top of the BP offering the following services:

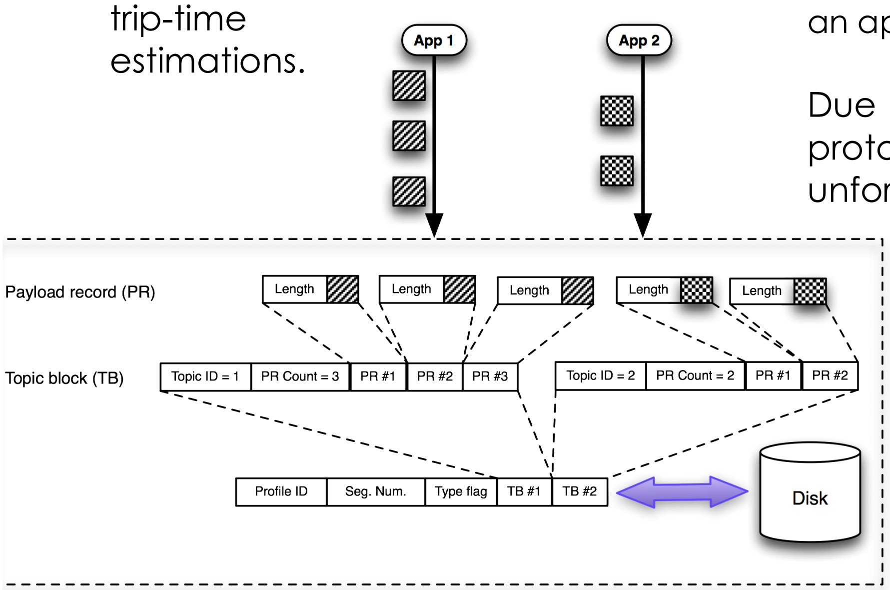
Controlled aggregation of application data units (ADUs) with application-specific elision

In order to regulate the overhead introduced by BP protocol when large volumes of small ADUs are transmitted, DTPC protocol offers an aggregation service that aggregates ADUs, possibly from different applications residing in the same node, which have the same destination and require the same quality of service (class-of-service, custody transfer, etc.).

The aggregation service is controlled by two thresholds: a length threshold sets a maximum bound on the total size of aggregated ADUs and a time threshold prevents undue delay before transmission of data during periods of low activity. Additionally, the aggregation service is coupled with an optional elision service that enables applications to remove obsolete or redundant ADUs from aggregated data units before transmission, based on application-specific criteria.

End-to-end reliability

DTPC protocol provides an additional degree of assurance in the delivery of application data when lower layer reliability mechanisms fail, by using an end-to-end ARQ mechanism that is based on positive acknowledgments. Retransmission timeout intervals are worst-case values based on data lifetime and limits on the number of retransmissions, rather than on round-trip-time estimations.



In-order delivery

Each DTPC protocol data unit is uniquely identified by a sequence number, enabling delivery of the contained application data units in transmission order. Additionally, DTPC protocol offers a “latest delivery” service that allows for in-order delivery of application data with relaxed completeness constraints, such that holes in the receiving sequence are permitted as long as the missing data units are considered expired. This “latest delivery” service assures that out-of-order data units never get stranded or expire at the receiver waiting for the reception order to be restored.

Duplicate Suppression

DTPC protocol suppresses the delivery of application data units (ADUs) that have already been received or that are considered expired, ensuring that duplicate ADUs are never received by an application.

Due to its flexible design, DTPC protocol can be easily adjusted to unforeseen usage scenarios. In that sense, DTPC protocol can be viewed as an application-independent framework for injecting end-to-end characteristics into the DTN architecture.

Fig. 3 DTPC Aggregation Mechanism

List of publications

- G. Papastergiou, C. V. Samaras and V. 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

- N. Bezirgiannidis and V. 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

- 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

- 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

- G. Papastergiou, N. Bezirgiannidis and V. Tsaoussidis, **"On the Performance of Erasure Coding over Space DTNs"**, 10th International Conference on Wired/Wireless Internet Communications (WWIC 2012), Santorini, Greece, June 6-8, 2012.

- F. Tsapeli and V. Tsaoussidis, **"Routing for Opportunistic Networks Based on Probabilistic Erasure Coding"**, 10th International Conference on Wired/Wireless Internet Communications (WWIC 2012), Santorini, Greece, June 6-8, 2012.

List of publications

- D. Vardalis and V. Tsaoussidis, **"Achieving energy-efficienct with DTN: A Proof-of-concept and roadmap study"**, 10th International Conference on Wired/Wireless Internet Communications (WWIC 2012), Santorini, Greece, June 6-8, 2012.

- S.-A. Lenas, S. C. Burleigh and V. Tsaoussidis**, "Reliable Data Streaming over Delay Tolerant Networks",** 10th International Conference on Wired/Wireless Internet Communications (WWIC 2012), Santorini, Greece, June 6-8, 2012.

- E. Katsiri, **"Cirrus: A Disruption-Tolerant Cloud"**, 10th International Conference on Wired/Wireless Internet Communications (WWIC 2012), Santorini, Greece, June 6-8, 2012.

- G. Drosatos, P. S. Efraimidis, I. N. Athanasiadis, E. D'Hondt and M. Stevens, "**A Privacy-Preserving Cloud Computing System for Creating Participatory Noise Maps**.", In proceedings of the 36th Annual IEEE Computer Software and Applications Conference (COMPSAC 2012), July 16-20, 2012.

- R. Dunaytsev, D. Moltchanov, Y. Koucheryavy, O. Strandberg and H. Flinck, "**A Survey of P2P Traffic Management Approaches: Best Practices and Future Directions**", Journal of Internet Engineering, Klidarithmos Press, Volume 5, Number 1, 2012.

- D. Vardalis and V. Tsaoussidis, "**Energy-efficient Internetworking with DTN**", Journal of Internet Engineering, Klidarithmos Press, Volume 5, Number 1, 2012.

- N. Bezirgiannidis, S. Burleigh and V. Tsaoussidis, "**Delivery Time Estimation for Space Bundles**", Technical Report: TR-DUTH-EE-2012-21.

- G. Papastergiou, I. Alexiadis, S. Burleigh and V. Tsaoussidis, "**Delay Tolerant Payload Conditioning Protocol**", Technical Report: TR-DUTH-EE-2012-24.

Complete list of publications can be found at SPICE website.

SPICE
SPACE INTERNETWORKING CENTER

Upcoming Events

Workshop on DTN communications

Upcoming Journal Special Issue

Space Data Routers project:
Summer school in DTN Communications

SPACE-DATA ROUTERS

More information available at SPICE website:

www.spice-center.org

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