



Networking for Communications Challenged Communities:
Architecture, Test Beds and Innovative Alliances
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D2.3

Integration Plan for N4C Test Beds with other Future Internet Test Beds, including Offer to Federation by Slovenian Test Bed

Version 1.0

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MEIS d.o.o. with additional input from Folly Consulting Ltd

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ABSTRACT

One of the goals set out in the Networking for Communication Challenged Communities (N4C) project proposal was for the creation of a test bed for Delay- and Disruption-Tolerant Networking (DTN) that would be sustainable beyond the lifetime of the N4C project. As part of the work in Task 9.4.2, N4C set out to see how it might be possible to integrate the test beds created during the project into the larger federation of test beds proposed under the FIRE banner. Three levels of business models have been developed for continuing test beds:

Level 1: A research test bed platform operating at a similar intensity as during the N4C Framework Programme 7 (FP7) project.

Level 2: A small scale test bed providing facilities for present research partners in N4C and for a few new clients.

Level 3: A large scale federated test bed operating in collaboration with the FIRE test bed network and providing facilities as a general service.

One of the N4C test beds in Slovenia has reached a point where it is likely to be sustainable beyond the end of the project by N4C partner MEIS and MEIS are willing to incorporate the test bed capabilities into a future federation subject to appropriate agreements. In the N4C offer to the FIRE federation, the Slovenian test bed is offered as a sustainable test bed operating at Level 3. The Swedish test bed continues as a Level 1 activity built on separate agreements with users/customers and test service providers.

The main purpose of the document is a general presentation of the **DTN test bed developed in Slovenia** by MEIS d.o.o. The test bed itself and, in addition, the technology and MEIS team skills to run it in the long term is our offer to the FIRE Federation of test beds.

The document describes the test bed topology, possible use cases, and hardware and software solutions.

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Dissemination level	
	Level
PU = Public	x
PP = Restricted to other programme participants (including the Commission Services).	
RE = Restricted to a group specified by the consortium (including the Commission Services).	
CO = Confidential, only for members of the consortium (including the Commission Services).	

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1 INTRODUCTION

One of the goals set out in the Networking for Communication Challenged Communities (N4C) project proposal was for the creation of a test bed for Delay- and Disruption-Tolerant Networking (DTN) that would be sustainable beyond the lifetime of the N4C project. As part of the work in Task 9.4.2, N4C set out to see how it might be possible to integrate the test beds created during the project into the larger federation of test beds proposed under the FIRE banner. Accordingly three levels of business model have been developed for continuing test beds have been developed and documented in N4C's Deliverable 9.6 [N4C-D9.6]. These are:

Level 1: A research test bed platform operating at a similar intensity as during the N4C Framework Programme 7 (FP7) project.

Level 2: A small scale test bed providing facilities for present research partners in N4C and for a few new clients.

Level 3: A large scale federated test bed operating in collaboration with the FIRE test bed network and providing facilities as a general service.

To make a stable offer of the type expected for the integration with the European Commission plans for a federation of test beds to be used in further Future Internet work, a commercially viable technical and management standard is obligatory. Specifically, to reach the Federation offer standard (Level 3) requires that the test bed offers services to the test bed user (customer) where the technical and procedural specifications and performance are guaranteed by the test bed owner.

In the event, one of the N4C test beds in Slovenia has reached a point where it is likely to be supported beyond the end of the project by N4C partner MEIS and can offer the requisite level of service to meet the Level 3 requirements. MEIS are willing to incorporate the test bed capabilities into a future federation subject to appropriate agreements. MEIS already provides services in the course of its usual commercial business that match the required high level of technical and organizational precision in relation to its customers. A list of some of the customers for which MEIS has provided such services in a related area of work can be found in Section 10.

The second N4C test bed in Swedish Lapland is not ready to offer the Level 3 type of services. It is however expected to continue as a follow up to N4C providing a Level 1 test bed, initially with users/customers that have already tested in the Swedish site during N4C. N4C Partner Tannak AB is willing to act as a contact point and, subject to suitable agreements, provide logistical support for ongoing testing. For information about how to contact Tannak AB see Section 11.

1.1 A Sustainable Test Bed in Slovenia

Within the N4C project MEIS is running a **permanent DTN test bed**. The hardware (HW) means and the knowledge gained will enable further use of the test bed after the end of project (with the proviso that the currently deployed HW is mostly in exposed positions and has been used in a harsh environment, but if necessary for further use of the test bed, missing and damaged items can be easily replaced with new off-the shelf ones).

This document describes the present state of the test bed and possible variations that can be easily configured with the knowledge and experience that we gained during the N4C project.

The test bed can be configured with various different types of nodes in varying quantities. This document describes a number of possibilities that could be deployed.

The test bed is suitable for running short testing campaigns (of perhaps a few days or a few weeks), but it is even more suitable for setting up essentially permanent operations– allowing long term testing of prototypes of new HW and software (SW).

The main core of the test bed legacy of N4C is not so much the presently existing nodes and network, but it is more the **MEIS team** (3 PhDs, 1 BSc and 1 technician) that is skilled in designing and setting up whichever of the configurations shown in the following chapters is appropriate. They can then assist with running the tests in the configured test bed, documenting the procedure(s), bugs, errors and results (all according to ISO9001 quality standard), evaluating the results, and offering advice and guidelines for the further development of the experiments.

In the present state of the test bed its components are not conveniently remotely accessible to enable on-line usage by third party users, but such an extension is potentially possible in the future at least for a sub-set of the test bed (keep in mind that we are offering DTN so many nodes are not accessible over the network with short time delays).

In this document we present the possibilities in a schematic way.

It is not the intention of this document to give full details of the test bed; the reader is encouraged to read the extensive N4C deliverables and milestone reports that present much more complete details of the experiments that have been carried out during N4C and the equipment deployments used for them.

2 DUALITY OF SLOVENIAN TESTBED

Meteorological and other environmental applications were chosen to demonstrate the Slovenian part of the DTN test bed capabilities in the N4C project. There were two different reasons for choosing these applications as the basis of the Slovene DTN test bed:

- to enable climatological and other environmental data collection from remote areas, and
- to have a test bed suitable for permanent testing of DTN and applications.

The first reason is directly related to the nature of the N4C project where we want to develop the infrastructure, tools and applications to enable communications in remote, communications challenged areas. Such areas have several needs related to communications. Firstly there are personal needs for emails, web access through a caching proxy system and similar applications. But then there are also the needs of the community and possibly also the government entities responsible for the area: the implications of not addressing these needs may not be so obvious at first glance, but if the sort of services that are provided via the conventional Internet in less challenged areas are not made available, the absence tends to lead to the development of an underprivileged class of regions: the *forgotten areas*. **One such need is the requirement for central collection of observations of climatological data** (including but not limited to basic meteorological observations). Making this data accessible for both local and global use has a number of advantages. These range from daily weather prognosis, assisting every day planning for outside work, to driving global models for climate change. Also the technically similar on-line measurements of gamma dose rate (radioactivity) that are needed for local early warning systems that will signal the imminent arrival of pollution (such as emanated from the Chernobyl nuclear reactor accident). This kind of measurement is normally available for the less remote areas of developed states, but such in-situ measurements are also needed for the whole area, including the communications challenged parts, to allow the research community to evaluate the past and present characteristics of natural and man-made pollution.

Therefore the aim of the Slovenian test bed was to develop the complete network (although on a small scale of up to 10 nodes) to provide collection and distribution of meteorological and radiological measurements, based on a DTN communication infrastructure and adapted to the sort harsh environment that is often encountered in communication challenged areas.

This goal was successfully achieved.

The second reason is purely technical, driven from the expectation of how a test bed and experiments should be undertaken.

To provide extensive testing of the HW and SW solutions for the DTN infrastructure we have to have a source of data that is generated automatically, is of appropriate quantity, can be generated periodically, and with the desired frequency in order to test in multiple ways whether the DTN infrastructure is working or not, highlight any bugs that may exist and examine the failure modes of the system. In addition it would be desirable for the information or data transferred through the system to be of such a nature (for example including time stamps and the structure of the information content) that it inherently provides more or less automatic quality and quantity control over the delivered information.

It seems that meteorological and radiological data transfer has all these desirable features.

Both are generated automatically (by a meteorological or radiological collection end-DTN node). The resulting data is packed into a small or medium sized plain text file, but the content of files has a physical meaning, so that at the delivery point, a multi-way data sanity and quality check is possible. Also all the data is automatically unique (the underlying processes are conveniently random), and has a time stamp embedded into the file in several ways which enables unique tracking of the related bundles of the DTN transfer. Thus the nature of the collected data enables us to carry out really long term testing of the DTN, although in a relatively small suite of nodes. The ongoing operation, (including incorporating upgrades), that took place over more than two years has helped to show up many bugs and failures that would be unlikely to be discovered in short term operations. Further, this long term operation has several significant aspects. Operation of the HW itself in relatively harsh conditions (down to -18 deg C, in winter and in hot sunny summer conditions, with some of the nodes running on scavenged solar power only), with generally limited power supply available, means that the HW was tested for its durability. The operating systems that were used, as well as the DTN infrastructure software and the DTN applications running on top of these were tested for bugs that occurred both in short and long term operation. The traceability of the routes of bundles and the unique contents of bundles disclosed some hidden bugs, including routing protocols failures and the like.

Last but not least we will soon implement a meteorological DTN station in the Slovenian underground cave of Postojna (this work will be done in the framework of another project for the application of meteorological and speleological capabilities co-financed by the Slovenian state research agency ARRS).

In addition to this environmental data driven network we also added some low cost web cameras for automatic observation of wild birds. In contrast to the meteorological and radiological applications, the web cameras produced frequent and relatively large files (panorama images of nature and birds). With this component we tested the ability of the DTN network to transfer this greater volume of data. This helped us to determine and solve some problems related to the larger quantity of data both in terms of storage and transfer capabilities.

This goal was also successfully achieved.

These two complementary approaches helped us to examine a wide collection of problems related to the use of DTN in real life. The experiments were designed in such a way as to help to technically develop, test, and verify several aspects of possible usage of the DTN infrastructure.

In principal for the further use of DTN the meteorological, radiological or bird photography applications can be replaced with any sort of application that delivers automatically produced technical data or another type of information source that makes it necessary to transfer data between locations in these remote and communication challenged areas.

In the following sections the characteristics of the Slovenian test bed are shown schematically.

In addition Section 9 provides references to several other publicly available deliverables of the N4C project, that contain all the details of the construction, development and usage of this test bed from a variety of perspectives. It is not the intention of this deliverable to repeat that information.

3 PRESENT STATE AND FUTURE POSSIBILITIES

In the following chapters we explain in a detailed schematic way what the existing modules of the Slovenian test bed are.

For the possible future use of this test bed there are no hard limitations on the number of nodes in the network. Additional nodes (mobile and fixed) can be easily added if needed for different or more complex topologies. Similarly different DTN implementations can be used.

The presently existing types of nodes (which include both SW and HW solutions) serve to show the variety of nodes that can and already have been successfully used in the long term N4C running of this test bed. They should not be seen as limiting the sorts of solution that could be deployed.

The existing nodes are designed for harsh environment and low power consumption.

If in the future more mobile and fixed nodes are required, it is entirely possible to use simple laptop computers (or netbook computers) as additional nodes provided that they would be actively operated in an office type environment since the existing SW runs on most of the common platforms (including Linux and Windows). It would, of course, be possible to use these as mobile units provided that they were adequately protected (and generally inactive) while outside the office environments.

In addition meteorological stations can be replaced by a software-based meteo-station simulator, if all that is required is a source of files for the purpose of testing the bundle flow in the DTN test bed.

With these two simple tricks it is possible to easily (and cheaply) enlarge the test bed if a more complex topology is desired.

Moreover to test the DTN parameterisation for more or less frequent data flow (bundles occurring every minute or once per week, travel time from node to node in terms of minutes or in terms of days or weeks) can be easily adjusted by designing a variety of scenarios of actual encounters of nodes. (For instance a car mobile node mule can deliver data only once per week or can take bundles from a station on Monday and deliver them on Wednesday.).

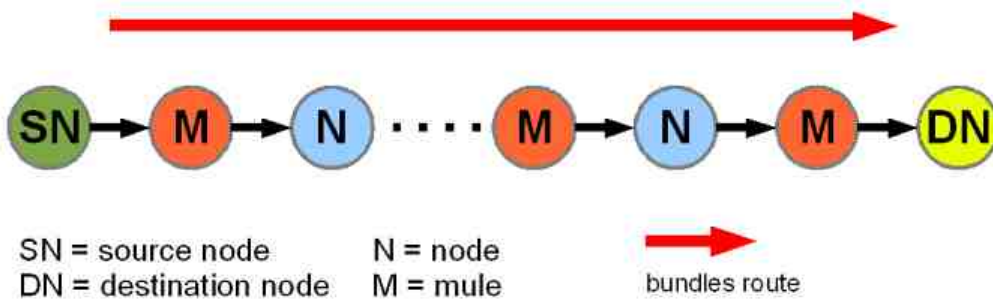
On the other hand meteorological nodes can remain and the existing DTN implementation could be replaced with any other solution (currently only DTN2 and DIMP (DTN implementation of Prophet routing) are used). Running the test bed would then provide a realistic test of operation of any other DTN stack solution.

The examples of reconfiguration of the test bed suggested here are only some of the possible future evolutions of the Slovenian DTN test bed. Research users (outside the N4C project) are encouraged to contact the MEIS team for possible use and application of the test bed (Dr. Marija Zlata Božnar, marija.zlata.boznar@meis.si).

4 POSSIBLE USE CASES

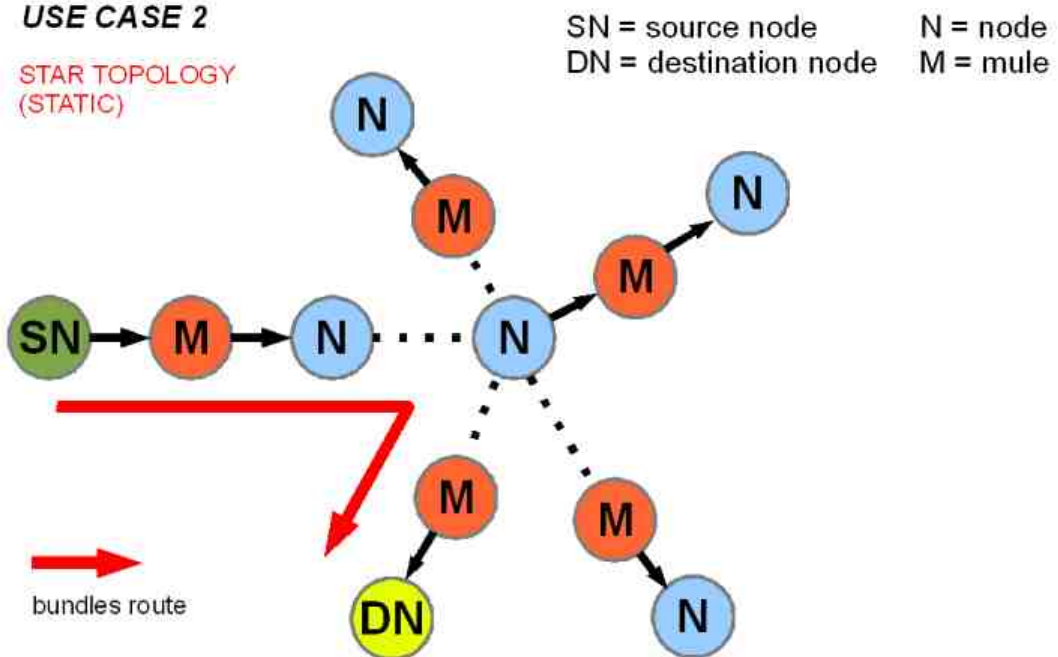
USE CASE 1

STATIC OR EPIDEMIC



USE CASE 2

STAR TOPOLOGY
(STATIC)

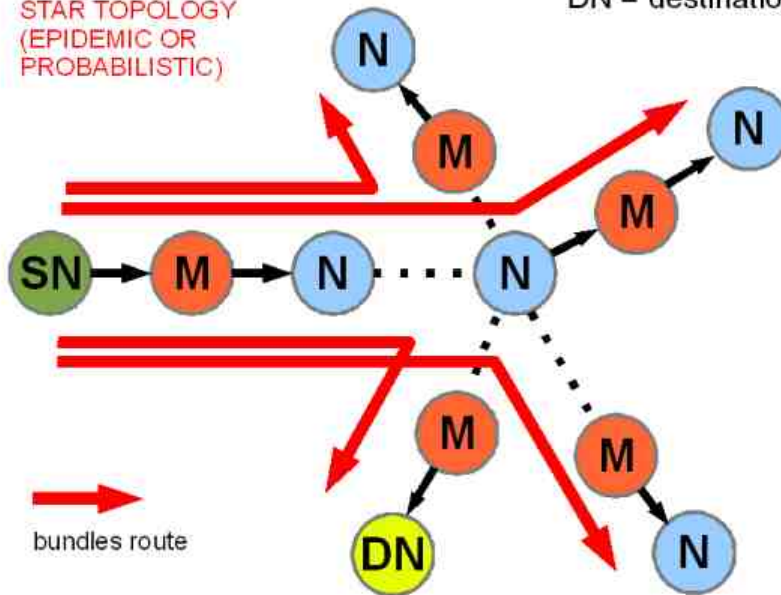


USE CASE 3

STAR TOPOLOGY
(EPIDEMIC OR
PROBABILISTIC)

SN = source node
DN = destination node

N = node
M = mule

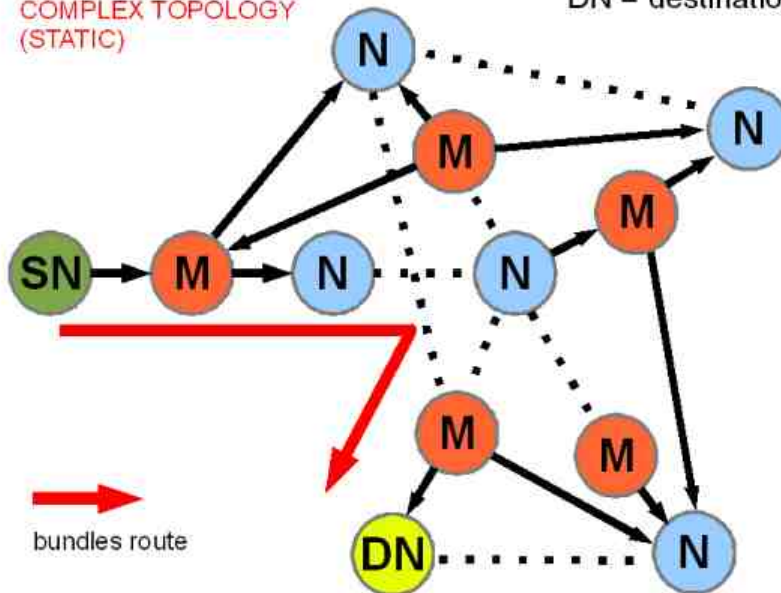


USE CASE 4

COMPLEX TOPOLOGY
(STATIC)

SN = source node
DN = destination node

N = node
M = mule

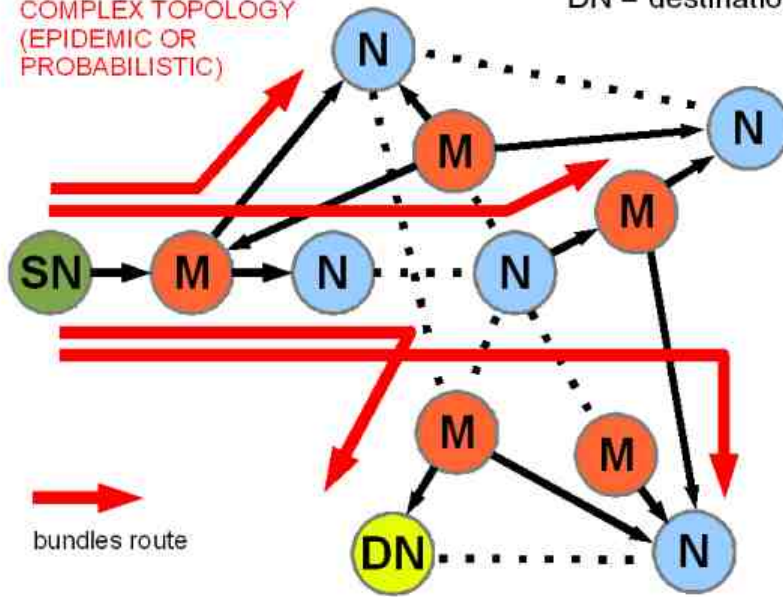


USE CASE 5

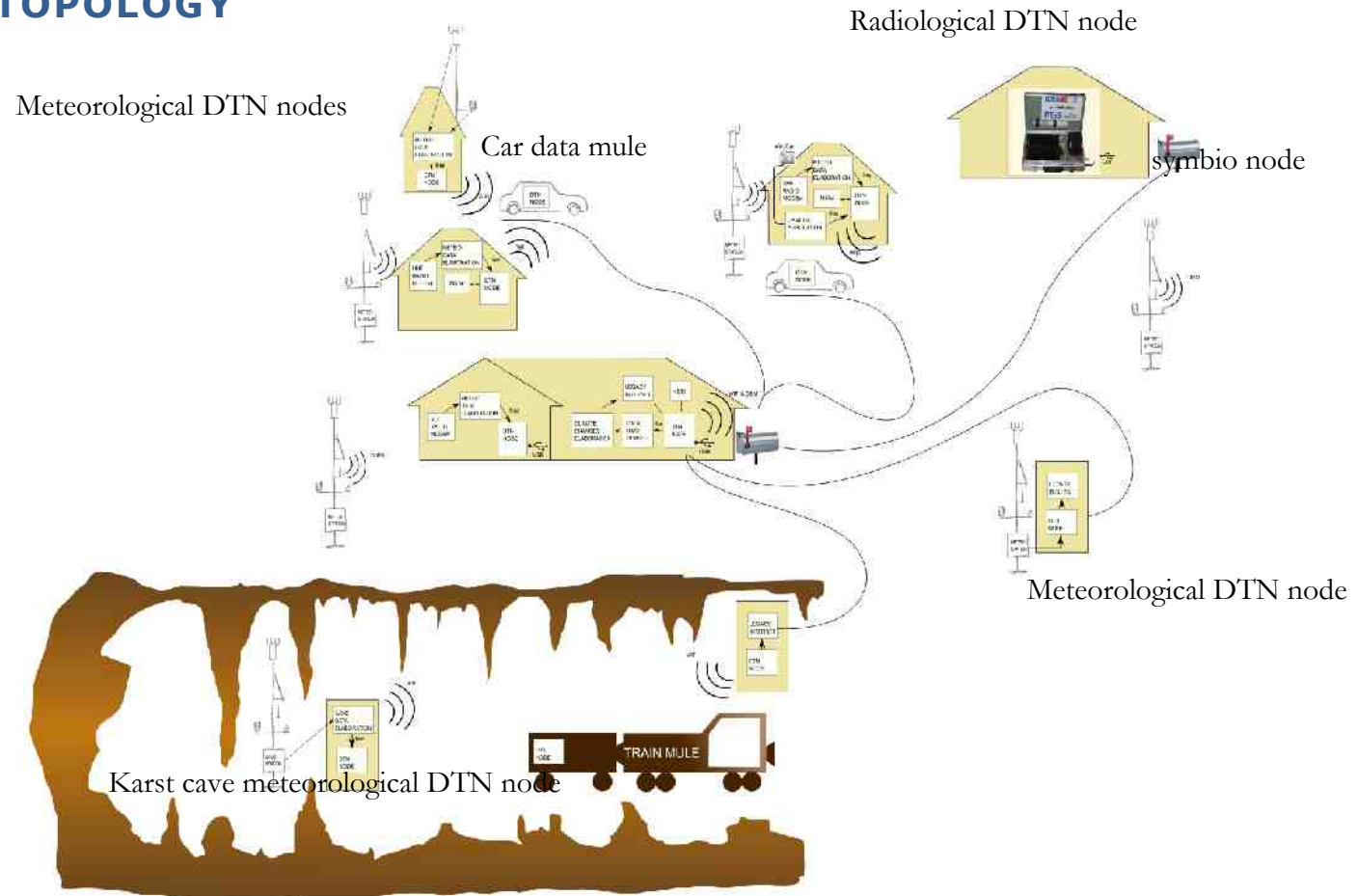
COMPLEX TOPOLOGY
(EPIDEMIC OR
PROBABILISTIC)

SN = source node
DN = destination node

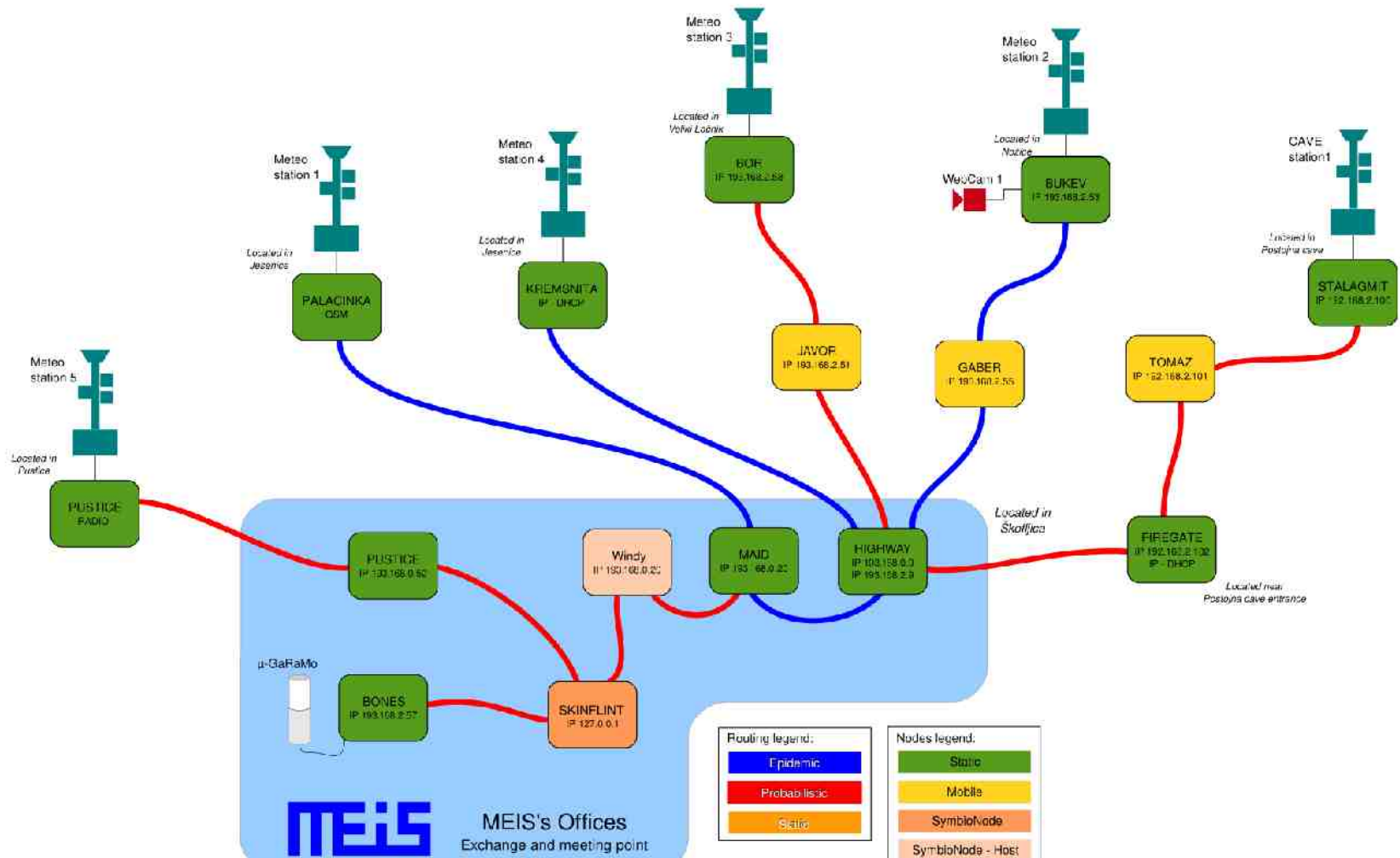
N = node
M = mule



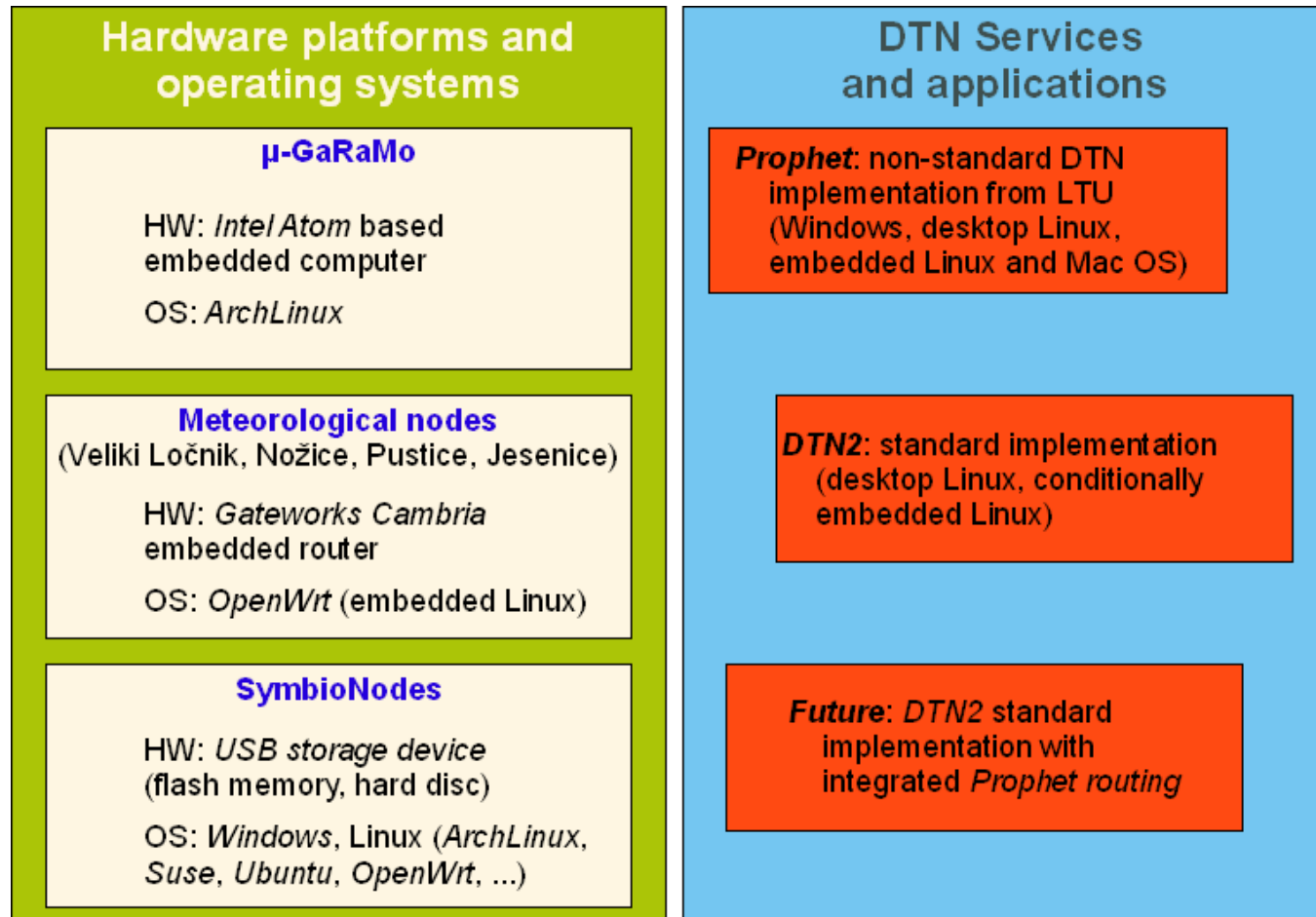
5 NETWORK TOPOLOGY



Meteorological DTN nodes, radiological DTN node, car data mule, train data mule, symbio-node, Karst cave meteorological DTN node



6 LIST OF PLATFORMS USED



DATA MULE HW PLATFORMS**SymbioNode DISK****SymbioNode USB key****Car mule****Train mule****Laptop****Netbook**

7 EQUIPMENT AND SOLUTIONS



CAMBRIA FIXED ROUTER



METEO STATION "PUSTICE"



CAR MULE



SYMBIO NODE (DISC)



SYMBIO NODE (USB PEN DRIVE)



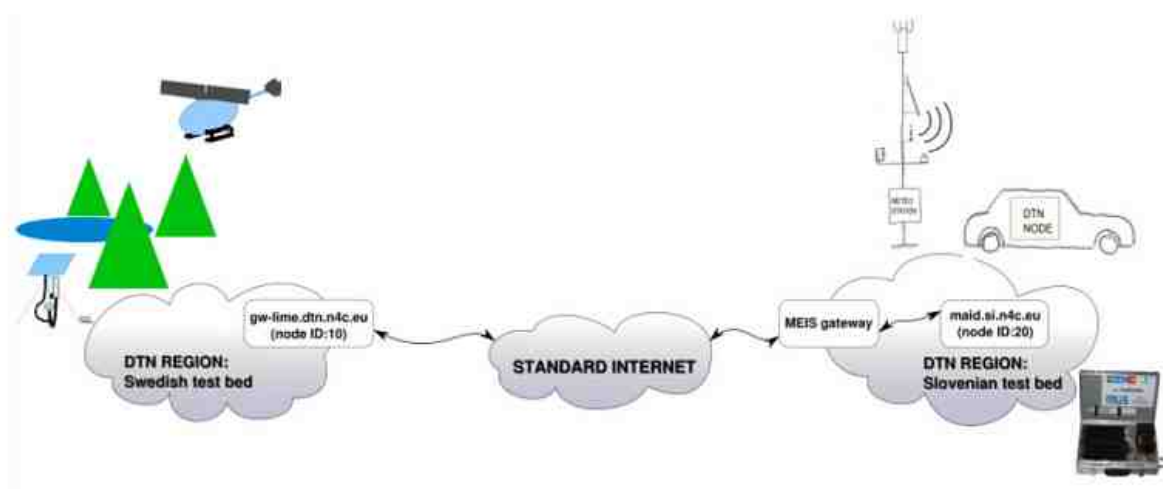
PORTABLE RADIOACTIVITY MONITOR (uGaRaMo)



CAVE STATION NODE POSTOJNSKA JAMA

8 CONNECTION OF DTN REGIONS (SLOVENIAN AND SWEDISH TEST BEDS)

In the following figure the connection of two DTN test beds is shown as it was configured during the winter tests in 2011.



DTN topology of two connected DTN regions: Swedish and Slovenian test beds

9 RELEVANT N4C DELIVERABLES

Details about running the test bed (including HW means) and the tests themselves can be found in:

Deliverable:

[N4C-D8.4] ITTI Sp. z o.o./MEIS d.o.o./Luleå University of Technology/Trinity College Dublin/Norut, D8.4 Test Results Documentation of test results from tests in Swedish Lapland and Slovenian mountains Version 0.1, Document: n4c-wp8-d8.4-test-results-2-0.pdf.

Milestone reports:

[N4C-M8.1] MEIS d.o.o., Luleå Institute of Technology, *M8.1 Summer 1 interconnected tests report*, Version 2.2, Document: M8.1_N4C-WP8.-2.2.doc

[N4C-M8.2-MEIS] MEIS d.o.o, *M8.2 Winter 1 interconnected tests report*, Version V04, Document: N4C_winter_test_2009_Slovenia_V04.pdf

[N4C-M8.3-MEIS] MEIS d.o.o, *M8.3 Summer 2 interconnected tests report*, Version V05, Document: n4c-wp8-004-M8.3-summer_test_2009_Slovenia_V05_and_QAQC_V50.pdf

[N4C-M8.4-MEIS] MEIS d.o.o, *M8.4 Winter 2 interconnected tests report*, Version V05, Document: n4c-wp8-005-M8.4-winter_test_2010_Slovenia_V05_and_QAQC_V10.pdf

[N4C-M8.5-MEIS] MEIS d.o.o, *M8.5 Summer 3 interconnected tests report*, Version V06, Document: n4c-wp8-006-M8.5-summer_test_2010_Slovenia_V06-app.pdf

[N4C-M8.6-MEIS] MEIS d.o.o, *M8.5 Winter 3 interconnected tests report*, Version V03, Document: n4c-wp8-009-M8.6-winter_test_2011_Slovenia_V03_QAQC_40.pdf

Details about DTN2 and DIMP (with Prophet routing) can be found in:

Deliverable: [N4C-D4.1] Trinity College Dublin/Intel, *D4.1 N4C Generic DTN documentation*, Document: n4c-tcd-007-d4.1-FINAL.pdf

(See also [N4C-D2.2] below).

Web page: DIMP, Prophet routing protocol, <http://prophet.grasic.net/> - work in progress.

Details about applications used are documented in:

Deliverable: [N4C-D3.3] Norut/Luleå University of Technology/Folly Consulting/MEIS, *D3.3 Prototypes, Final Version, Version 1.3*, Document: D3-3_Prototypes_Final_v1-3.pdf

Details about methodology for setting up the DTN test bed can be found in:

Deliverable: [N4C-D8.3] Luleå University of Technology, *D8.3 Test bed creation Methodological report Version 1.0*, Document: n4c-ltu-40-D8.3-1.0.pdf

Details about DTN architecture used can be found in

Deliverable: [N4C-D2.2] Folly Consulting/Luleå University of Technology, *Functional Specification for DTN Infrastructure Software comprising RFC 5050 Bundle Agent and Associated Components Version 1.2*, Document: n4c-wp2-023-dtn-infrastructure-fs-12.pdf

Discussion of the possibilities for integration of and economic positioning of the N4C test beds:

Deliverable: [N4C-D2.4.1] Luleå University of Technology, *Horizontal Project Issues Version 1.0*, Document n4c-wp2-041-Horizontal-Issues-10.pdf

Discussion of the business models for sustainable test beds can be found in:

Deliverable: [N4C-D9.6] Fransson, Barbro (2010). *Deployment Plan / Business Plan*. N4C Document: Deliverable 9.6 Version 1.0.

10 CONTACTS FOR THE OFFER TO FEDERATION

Documents can be downloaded from www.n4c.eu. Many are already available but some of them will not be available until the end of the project (30th April, 2011).

The primary contact for organization interested in this offer to federation is:
Marija Zlata Božnar PhD, MEIS d.o.o. director

Marija.zlata.boznar@meis.si

Telephone: +386 1 3663 226

MEIS has provided services similar to those needed to offer the sustainable and federated test bed to the following companies in Slovenia:

Krsko Nuclear Power Plant
Krsko municipality
Slovene Nuclear Safety Authority
Environmental Agency of Slovenia
Sostanj Thermal Power Plant
Trbovlje Thermal Power Plant
ACRONI steel factory

A more complete list of MEIS customers along with other information about the company can be found on their web site:

www.meis.si

11 FURTHER TESTING IN SWEDISH LAPLAND

Partner Tannak AB would be willing to discuss providing logistical support for future DTN testing in the Sirges Sámi village reindeer herding areas and other locations around Jokkmokk as they have done throughout N4C. Tannak have particular expertise in animal tracking technology and would be happy to discuss possible further experiments relating to tracking of reindeer as well as more general DTN testing. Contact:

Susanne Spik and Karin Kuoljok

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