Networking for Communications Challenged Communities:
Architecture, Test Beds and Innovative Alliances
Contract no: 223994

D3.1

Functional Specification

Version 1.5

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ABSTRACT

Starting in May 2008, N4C is a 36 month research project in the Seventh Framework Programme (www.cordis.lu/fp7). In cooperation between users in Swedish Lapland and Kočevje region in Slovenian mountain and partners, the project will design and experiment with an architecture, infrastructure and applications in field trials and build two test beds.

This document is the functional specification for Work package 3: R&D pervasive applications: E-mail, Not So Instant Messenger, Web Cache, Hikers, Hunters, Herders and Rangers Applications. It describes how Hiker's Personal Digital Assistant (PDA) might be used in a Communications Challenged Region (CCR) where a Delay and Disruption Tolerant Networking (DTN) based infrastructure has been established. Section 1.3 describes how the requirements and the functional specifications were captured, and section 2.4 describes the methodology used for developing the applications.

For WP3 the Description of Work states that quantitative review indicators are to be suggested with D3.1. The indicators the Consortium suggests are described in section 4.

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Dissemination level	
	Level
PU = Public	
PP = Restricted to other programme participants (including the Commission Services).	**PP**
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

There are many locations in the world that are not within reach, or at least not within affordable reach, of the optical fibres, copper cables, radio waves or even satellite links that make up the physical infrastructure of the world's networks. This makes a true challenge for the Future Internet. One of the new technologies currently being investigated as one possible enabler is Delay Tolerant Networking (DTN), the future standardization of which is prepared in the DTN research group, DTNRG[1], within the realms of IETF/IRTF.

The Networking for Communications Challenged Communities project (N4C) envisions taking a major next research step in building converged networks that deliver delay and disruption tolerant Internet services for nomadic and other use. The challenges in that work are considerable:

- A full solution requires the development of networking infrastructures which are pervasive, ubiquitous and highly dynamic, supporting a wide variety of nomadic interoperable devices and services, a variety of content formats and a multiplicity of delivery modes.
- Actually delivering data and services in Communications Challenged Communities (CCRs) will require the opportunistic use of all possible connectivity methods, including DTN connectivity. This is a major challenge to advanced architectures and protocols.
- Ensuring that the technical advances made are actually implemented at local level.

Providing applications that exploit these advances is generally perceived as vital to getting these advances out into the field. The Work packages of N4C are:

WP1 Project management	
WP2 System architecture	WP6 Air-interface technologies
WP3 Pervasive applications	WP7 System integration
WP4 Software for DTN and opportunistic networking	WP8 Tests and validation in two remote test beds
WP5 Specialized hardware for DTN networking	WP9 Dissemination

Work package 3 Pervasive Applications subsumes the majority of application developments in N4C that are closely connected to software development. Animal tracking and monitoring applications are more closely tied to air interface hardware and are developed in Work package 6.

1.1 THE CHALLENGES OF N4C APPLICATIONS DEVELOPMENT

Because of the novelty of DTN and the architecture that N4C works with, there is a distribution of the actual development work for the applications. The N4C integrated networking architecture is

[1] http://www.dtnrg.org

intended to treat the conventional Internet infrastructure and DTN as peers rather than presenting DTN as an alternative link layer technology as is usual when integrating different sort of transmission technology into IP networks. This is appropriate because of the very distinct communication paradigms used in the networks and is an important research issue because there are a number of other situations (such as mobile networks) where closely related problems are likely to arise in the near future:

- Routing across the boundary between the two types of infrastructure with multiple connection points
- Addressing for the DTN
- Mapping between the addressing schemes in the IP and DTN domains

In "common" language the above means that the novelty of DTN as such and, the complications that arise by the combination of DTN with opportunistic routing, affect the issues that application development in N4C needs to tackle. The applications cannot straight forwardly be placed on top of existing standards and commercial solutions. For instance, web caching and e-mail which are two of the applications that are dealt with in N4C, is a matter not only for WP3 but also for WP2 *System Architecture* as the functionality within the DTN opportunistic routing architecture of N4C is a matter of issues as naming and addressing. They are also a matter for WP8 *Tests and validation in two remote test beds*, as they are used to generate and measure end user relevant traffic in the field test networks. Reaching at the circumstances that allow real life use requires routing protocol implementation which is a time consuming and demanding task that builds on interplay between above mentioned WPs 2, 3 and WP8 and also WP4 *Software for DTN and opportunistic networking*. Similarly, the development of Meteorological and Environmental Data Capture takes place in WP3 Pervasive Applications, WP4 Software for DTN and Opportunistic Networking and, WP8 Tests and Validation in Two Remote Test beds. At the technical kick-off meeting in Slovenia in project month 5 (reported in Deliverable 8.1) it was decided, that a spiral development model shall be used to guide the routines for the interaction between work packages and the generations of solutions that are developed and exist in parallel during overlaps in development cycles.

1.2 THE N4C APPLICATIONS AND THE PURPOSE OF THIS DOCUMENT

In sum, the purpose of the document is, to collect initial versions of the functional specifications for three application suites which the project is assigned to develop.

These are:

- Hikers, Hunters, Herders and Rangers Applications
  (in daily speech within N4C also referred to as "Hiker's Personal Digital Assistant" (PDA))
- Meteorological and Environmental Data Capture
- Web Caching

Two other applications that are already well established in their form and content but are of interest to the project have additionally been included in the collected specifications.

- E-mail
- Not So Instant Messenger

Relative to the project's internal needs, an important function for this initial WP3 Deliverable is to provide guidance and input on the application level functionality that will be required from the DTN infrastructure for reference in other work packages.

Each application has its own history and raison d'être in the project. *Web caching* and also *e-mail* are essential applications for providing what is in every-day terms thought of as "internet access" by end-users. It is well known that people in general often confuse the World Wide Web with the Internet as a whole and, having been one of the first the e-mail remains the most used application. To claim impact on the Future Internet it is hard to think of applications that are more convincing to target today. Hikers' PDA on the other hand, is an application particularly envisioned for use in wilderness and unsettled areas. The background is consecutive workshops and seminars connected to the previous EU Interreg North Calotte project *CroCoPil*.

The *Not So Instant Messenger* (NSIM) is an example of an application developed as side-effects in other development efforts. The name is a joke with the delay component in DTN, and reveals this application's geeky origin. First developed as an uncomplicated mean for technicians to check DTN delivery in a test set up, it showed useful as communication media between camps in the DTN field tests that paved the way for the N4C FP7 funding application.

Common to all applications that are included in N4C research and development, is a prehistory among the consortium members. Thanks to the chosen applications having prehistories among the consortium it was possible to produce specifications for five applications already in this document that is in month 6 of N4C project time. It is also thanks to these prehistories that applications can be included in field trials of the novelty DTN opportunistic routing network, in communications challenged areas already during the 36 months that N4C is running. The N4C Description of Work aims at Living Labs type trials for summer test 3 in 2010. Before reaching to that point, the routines for setting up the DTN infrastructure must be developed to stable performance for user controlled settings, but the applications are included already in that earlier research and development as elements in lab tests, system integration and field trials. It is a challenge that the application development takes place in parallel to the network concept going through the same process, why challenges turn up iteratively between them. That is why one important function for this initial WP3 Deliverable was to specify requirements, methodology and "starter" data for reference in other work packages.

Except the above mentioned applications, animal tracking is addressed in connection to the air-interface technology work package (WP6). Meteorological and Environmental Data Capture and animal tracking are of direct interest to two SMEs in the N4C consortium; MEIS storitve za okolje d.o.o., Slovenia and Tannak AB, Sweden. MEIS was established in 2007 by young professionals. The two owners both have PhD degrees. Its primary work field is air pollution modelling, engineering and software development for environmental measuring systems. They also make other environmental R&D. Developing DTN routines for delivery of data from remote areas is a way to increase the palette of services the company is able to offer. Tannak AB was started in 2006 and is located in Jokkmokk, Sweden in the northern outpost of the European Union. Both owners were born and raised in reindeer herding families and Tannak's business idea is to commercialise technical systems, products, prototypes and consultancy services for identification and tracking of cattle and animals. It can be noted that meteorological and environmental data capture as well as animal tracking are

generally regarded as interesting for deployment of distance spanning solutions today, including through use of DTN. Animal tracking design and achievements are reported in D6.1 and will not be described in this document. To create coherence in the general level description in this introduction however, some of its background and role in N4C is included in overall level descriptions in this document.

1.3 ABOUT REQUIREMENTS AND FUNCTIONAL SPECIFICATIONS

The applications worked with in N4C have, as indicated above, become part of the project consortium's scope via different paths. Accordingly, there are differences with regards to the ways in which requirements and functional specifications are approached, and to how users play parts in the respective design processes. A shared characteristic for all applications in the N4C scope is that their development is connected to envisioned future internet capabilities, as opposed to being positioned on top of well defined and already commercially established layers. This implies interrelations between the ideas of how to stretch current limits of the internet/networking and, the application design and verification processes. Work of relevance to the realization of application specifications and evaluation is distributed in several work packages.

Requirements and specifications are collected through:

- Capturing previously described requirements and specifications captured and developed in previous projects KIS (Woman in the Sámi Village), SNC and CroCoPil
- For the meteorological and animal tracking applications certain requirements are given from respective company's existing business idea, the professional, ethical and other considerations that regulate the operations of the respective sectors (a.o. WMO standards)
- Developing new requirements and specifications in N4C

This is further described in chapter 2: In section 2.1.1 the requirements from the SNC project, and in section 2.1.2 for the CroCoPil project, are described. The new requirements captured in the N4C project are described in section 2.2. In section 2.2.1 the hardware requirements, and in section 2.2.2 the software requirements for the meteorological application are explained in detail. Both sections are divided into requirements from previous MEIS work and WMO standards, and requirements identified within the frame of N4C. The same is done for the monitoring of wildlife applications in the sections 2.2.3 and 2.2.4. Section 2.4 describes the methodology used for developing the applications.

As a major rule, while the requirements behind the applications to a large degree rest on earlier identifications of needs and potentials in communications challenged communities, the specifications presented in the initial version of this document was developed within the period of N4C's first six months. This version will be resubmitted in month 17, and there is also an internal version scheduled in month 18. The final version of this living document is scheduled in month 30.

1.4 FOCUS IN THE DEVELOPMENT OF EACH APPLICATION

Each DTN application has it's own of technical focus/importance within the WP3. That means the development of the applications don't necessary has the same technical focus but might have different kinds of problems to overcome. All developers in WP3 are trying to solve basic, but difficult technical problems that arise when developing DTN applications/services that normally are used in legacy internet where electricity and delays is not an issue.

E-mail

E-mail is a 'fundamental' service in the Internet which users (almost) always expect to be provided as part of the services where the Internet is extended by means of DTN. Since E-mail is inherently a 'store and forward' application, adaptation to the DTN environment does not require any alteration to the user interface or specific alteration of user expectations. Implementation requires provision of a DTN-based E-mail transport mechanism that can be used by mail transfer agents where delivery is configured to take place over links that utilize DTN. Although E-mail is not explicitly mentioned in the DoW description of WP3, N4C will continue the experimentation and deployment of E-mail as an application begun during the predecessor SNC project. Two different use cases will be considered:

- Using DTN to transport E-mail between a gateway in the existing Internet and one or more gateways located at 'villages' or 'camps' allowing users to access the E-mail via existing 'standard' mechanisms from a host that is not necessarily DTN-enabled while located close (e.g., within Wi-Fi range) of the village gateway
- Using DTN to transport E-mail, either between a gateway in the existing Internet and a nomadic host that is DTN-enabled, or directly between DTN-enabled nomadic hosts.

Hiker's Applications

Hiker's applications aims to include useful tools built for hikers and comparable groups with a portable handheld computer (PDA) in a Communications Challenged Region (CCR).This is a user focused product that includes use of DTN E-mail and Web caching, together with the implementation of a concept called Geoblog and photo sharing. Developers take into consideration and are working on the issues of locational privacy [EFF], security, battery life time, wireless range and ad hoc connections, all very important for the functionality and usefulness of the applications.

Meteorological and Environmental Data Capture

The focus in this application is on research and development of technical (hardware and software) services for measuring the environment with advanced equipment, and then sending periodic reports via DTN. The application is a part of the MEIS business idea.

Web Caching

The idea of cached web in a DTN was already made a reality in the SNC project (one of the predecessors of N4C). What is new in N4C and this document is that we are for the first time developing use-cases for web caching. "Web caching" is used as a shorthand for techniques that will allow users who do not have an Internet connection that meets the relatively low round trip time

bounds expected by the HTTP protocol and today's web sites. Short round trip times allow a displayed web page to be constructed from the responses returned from a number of separate requests to one or more web servers, each requiring a network round trip. In a DTN network the round trip time might be many hours, making the existing system effectively unusable. The web caching work in WP3 involves both technical development and research. The basic idea is that we are bringing limited web surfing to a CCR. We take something from legacy internet, make a package of it, and sent it out to the DTN. The problems WP3 is trying to solve includes the large amount of data that must be sent over DTN, with whatever bottleneck might be out there, and how to supply web pages that contain scripts and are normally meant for the non-delayed legacy internet. On the research side there are questions on how to handle user webpage requests and browsing, presenting web pages to users, and building user interfaces.

NSIM

The Not so instant messaging service was originally meant for developers to test the functionality of a setup between nodes in a DTN. A developer can choose a specific node from a list of known DTN nodes and send a text message, and the receiving end can read it when it arrives. For one example of using NSIM as tool in N4C research and development, see Figure 20. It is a purely technically focused service but nevertheless it has seen some usage even from users. N4C aims to keep using NSIM for development reasons, but it might be that it could be useful as a foundation for a messaging system even for other cases in the future as well. It is closely tied to the addressing scheme used for DTN nodes as compared to e-mail that uses a more general addressing scheme. NSIM is therefore restricted to communication with a DTN-enabled area.

1.5 THE TEMPLATE AREAS AND SCENARIOS

The original template for the N4C approach to DTN networking was given by the reindeer herding communities, also referred to as "Sámi Villages", in the Jokkmokk municipality in north-west Sweden. Part of the year, these communities operate in wilderness in UNESCO World Heritage Laponia. The two other key template areas are the regions Kocevje in Slovenia and Troms in Northern Norway. These three regions are 'communications challenged' in the sense that they have little or none of the infrastructure that is needed to support today's conventional wired and wireless Internet communications, and the economics of the regions are such that it is highly unlikely that this infrastructure will be installed in the foreseeable future.

Jokkmokk region: Jokkmokk municipality (Jokkmokks kommun) is situated along the upper parts of the two Lule rivers Stora Luleälven and Lilla Luleälven, in a band from the mountains and the Norwegian border towards south-east, in direction towards the Bothnian Bay. The town Jokkmokk, the district centre, is situated slightly north of the Arctic Circle, while the mountain part of the district lies between 67 and 68 degrees north. The district comprises 18144 km2 and 6019 inhabitants (year 2000). With its 500 members and 15500 reindeer, Sirges is the largest Sámi village in Swedish territory and the cooperation between internet experts and reindeer herders that has lead to N4C was initiated by an EU Objective 1 project run by this Sámi village. The people of Sirges and their neighbours live in a remote area characterised by a small number of population centres spread in a vast land of forest and its alpine mountains in the west. The herders move their bread winning activity geographically through the year, in a cycle dictated by the accommodation between a number of factors. These are: natural behaviour of reindeer; climate and pasture variations; laws and regulations; impact from

various industrial activities (e.g. hydro-power, timber logging, tourism); current herding practice; and own economic and social situation (including such as family situation, health status).

The Kočevje region: Kočevje is situated in south-east Slovenia. It is a mountainous region of approximately 20km by 25km south-southeast of the capital Ljubljana. After the Second World War this area became sparsely populated – almost without settlements in the last 60 years. It is now mostly overgrown with forests. Only a few villages with poor infrastructure remain. The lack of economic development during the closed period has led to an economic downward spiral where the lack of high technology and well-paying jobs has encouraged young people to migrate out of the region further exacerbating the population decline. There is little or no infrastructure away from the few permanent roads. The extensive forest areas have a large population of wild animals including many bears, wolves and deer, especially roe deer.

Northern Norway:

The actual area lies in Troms County in Northern Norway on the border between Norway and Sweden. The distance of a hiking route across this area is approx 200 kilometres, and the area is approx. 4000 – 5000 square kilometres. Most of this area is classified as "wilderness":

*"**Wilderness** or **wild land** is a natural environment on Earth that has not been significantly modified by human activity. It may also be defined as: "The most intact, undisturbed wild natural areas left on our planet—those last truly wild places that humans do not control and have not developed with roads, pipelines or other industrial infrastructure."* (From wikipedia.com)

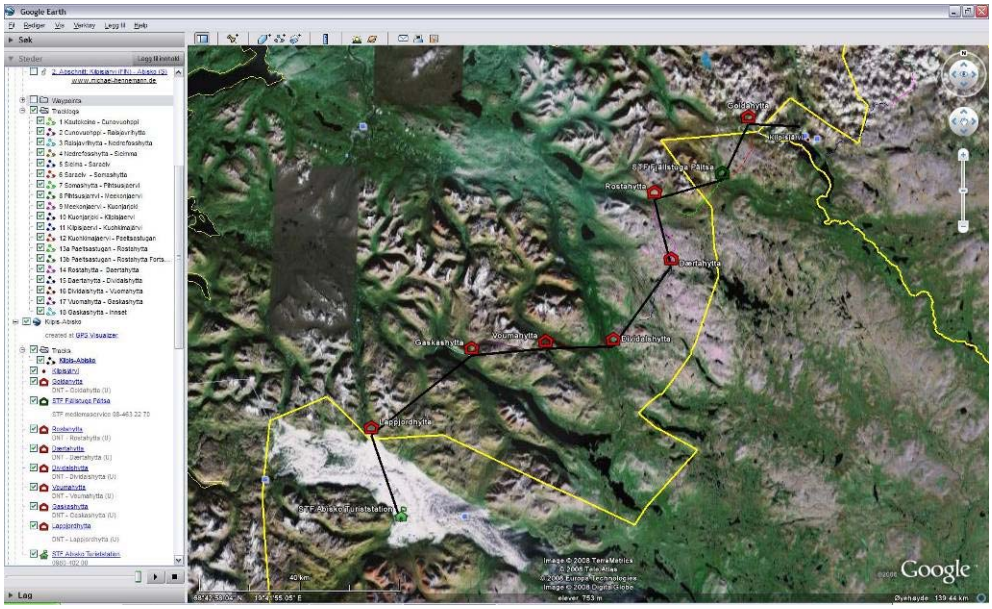


FIGURE 1: HIKING THE NORTH CALOTTE ROUTE

Still, the area is not completely untouched. There are several cabins for mountain walkers (The Norwegian Tourist Association has cabins at 9-10 different locations, Statsskog has cabins at least at 5 locations), there are several marked routes for walking (the track from north to south is marked all the way – part of the ***North Calotte Route*** - , but it is also allowed to hike outside these marked routes), there are hiker's bridges making it possible to cross deep rivers, there are several villages for reindeer herders - used on a nomadic basis, and there are several archaeological sites from ancient history.

Occasionally the Norwegian Army may have some activities in the area, but they have no established infrastructure. Even if the area is classified as "wilderness", the distance to populated areas are not very long, due to the valleys which penetrate the landscape from the coast to the inland. The Telecom operators in Norway say it is very unlikely that they will establish new infrastructure in the inland, because the area is scarcely populated and there are few roads.

Based on the statistics from the Norwegian Tourist Association, we can assume that approx. 4.000 – 5.000 persons walks in this area every year, equally divided between the winter and the summer season. In addition to this there are hikers not using the cabins, and there are hunters, environmentalist surveyors and reindeer herders more or less regularly staying in the area. Totally we can assume that in the tourist season (/winter: February, March, April, may), summer (June, July, august September) approx 500 - 1000 persons are in the area every month.

A complete scenario for walking in this area is described in Appendix A [N4C-HPU].

For testing purposes, a more accessible area - still without telecom infrastructure – has been chosen. This area- around Ytre Fiskelausvatn in Balsfjord Municipality in Troms County - is closer described in [N4C-VST].

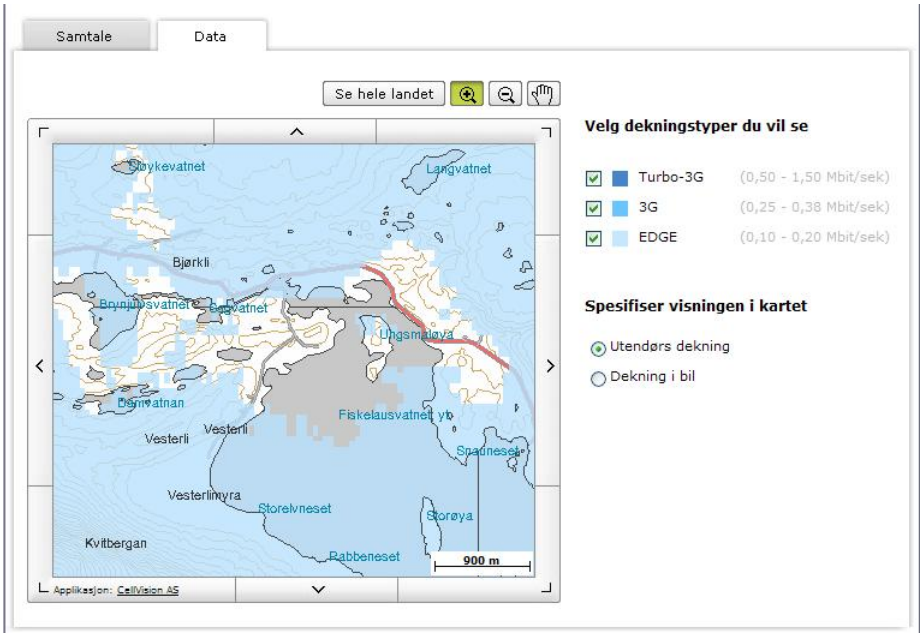


FIGURE 2: TELENOR MOBILE 3G AND EDGE COVERAGE AT FISKELAUSVATN

1.6 THE BUSINESS AND SOCIAL ENTREPRENEURSHIP DIMENSIONS

In N4C achieving technical edge brings with it the social and economic goals of growth in remote rural areas; through technical experts co-working with rural inhabitants to address the challenges they put to ICT; through creating business opportunities for rural inhabitants out of this type of co-operation. The economic effects of poor communications coverage are not confined to traditional rural industries as agriculture, forestry, tourism. Studies conducted by N4C coordinator LTU within Process IT shows that robust and flexible communication infrastructure can play a key role in

improving the effectiveness of regional and local process industries which have widely distributed infrastructure. Large gains in GNP could be achieved with more effective communications. (At http://www.youtube.com/watch?v=ApIVAXeEgfI there is a You Tube presentation of Process IT)

The dissemination and business model development that shall instrumentally create the links between the technical efforts in N4C and the realization of the potentials thereby created are focused to WP9 Dissemination. However, already in the content of the technically oriented Work packages certain hypotheses are maintained. Among the N4C applications and WP3 three groups can be identified that represent three different assumptions about how traffic in coming DTN networks in communications challenged communities will be generated. These are:

E-mail and web caching/web services – The basic assumption is that the traffic will be generated through access to the applications that are presently most used in the "normal" internet and without being bound to specific equipment.

Hikers, Hunters, Herders and Rangers Applications/Hikers' PDA – The basic assumption is that traffic will be generated from tailor-made service packages implemented in wilderness friendly small size equipment. The services are still generic in the meaning that the same services with small alterations can be used by several user groups and, the equipment can well be consumer off-the-shelf products.

Meteorological and Environmental Data Capture as well as **Animal tracking** – The basic assumption is that traffic will be generated from highly specialized use involving trained professionals. Specialized equipment, some of which is very expensive, is necessary for these applications, even if the DTN component does not necessarily differ from in the other cases.

It is significant that these different approaches are all represented together in the N4C project. The different actors who have brought them to the work plan naturally believe in their respective choices. Generating most traffic in a starter stage for DTN networks in communications challenged communities is not necessarily the same as eventually being the most useful applications in terms of sustainable development. Yet, the driver for getting the traffic and thus the network running is of given reasons of interest and the business and social entrepreneurship dimensions come out differently in relation to these different assumptions. **E-mail and web caching** is a matter of social entrepreneurship; offering communications challenged communities better options for inclusion in the knowledge society. The key tool envisioned for this, is the N4C wiki presented in Deliverable 9.5 N4C wiki (the wiki is available at http://wiki.n4c.eu) One idea is that services based on these well known applications can be developed by local entrepreneurs. **Meteorological and Environmental Data Capture** is of direct interest to SMEs in the N4C consortium; MEIS storitve za okolje d.o.o. MEIS' primary work field is air pollution modelling, engineering and software development for environmental measuring systems. They also make other environmental R&D. Developing DTN routines for delivery of data from remote areas is a way to increase the palette of services the company is able to offer. **Animal tracking** is of direct interest to the SME and N4C beneficiary Tannak AB. Tannak's business idea is to commercialise technical systems, products, prototypes and consultancy services for identification and tracking of cattle and animals.

Hiker's Applications Business dimension:

Even if traditional paper based maps and traditional compasses still are very valuable for Hiker's in the wilderness, there is a trend toward the use of electronic maps, electronic compasses and positioning systems (GPS). This has also developed further into the use of new services, in a combination of using Internet services on laptops for planning and using handheld devices in field. One such example is www.mapmyhike.com.

Additionally; hikers are often quite spread out in the wilderness, and sometimes uses walkie-talkies and radio equipment for keeping in touch with each other.

However; carrying heavy load is always a challenge for hikers and there is always a requirement to keep the number of devices and hence the weight as low as possible.

By designing and implementing hiker's applications as described in N4C, it will be possible to combine functionality from handheld devices (PDA's) and communication equipment, and to add **new functionality enabling delay tolerant contact with the rest of society**. Such a combined system with new functionality could develop into a very valuable application in a market segment where disposable income for electronics and hiking gear is quite high.

Social dimension

Staying out in wilderness for a relative long time with no contact to society is in many cases a serious obstacle for hikers who have to address some "traditional tasks" (related to work, family, society participation, etc) even on an irregular basis. A well-defined hiker's application may give hikers possibilities to perform their hobby and still take care of other responsibilities and tasks. Additionally, relatives "at home" may feel more secure and safe by having the possibility of being in touch with the hiker.

New possibilities

Some of the services and functions, which are being implemented in Hiker's application, may give rise to new services which can be exploited in an urban setting. Direct communication between handheld devices (or even laptops) may be possible substitutes for fixed network connection delivered by telecom operators. A successful experience with hiker's application should definitively lead to a possible project with direct communication between handheld devices anywhere. This should give new possibilities for innovation, both in a business and a social context.

1.7 TERMINOLOGY

Networking for Communications Challenged Communities (N4C):
This project.

Delay and Disruption Tolerant Networking (DTN):
Extension of the Internet paradigm to situations where the upper bound on round trip times for messages between nodes exceeds the expectations and immediate tolerance of human users and/or networking is subject to disruption in a regular basis for reasons beyond the control of the user.

Personal Digital Assistant (PDA):
A mobile device, cell phone, handheld device, handheld computer

Round Trip Bound (RTB):
Maximum time for a network round trip

(Current) Internet (CI):
The 'core' connected part of today's Internet
Environment with low elasticity on RTB

Communication Challenged Realm/Region (CCR):
Area that needs DTN or some other technique
Environment with high elasticity on RTB

Enclave:
Area with CCR that can use CI techniques locally but is not connected to CI core with low latency links.

Gateway Nodes:
Generally static nodes linking CCR and CI or providing an interface into an Enclave

Ability of DTN nodes to provide bundle 'custody':
May be a significant extra categorization

Store and Forward Paradigm:
E.g., e-mail, maybe peer-to-peer applications

Client-Server Paradigm:
Request-response mechanism, e.g., World Wide Web (WWW)

Unidirectional Real Time Stream Paradigm:
E.g., time-shifted TV programme

Interactive Real Time Stream Paradigm:
E.g.. Skype

Licklider Transmission Protocol (LTP):
Inter-DTN node transport unidirectional protocol originally designed for use between spacecraft in the 'Interplanetary Internet' predecessor of DTN.

Use-case diagram:
A modelling type witch uses Unified Modelling Language (UML) to describe the system from the end user perspective.

Actor:
In UML: entity that interacts with the system, either human or machine.

Interface:
In UML entities interact with each other using interfaces.

1.8 REFERENCES

[CroCoPil] Luleå University of Technology, "CroCoPil project", Project web site, http://www.cdt.ltu.se/~zcrocopil

[DakNet] A.Pentland, R. Fletcher, and A. Hasson, "DakNet: Rethinking Connectivity in Developing Nations", IEEE Computer, 2004, http://www.firstmilesolutions.com/documents/DakNet_IEEE_Computer.pdf

[DTNRG] http://www.dtnrg.org

[DTNmail] "E-mail services for delay tolerant network", Royal Institute of Technology -Telecommunication Systems Laboratory – Kista, Master thesis report, 2007-09-13, Magnus Kindgren

[EFF] Andrew J. Blumberg, blumberg@math.stanford.edu, Peter Eckersley, pde@eff.org, (August 2009). On Locational Privacy, and How to Avoid Losing it Forever. http://www.eff.org/

[Farrell07] S. Farrell, "Lakes, Noise and DTN Protocols: SeNDT & DTN Transport", SeNDT Presentation at Nokia, June 2007, http://down.dsg.cs.tcd.ie/sendt/SeNDT-LTP-T-20070619.ppt

[MASE05] Centre for Embedded Network Sensing (CENS), "Broadband Seismic Network, Mexico Experiment (MASE)", Project web site, 2005-, http://research.cens.ucla.edu/projects/2005/Seismic_Monitoring/broadband/

[MER] http://www.selenic.com/mercurial/wiki/

[N4C] http://www.n4c.eu/

[N4C-ART] D2.1 DTN - The State of the Art Version 1.1

[N4C-CR] N4C Code Repository Proposal (n4c-tcd-002-code-managemenr)
[N4C-D2.1] D2.1 N4C System Architecture (N4c-wp2-004-sys-arch-04.doc)
[N4C-D3.1] D3.1 N4C Web Application Requirements (Version 0.0)
[N4C-D8.1] D8.1 PART A: Preparation and Planning of Tests (n4c-wp8-1 Version: 2.6)
[N4C-DOW] N4C Annex I - "Description of Work"
[N4C-EN] WP3 Email and NSIM Applications (n4c-fc-002-email-nsim, Version 0.0)
[N4C-HPU] WP3 Scenario for Hiker's PDA, Use cases

[N4C-M8.1] M8.1 Summer 1 interconnected tests report (n4c-wp8 - Version: 2.3)
[N4C-SEC] DTN Security (n4c-tcd-004-security)
[N4C-VST] N4C Verbal log Norut Summer Test 2009.doc
[N4C-WP3-1] Allocation of Effort for WP3 (n4c-wp3-1)
[N4C-WTP] N4C Plan for winter test 2009 - Hikers PDA v0-9

[N4C-WTR] M8.2 Winter Tests Report 2009, Version 0.5

[SPINDLE07] BBN Technologies, "Disruption-Tolerant Networking Research at BBN: Survivable Policy-Influenced Networking: Disruption-tolerance through Learning and Evolution II (SPINDLE II)", Project Web page, 2007,

http://www.ir.bbn.com/projects/spindle/index.html

[Zebranet] M. Martonosi, "The ZebraNet Wildlife Tracker" Project web site, Princeton University, 2002-5, http://www.princeton.edu/~mrm/zebranet.html

Beck, Richard et al (2007) GPSDTN: Predictive Velocity-Enabled Delay-Tolerant Networks for Arctic Research and Sustainability. The First International Workshop on Tracking Computing Technologies, IARIA-IEEE Track 2007, July 1-6, 2007 - Silicon Valley, USA. Proceedings are published by IEEE Computer Society Press, and posted via IEEE Xplore Digital Library.

Cerf, V. et al (2002). *Delay-tolerant Network Architecture: The Evolving Interplanetary Internet*. draft-irtf-ipnrg-arch-01.txt. Internet Draft.

Farrell, S. and Cahill, V. (2006) *Delay- and Disruption-Tolerant Networking*, Artech House, ISBN: 1-59693-063-2.

Intergovernmental Panel on Climate Change (2007) *Climate Change 2007 – Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the IPCC. *Cambridge University Press,* 2007 (ISBN 978 0521 88010-7 Hardback; 978 0521 70597-4 Paperback, http://www.ipcc-wg2.org/index.html).

Lindgren, A., Doria, A., Davies, E., Grasic, S. (2009) *Probabilistic Routing Protocol for Intermittently Connected Networks* draft-irtf-dtnrg-prophet-02 http://ietfreport.isoc.org/idref/draft-irtf-dtnrg-prophet/

Lindgren A., Doria, A., Lindblom, A., Ek, M. (2008). Networking in the Land of Northern Lights - Two Years of Experiences from DTN System Deployments. In International Conference on Mobile Computing and Networking *Proceedings of the 2008 ACM workshop on Wireless networks and systems for developing regions*. Available via http://portal.acm.org/citation.cfm?id=1410066.

Mainwaring, A., Polastre, J., Szewczyk, R., Culler, D. and Anderson, J.(2002) *Wireless Sensor Networks for Habitat Monitoring. WSNA*, September 2002, Atlanta, Georgia, USA.

Udén, Maria, Doria, Avri (2007). Technology producers meeting Indigenous users: The case of Sámi Network Connectivity. *International Journal of Agricultural Resources, Governance and Ecology* (IJARGE), special issue on indigenous cultures and diffusion of innovations, Vol. 6, No. 6, 2007, pp 693-705.

Udén, Maria; Doria, Avri; Sjursen, Sigurd & Theodorsen Arne Wilhelm (2006). Anywhere? Anytime? The Northern challenge to ICT developers. In Matilainen, E. (ed.) *ICT – Tools for providing information, advice and services for rural SMEs?* RUBIES Seminar proceedings 6.–7. April 2006, Oulu Finland. Reports 10. University of Helsinki Ruralia Institute. The report is available via http://www.helsinki.fi/ruralia/information/publications.htm

WMO Guide To Meteorological Instruments And Methods Of Observation, 2008. WMO-No. 8 (Seventh edition). http://www.wmo.int/pages/prog/www/IMOP/publications/CIMO-Guide/CIMO_Guide-7th_Edition-2008.html

2. REQUIREMENTS

The N4C project is one of several projects aiming to provide Internet services (or some equivalent) to Communication Challenged Regions (CCR). The requirements were developed from:

- A request that Sámi reindeer herders in Jokkmokk municipality, Sweden, put in 2002 to the regional university in their area, to help working for genuine ICT access in their herding territory
- Basic hypotheses formulated from an expert judgement about how such a request is best met, for:
    - the Reindeer Herders in the Nordic mountain areas
    - the Mountain Police, authorities and Mountain Rangers in the Nordic mountain areas
    - other wilderness based users in communications challenged communities, who were brought in to the discussions and the ambitions also expanded to a shared North Calotte endeavour
- Elaborating those hypotheses in a dialogue and practical experiments with users. This dialogue has included that users participate in design and ownership of projects
- Performing traditional user surveys
- Requirements developed by SMEs that are participants in N4C and aim to develop services that make use of DTN

The requirements for the applications to be developed in N4C have been derived partly from previous projects, and partly in the writing of the N4C project proposal and in the initial phase of the project itself.

E-mail and web caching/web services – The starter requirements for N4C, which are developed in this Deliverable to use cases, were originally put together in a dialogue with the reindeer herder communities in Jokkmokk municipality, Sweden. A key project for the technical research getting going in this process was Sámi Network Connectivity (SNC). It also was in this project group that **Not So Instant Messenger** was developed.

Hikers, Hunters, Herders and Rangers Applications/Hikers' PDA – The base work of requirements and starter specifications were collected in the CroCoPil project. The idea that tailor-made service packages for hikers, hunters, herders and rangers, implemented in wilderness friendly small size equipment will be the most useful application was one result from a workshop about future applications in Finnish Lapland, where a main result was the EU Interreg project CroCoPil 2005-2007.

Meteorological and Environmental Data Capture and **Animal tracking** – These applications are included in N4C as result of direct interest among SME partners, who operate in communications challenged regions, to investigate how the services they offer can be furthered with DTN.

2.1 REQUIREMENTS CAPTURED FROM PREVIOUS PROJECTS

Important contributions to the N4C requirements come from two projects: Sámi Network Connectivity (SNC) and Cross Border Co-operation Pilot Network (CroCoPil). Below we present their settings and "legacy" to N4C.

2.1.1 Requirements Captured from SNC

The first step towards the formation of SNC was taken in June 2001 when a group of women reindeer herders in Sirges Sámi Village in Jokkmokk, Norrbotten County in northern Sweden, decided to start a gender equality project aimed at equal opportunities for women in reindeer herding communities and specifically Sirges itself. This project, Woman in the Sámi Village (KIS) contacted Luleå University of Technology (LTU), to invite research and development assistance. Promoting women's possibilities to remain in reindeer herding and the traditional Sámi community, especially social and technical conditions for work and business development were the focus in the discussions. Several technical and organizational dimensions were investigated and eventually, ICT access became central in the shared efforts. It was in this setting that the idea to use DTN for creating robust connectivity developed. The hypotheses among the internet experts that engaged in the effort was that the presently most widely used internet applications at global scale, e-mail and www would provide the best basis for community development. The hypothesis was confirmed in terms of the usability of e-mail and www being confirmed by the target community in formal as well as informal settings including one future workshop at the Sámi Educational Centre in Jokkmokk 2002. As demonstrated within N4C, also other hypotheses are possible and can on realistic grounds be promoted in technical and business R&D. By including several ideas about useful applications, strategic diversity is created within the N4C effort.

> The functional requirements promoted in the SNC process have been presented in several papers and presentations for instance "Providing connectivity to the Saami nomadic community" presented at the Development by Design (D2D) conference in India 2002.

The SNC functional requirements have been adopted in the N4C project and they are summed up in Section 2.7 Functional Requirements.

2.1.2 Requirements Captured from CroCoPil

CroCoPil or Cross-border Cooperation Pilot Networks was an Interreg III A North project run by Luleå University of Technology, Sweden (coordinator); Norut Tromsø and Kirkenes Kompetansesenter in Norway and, Kemi-Tornion ammattikorkeakoulu, Finland. The project was inspired by the SNC way of working and as a key step of preparation a future workshop was organized by the Finnish partner, where civil society actors, tourism and other entrepreneurs, SMEs, national and local authorities and researchers participated. The project in itself involved several activities that generated input to requirements and service ideas. The concrete legacy to N4C is the idea that evolved to "Hiker's PDA".

The objective of the CroCoPil project [CroCoPil] was to

- Develop new Internet connections and distance spanning technologies for people living in CCRs in the North Calotte Region
- Make it easier for end-users to get location-dependent Internet access

- Create meeting opportunities between end-users, researchers and technicians.
- Establish a new commercial niche in the IT-arena for the North Calotte, with an international market.

The CroCoPil project was related to the SNC project in the sense that they both addressed the challenge of connectivity for people inside a CCR. However, CroCoPil did not use the DTN platform for communication, but was based on ad-hoc Wi-Fi connections between small, hand-held computers (PDAs). This implies that the actual network would be the encounters between (carriers of) PDAs. The target users in CroCoPil were people who lived and worked in the CCR, specifically

- Semi-Nomadic Reindeer Herders
- Mountain Rangers
- Mountain Police

An important activity in CroCoPil was to identify, and, if possible, develop any new types of applications that might be useful in a CCR setting, and evaluate any commercial potential of the applications. The methodology for collecting user requirements was Focus Group Interviews with the target users (Herders, Rangers and Police). The Focus Group Interview is a very comprehensive method and is well suited for large user-driven development projects. The methodology had to be adapted somewhat to a small project with limited time and resources like CroCoPil. Nevertheless, even if no end user applications were developed, the process gave valuable insight in what kind of applications the target users wanted. Part of the CroCoPil requirements has been adopted in the N4C project and they are summed up in Section 2.7 Functional Requirements.

2.2 REQUIREMENTS CAPTURED FROM STAKEHOLDERS IN THE N4C PROJECT

The previous projects KIS, SNC and CroCoPil, have provided requirements from the Saami reindeer herders in Sweden and Norway, Mountain Rangers and Mountain Police in Norway.

From the start of the N4C project we have looked at new user groups that are likely stakeholders and beneficiaries from DTN technology. Remote sensor networks for meteorological and environmental data is one example, where MEIS in Slovenia have collected the requirements. They have also studied requirements for collection of data from sensors for wildlife observations in remote areas.

Another interesting user group is the growing number of tourists and hikers who spend a great deal of time and resources on their expeditions. Both in the summer and winter there are a significant number of tourists trekking in the most remote regions of the Scandinavian wildlife preservation areas and national parks. These areas are definitely CCRs with no mobile connectivity because preservation requirements prohibit any man-made infrastructures. Through hiker's possible use of DTN and Geoblog, the challenges related to research, development, implementation and experimentation with handheld devices in communication challenged regions, will be expanded and elaborated. Additionally a successful result of N4C will develop competence and knowledge which may be exploited in other ICT research, related to communication challenged regions in the wilderness. This may result in new applications (or services) in the military sphere or in emergency scenarios.

2.2.1 Requirements for hardware of meteorological applications

Requirements for the hardware of meteorological applications are collected from the previous and current projects of MEIS and according to special requirements of the N4C project. They have been evolving during long-term close cooperation with the Slovenian environmental agency (ARSO). Additional requirements are collected for special purposes of N4C project with cooperation with the staff from local airport in Kočevje and staff from local environmental station Iskrba. Some special requirements have been collected also during the public presentations of N4C project to children in local school.

Requirements from previous and current work of MEIS:

- Determination of the right measuring site is of great importance to ensure the representativeness of the collected environmental data for the wider area. Criteria and guidelines for selecting new measuring sites are given by World Meteorological Organization (WMO). Major recommendations include: location should be chosen within the most homogeneous geographical areas (basins, plains, hilly areas), near the station may exists geographical features (proximity to rivers, lakes, mountains ...) which could affect the measurement results and thus affect the representativeness of the measurement stations, terrain in the area of the measuring site should be level, covered with low grass, with no tall trees or buildings, as the spatial representativeness of the stations affected by CVP micro-features (proximity to shrubs, trees, other plants) or single accommodation station (soil properties ...).

- Other recommendations of WMO are mainly related to the measurements. Separately by different variables, some important recommendations from WMO are listed as follows. Air temperature - temperature sensor with radiation protection must be installed as recommended by the WMO at a height of 1:25 m and 2 m. Meter below the soil may not be concrete or asphalt, but to be either without vegetation or soil increased with low grass. Install shield should allow such protection against solar radiation as well as protection against the possibility of spray-suppression in case of wet road. Relative humidity in the air - the sensor can be installed together with the temperature sensor, if the self-heating does not affect the temperature measurements. The quality of these measurements is highly dependent on the contamination of the sensor to the pollutants from the air or road, so the sensor must be regularly monitored; calibration is done at least every 6 months. Wind speed and direction - wind sensor must be installed on a standard rate of 10 m above the ground, in the open field to avoid the impact of disturbance (turbulence) due to traffic and local obstacles. Precipitation - sensor that measures the value of accumulated precipitation must be regularly cleaned, the same applies to sensors that measure the type of precipitation (snow, rain, spray). In the latter calibration is essential. Solar radiation - when installing pyranometer for measuring of the solar radiation (direct and diffuse) is extremely important that in the vicinity of the plane of the sensor are not present any major obstacles and that sensor is not under the influence of shadow or reflection of the nearby obstacles. The pyranometer should be regularly inspected and cleaned.

- The maintenance is of great importance for the reliable operation of the automatic environmental measuring station (AMSt). It generally depends on the number and type of

measuring parameters and complexity of the AMSt. All sensors and monitors must also be calibrated in accredited laboratories periodically according to WMO standards.

Requirements for N4C and future projects:

- Low power consumption is required because the environmental stations are placed in environment away from standard power lines and only power from solar panels, wind generators and batteries is available.

- Multifunctional hardware interface is required to establish connections with the environmental stations and sensors as well with other communication devices (i.e. notebooks, PDAs, embedded computers) that will serve as data mules in DTN networks. Its tasks are collection of data from different types of environmental stations/sensors and routing of the collected data trough the DTN network. This hardware interface should meet special operation requirements in extreme environmental conditions (i.e. operating temperature range from -40°C to +85°C, outdoor enclosure, GPS, etc). It should also enable connectivity through different types of connections (i.e. WiFi, Ethernet, RS232/485, USB,).

- Animal proof - the extensive forest in Slovenian areas have a large population of wild animals including many bears, wolves and deer, especially roe deer. Permanent installations of equipment for environmental monitoring typically require measuring masts (e.g., for recording wind speed and direction) and sensitive measuring equipment. The presence of these large animals requires that this equipment is, as far as possible 'shock proofed' to survive accidental collisions.

- Animal safety - in addition it is important that risk of harm to the large animals resulting from the equipment parts needs to be minimized. For example, the use of thin ropes or wires to steady masts has to be avoided as these could hurt running animals.

Environmental pollution - it is important that equipment used in the test beds does not result in pollution of the environment. Since there is little or no mains power supply available in the test bed areas, one particular concern is that equipment that is likely to be lost (for example tracking collars for animals) or left behind in the region accidentally should not use battery technology that contains polluting heavy metals or similar, and would not be toxic or otherwise harming to animals if consumed.

2.2.2 Requirements for software of meteorological applications

Requirements for the software of meteorological applications are based on the international and national standards for the collection, distribution and storage of the meteorological data. They are mainly collected from previous projects within the collaboration of MEIS with European and Slovenian governmental agencies and institutes. For the N4C project some additional requirements appeared and are also added. Following requirements are used for determination of the final format of collected meteorological data from automatic environmental stations. The format is described in detail Appendix B. It is based on a Slovenian national format, which has enough information, so that other formats can be derived from it. Additional requirement is requested for hiker, hunters, herder, and ranger applications in the scope of the N4C project. Within these applications a PDA will be used where meteorological data will be presented in a form of RSS web feed. RSS web feed format is based on XML. For the needs of N4C project software will be able to generate RSS web feeds that will

contain environmental data derived from standard format. The RSS web feed and its data format will be developed in cooperation with NORUT team.

Requirements from previous and current work of MEIS:

- Quality control of the measured data is the most crucial function of the AMSt. It is based on measured and statistically processed data and on collected data about measuring conditions of the AMSt. An additional status information string is appended to all measured data. This status information is usually empty if the data passes the quality control. If the measured data does not pass the quality control the status string is filled with the information about failures identified by quality control. The quality control consists of various controls which vary according to the measured parameters. Examples of complex controls include: For the wind measurements the bits of the wind direction sensor are checked and it is expected that all bits should change their status over a certain period of time. If some of the bits do not change it is expected that the measurement fails. On the other hand for the air temperature measurements it is not expected that the air temperature should change rapidly in very short period of time. If such event happens the quality control is set to warn the maintainers of the system.

- Slovenian national format of environmental data is defined by Slovenian environmental agency (ARSO) as described in Appendix B.

- METAR (fr. MÉTéorologique Aviation Régulière, en. Aviation Routine Weather Report) is a meteorological report mainly used by pilots as part of a pre-flight weather briefing. It is also used by meteorologists, who use aggregated METAR information to assist in weather forecasting. It is standardized through the International Civil Aviation Organization (ICAO). This allows it to be understood throughout most of the world.

- SYNOP (surface SYNOPtic observations) is a numerical format used for reporting weather observations from manual or automatic environmental stations. It is also called FM-12 by as defined by World Meteorological Organization (WMO). A report consists of groups of numbers (and slashes where data is not available) describing environmental information.

- EURDEP (EUropean Radiological Data Exchange Platform) is a standard format for radiological data exchange in Europe as defined by The Radioactivity Environmental Monitoring (REM) group of the Institute for Environment and Sustainability, European Commission, Joint Research Centre. The latest release of the format is version 2.0, which is in use since the beginning of 2002. The data-format is applied for participation to the EURDEP network, but also for other national and international systems such as CBSS, MODEM, ARGOS, RODOS etc.

- ECURIE is a data format used in European Community Urgent Radiological Information Exchange system for the early notification and exchange of information in the event of a radiological or nuclear emergency. It is defined by The Radioactivity Environmental Monitoring (REM) group of the Institute for Environment and Sustainability, European Commission, Joint Research Centre.

Requirements for N4C and future projects:

- Software must be available for different operating systems which mean that the source code must be made using the cross-platform application and UI framework. Software should be deployed across desktop, mobile and embedded operating systems without rewriting the source code.

- RSS web feed RSS is a Web content syndication format. Its name is an acronym for Really Simple Syndication. RSS is a dialect of XML. All RSS files must conform to the XML 1.0 specification, as published on the World Wide Web Consortium (W3C) website. A summary of RSS version history: At the top level, a RSS document is a <rss> element, with a mandatory attribute called version that specifies the version of RSS that the document conforms to. If it conforms to this specification, the version attribute must be 2.0. Subordinate to the <rss> element is a single <channel> element, which contains information about the channel (metadata) and its contents (reference: RSS Advisory Board, http://www.rssboard.org/rss-specification). An example of RSS file containing basic meteorological data is presented in following figure.

```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<!-- Edited by XMLSpy® -->
<rss version="2.0">
<channel>
  <title>N4C meteorological data</title>
  <link>http://www.n4c.eu</link>
  <description>Meteorological data from N4C test beds in Slovenia and
Sweden on 22.08.2009 at 10:30:00</description>
  <item>
    <title>Ribnica</title>
    <link>http://www.n4c.eu/ribnica</link>
    <description> Air temp.: 25 deg., rel. hum.: 67, air pressure: 994 hPa,
precipitation: 0.0 mm, wind sp.: 0.8 m/s, wind dir.: 135 deg.</description>
  </item>
  <item>
    <title>Kočevje</title>
    <link>http://www.n4c.eu/kocevje</link>
    <description>Air temp.: 24 deg., rel. hum.: 55, air pressure: 993 hPa,
precipitation: 0.0 mm, wind sp.: 0.8 m/s, wind dir.: 135  deg.</</description>
  </item>
</channel>
</rss>
```

2.2.3 Requirements for hardware of Wildlife applications

For the wildlife applications a picture collection of the wild animals will be performed. Requirements for wildlife applications have been collected in close cooperation with local hunters and staff from environmental measuring station located in Iskrba. Several meetings have been organized over the telephone lines as well as at the location Iskrba where it is expected to place the devices. All requirements have been collected only for the purposes of N4C project.

Requirements for N4C and future projects:

- Camera - for a picture collection of wild animals a low power, high quality and robust camera is required. So far some of the web cameras already fulfil these requirements. Another advantage of the web cameras is the USB interface which makes them relatively simple to connect to modern embedded computers.

- The hardware should not upset the wild animals which mean that pictures will be made at daylight. At night no pictures will be taken because the photographing at night requires flashes of light which would scare the wild animals away. For this purpose also power saving is required over night when the equipment should be in sleep mode.

- Multifunctional hardware interface based on embedded computer is required to be able to collect pictures from camera as well with other communication devices (i.e. notebooks, PDAs, embedded computers) that will serve as data mules in DTN networks. Its tasks are collection of pictures from web cameras and routing of the collected pictures trough the DTN network. Embedded computer should meet special operation requirements in extreme environmental conditions (i.e. operating temperature range from -40°C to +85°C, outdoor enclosure, GPS, etc).

- Extremely low power consumption is required because the wildlife applications are placed in extreme environment away from standard power lines and only power from solar panels and batteries is available.

- Animal proof - The equipment for the wildlife applications will be installed on the similar locations as the automatic environmental stations where wild animals are present. The presence of some large animals requires that this equipment is, as far as possible 'shock proofed' to survive accidental collisions.

- Animal safety - as in the case of automatic environmental stations also in addition it is important that risk of harm to the large animals resulting from the equipment parts needs to be minimized.

- Environmental pollution - it is important that equipment used in the test beds does not result in pollution of the environment.

2.2.4 Requirements for software of wildlife applications

Requirements for wildlife applications software have also been collected in close cooperation with local hunters. Several meetings have been organized to determine them. All requirements have been collected only for the purposes of N4C project where pictures of wild animals will be collected and distributed to central database. At the central database this pictures will be analyzed manually where some estimations about the wildlife population will be made.

Requirements for N4C and future projects:

- For the collection of pictures of wild animals special software is required that monitors the changes on the pictures from the camera. When changes or motion on the pictures is detected a photo is taken and transferred over the DTN network to central database.

- Some research has been made to find such software in the open source community. The software solution named "Motion" has been found that fulfils all the requirements. It is going to be implemented on embedded computer. "Motion" is a program that monitors the video signal from one or more cameras and is able to detect if a significant part of the picture has changed; in other words, it can detect motion. The program is written in C and is made for the Linux operating system. Motion is a command line based tool whose output can be either jpeg, ppm files or mpeg video sequences. Motion is strictly command line driven and can run as a daemon with a rather small footprint. Some of motion's features include: taking snapshots of movement, watch multiple video devices at the same time, watch multiple inputs on one capture card at the same time, live streaming webcam (using multipart/x-mixed-replace), real time creation of mpeg movies using libraries from ffmpeg, take automated snapshots on regular intervals, take automated snapshots at irregular intervals using cron, execute external commands when detecting movement (and e.g. send SMS or e-mail), motion tracking (camera follow motion - special hardware required), feed events to a MySQL or PostgreSQL database, feed video back to a video4linux loopback for real time viewing, lots of user contributed related projects with web interfaces etc., user configurable and user defined on screen display, control via browser (older versions used xml-rpc), automatic noise and threshold control, is a daemon with low CPU consumption and small memory footprint. (Reference: http://www.lavrsen.dk/twiki/bin/view/Motion/WebHome).

2.2.5 Requirements captured from hikers

Based on the hypothesis from experts and discussions with experienced mountain tourists, we have developed a set of scenarios for the typical hiker, illustrating the most likely functions and applications that s/he would need in a DTN setting. The scenarios are described in Appendix A: WP3 Scenario for Hiker's PDA, Use cases [N4C-HPU].

The scenarios give rise to a number of use cases for the Hikers PDA. The use cases have been shaped into simple UML-like schemas that will serve as the functional descriptions and will subsequently be the basis for developing the actual applications.

The scenario method is useful not only for capturing functional requirements, but also say something about the class of equipment that can be used, physical properties of the equipment (the problems of weight, humidity resistance, power and batteries), the interaction between different user groups (social aspects), the societal infrastructure and context of the system etc. The functional requirements are summed up in Section 2.7 Functional Requirements.

2.2.6 Requirements from other beneficiaries and stakeholders

As the N4C project has progressed and more people have heard about the experiments we have carried out, it has attracted the interest of some new potential users. We have been approached by colleagues from the National Centre of Telemedicine in Norway, and put in contact with an Indian doctor who runs a small hospital in rural India. The challenge we are confronted with is: can DTN be a useful technology for telemedicine services in a developing nation like India? We do not have the resources to pursue this challenge within the framework of the N4C, but it certainly is a task for future investigation.

2.3 IMPACT FROM OTHER APPLICATION SCENARIOS

In [N4C-ART] section 4 "Usage Scenarios and Challenges" there is a comprehensive description of the on-going research activities in DTN. Significant resources have been allocated to a great number of projects world wide. Application scenarios include spacecraft communication, military and tactical systems, disaster and emergency response, static and mobile wireless sensor networks, various methods for extending the Internet.

The test beds of N4C concentrate primarily on the kind of unstructured scenario described in the SNC project, but there will also be elements where the kind of predetermined mobility paths described by MIT Media Lab in the [DakNet] project will be relevant:

- In northern Sweden there are relatively regular helicopter routes which are seen as one way of delivering bundles into the heart of the N4C test bed area.
- In Kočevje the forest outposts and environmental monitors may be visited relatively regularly by forestry operatives.

Integrating the highly unstructured basic SNC type of scenario with a more predictable type of mobility will be important for N4C.

The Hiker's PDA application to be developed by WP3 of N4C is intended to allow tourists to collect relevant information from other hikers, local people and static posts within the communication challenged test bed regions. Here the information is not necessarily specific to a particular person or destination node, and the intentional addressing mechanisms that were prototyped in the SPINDLE II project [SPINDLE07] and are now being deployed in military/tactical scenarios, are likely to be relevant to N4C. Information can be addressed to describe its content which allows end users to determine the relevance or otherwise of such bundles.

The basic proposal for the N4C reindeer tracking application has already considered the input from the Zebranet project [Zebranet], but there is likely to be some useful synergy in looking at other projects in this general area.

The N4C partners that were previously involved in the wireless sensor project SENDT [Farrell07] and the partners involved in environmental sensing (primarily in Slovenia) are likely to be assisted by

experiences in the CENS portfolio [MASE05]. The hierarchical sensor networks developed by CENS may prove to be of relevance here.

The work which CENS have done in the MASE project is relevant to extending the range of wireless point-to-point links so that it might be possible to link gateways more closely into the communications challenged regions as is envisaged in N4C WP6.

2.4 METHODOLOGY

The N4C project will develop a limited number demonstrators or prototypes of applications for a DTN environment. The software development process has been described in the DOW as follows: "An iterative development process adapted to the overall progress of the project will be chosen. Each iteration will include an opportunity for user feedback either through foil presentations at project meetings (most important through early iterations), or through seasonal field test (most important through later iterations)."
Many partners are involved in the development, and have their specific software development environments. However, after some deliberation among the partners, there is a common view that the software development process will be a simplified version of the spiral model, which is iterative. The spiral model is a software development process combining elements of both design and prototyping-in-stages, in an effort to combine advantages of top-down and bottom-up concepts.

The spiral model is intended for large, expensive and complicated projects; therefore we will not reach the final stages during the N4C project. The applications must be realistically possible to implement on the chosen platform, within the timeframe and resources available in N4C. A guiding principle will be to adopt existing open source applications, and with a minimum of changes, modify them to run over DTN.

This document, Functional Specification (Initial), is part of the spiral development cycles. The initial version was due as deliverable D 3.1 in month 6. According to the DOW it will be a "living document" and updated for internal use throughout the project, with internal delivery dates in month 18 and 24. The final version of this document and the rest of the WP3 documentation will be delivered in month 30 together with the final version of the prototypes (D3.3).

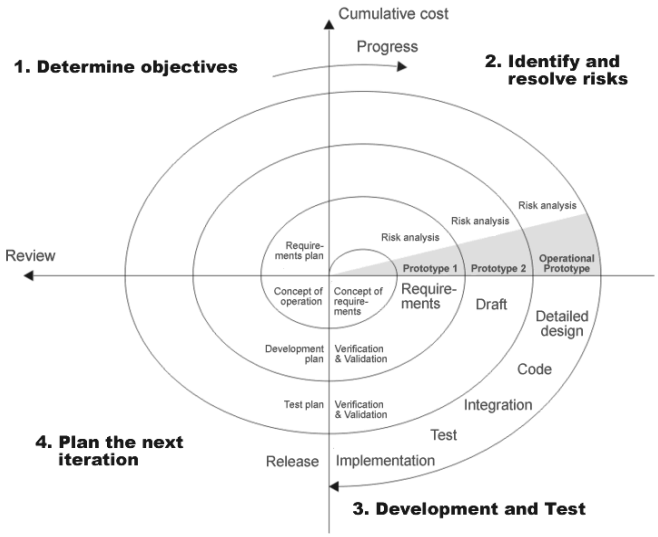


FIGURE 3: FROM WIKIPEDIA: SPIRAL MODEL (BOEHM, 1988).

2.5 NUMBERS

It is envisioned that a CCR would have a maximum of perhaps 200 users, of whom maybe 30% would be active, in the sense of using DTN services regularly on a daily basis, at any one time.

2.6 EXISTING SYSTEM

In the target areas of the N4C test beds it can be argued that there is no existing system The kind of Internet-style access familiar in more populous regions essentially does not exist, so that the kind of applications that we are seeking to introduce are not available other than possibly in an extremely limited form using satellite communications. Thus we are trying to replace a (non-)system with no basic Internet services (e-mail, web access and services built on such systems), with a system that provides (possibly) some basic Internet services. Many current applications rely on running in an environment that has a Round Trip Bound (RTB) taken from a limited range with a maximum value that is comparable to the attention span of the human users of the system as with the current Internet. In the DTN-based systems envisaged in N4C the RTB will often be much larger, measured in hours or even days, with a much higher variability. We have used the term high-elasticity RTB for this 'constraint' on the system. Apart from e-mail, which was originally designed to work in such an environment, most existing applications are not directly applicable to this environment and the aim will be to provide the users with applications that mirror the key features of corresponding Internet applications but which will operate in the high-elasticity RTB environment while managing user expectations to provide a useful service in this environment.

Adapting applications requires:

- Technical solution that extends the domain of operation to one which may include DTN transports in addition to conventional IP transports
- User Expectation Management (this may imply different or extended User Interfaces): A critical requirement because the applications cannot guarantee any response, so users may be frustrated etc.
- Some applications are unlikely to work effectively in a DTN environment with long Round Trip Bounds: Especially true of applications using **Interactive Real Time Streams** (note that this does not necessarily imply that you cannot implement, say, Voice over IP over DTN transport, but it is unlikely to provide an equivalent user experience to an Internet Telephone application in a situation where the round trip time is measured in hours).

Interactive transaction applications like DTN sensitive remote banking might be possible to develop, but security will remain a serious challenge.

Existing applications that could or have been used in CCRs during previous projects include:

- 'Standard' Internet e-mail clients - little or no adaptation is required in these applications but the e-mail addresses to be used while in the CCR and elsewhere need to be considered. Generally it will be difficult for users to make direct use of the e-mail addresses that they have

been accustomed to using in the Current Internet as the naming conventions are likely to differ somewhat in the CCRs.

- 'Standard' web browser clients (e.g., Mozilla Firefox, Internet Explorer, and Opera) are intended to remain the primary means for displaying content delivered over the DTN infrastructure. This has been demonstrated during previous projects and during the N4C tests in summer 2008. However, 'plug-ins' or similar add-ons will be needed to inform the user about the status of requests for content that are being fulfilled using the DTN infrastructure, and hence will take a longer time to deliver than is expected when using the Current Internet.

- The Wwwoffle HTTP proxy and content cache (http://www.gedanken.demon.co.uk/wwwoffle/). This package has been used to manage the delivery of web content to users in a CCR during previous tests. However, it was only used in a limited form of 'event driven provider push' mode where pages and sites to be delivered to clients in the DTN were pre-configured by administrative action at the gateway in the Internet. Extension of this system to work with different types of content and HTTP/1.1 will be desirable.

- Prototype NSIM application. Delivers messages to machines rather than users; was originally intended for debugging purposes.

- DTNmail application. This application was written as a Masters Diploma Project [DTNmail] by Magnus Kindgren. The application has been used during a number of trials in 2007 and 2008. The project uses a number of open source applications to provide mail delivery and display over a DTN infrastructure. Mail is interchanged between nodes using the Batch SMTP mechanism encapsulated in DTN bundles. The existing version uses a number of 'heavyweight' applications (including Exim, Apache, Dovecot and Squirrelmail), which may overload some of the low end platforms that are envisioned as hardware for (for example) the Hiker's PDA platform. Development will possibly seek to reduce the 'footprint' of this application. One issue that has to be addressed is the e-mail addresses to be used when working in a CCR.

2.7 FUNCTIONAL REQUIREMENTS

This section lists the selected functional requirements captured from SNC, CroCoPil and N4C.

The functional requirements from SNC are:

- E-mail - both fully nomadic and delivered to village gateways for pickup by standard hosts
- NSIM - Not So Instant Messaging [N4C-EN]
- Web caching capabilities for DTN environment [N4C-D3.1]:
  - Event driven provider pushed information
  - Event driven user pulled information
  - Ad hoc user site requests
  - Ad hoc user search requests
  - Weather (snow, rain etc. in-field Weather services)
  - Health services (location of medical-, physical-, heart starter etc.)
  - eLearning, Governmental services: etc.

The functional requirements from CroCoPil are:

- Geoblog /Photoblog application with Mobile Ad-hoc Wi-Fi Network (Manet)
- Auto Discovery (using IPv6 and multicast to automatically discover other devices in the field)

The functional requirements for N4C are:

- Establishing membership in a CCR and Initializing the Hikers PDA (requires Internet connection)
- Initializing the Hikers PDA (in Manet and DTN mode)
- Geoblog, Photo blog (automatic blog with GPS for my location and/or photo location)
- Map with GPS for own location: Maemo Mapper
- Point Of Interest (POI).
- Message with own location
- Information-push (Functionality like iPhone apps: AIM, Centrl, fring and Nimbuzz)
- DTN RSS feed (RSS/Atom feeds delivered to you over DTN, http://reeves.viagenie.ca/)

Initialization of location dependent information

- Tourism service providers and Wildlife surveyors
- In-field Weather services
- Geology, biology, local flora and fauna
- Point Of Interests: Location of nearest tourist shelter and food services etc.
- Health services (location of nearest medical-, physical-, heart starter, first aid info for field use)
- Communications installations: Emergency phones, ICE Coverage maps
- Authorities: E-government service (web service)
- Fishing- and hunting-permit
- Access information (keys to cottages etc.)

The functional requirements for N4C from MEIS are:

- WMO (World Meteorological Organization) standard meteorological station using DTN to transfer meteorological data [N4C-D8.1]

3. FUNCTIONAL DESCRIPTION

3.1 GENERAL CONSTRAINTS, SIZING AND PERFORMANCE

The applications and the platforms on which they run will need to meet a number of general constraints which will in turn impact on the sizing and performance targets that are appropriate for these applications.

3.1.1 Power Availability

In CCRs power is at a premium. Mains power is very unlikely to be available and power from local renewable resources will be variable and limited in amount. All platforms and applications will need to be designed with power conservations as a top priority. In particular functionality needs to be implemented to allow platforms to spend as much time as possible in power saving sleep modes, especially when the applications are idle. It is expected that Wi-Fi will be the mainstay of communications and care needs to be taken with the use of ad-hoc mode which can result in heavy power consumption due to scanning for potential communication opportunities at regular intervals.

Portable power is a field we are watching, to utilize sun[2], wind, Peltier or Seebeck effect.

3.1.2 Portability

Hosts need to be lightweight and readily portable as many of them will be permanently accompanying people on foot when in use.

3.1.3 Processor Capability

To meet the power consumption requirements, processors used in platforms will not be at the top end of the available performance spectrum. Applications should reduce their demands on the processor capability wherever possible.

3.1.4 Memory and Non-volatile Storage Size

At this time the CCRs in which the applications will be operating are expected to arrange from tens to hundreds of machines and users. Memory and storage on hosts will typically be appropriate for a single user, and village gateways and routers will need to cater for a proportion of the expected user population. The exact volume of data that might be expected needs to be monitored during testing, but can be estimated from typical E-mail and web page data volumes. Further work is needed to determine appropriate guidelines.

3.1.5 'Bandwidth' and Communication Opportunities

The N4C DTN architecture is reliant on opportunistic communications. The network throughput, and the achievement of 'broadband'-like performance, is dependent on achieving a good communication rate during communication opportunities. Experimentation indicates that the effective range of Wi-Fi communication is approximately 100 metres with handheld units and perhaps 250 metres with better antennas. Duration of typical communication opportunities is in the range of a

[2] https://powertraveller.com/iwantsome/primatepower/

few seconds (when mobiles pass without stopping) to maybe 10 minutes (for example when a helicopter stops to unload). This indicates the throughput that would be necessary to transfer the DTN bundles at each communication opportunity. When using Wi-Fi there is a significant delay in starting up a connection and the bit rate depends on the quality of the connection. Experience show that it may be better to force the communication rate to a fixed value in short opportunities to avoid wasted time and bandwidth renegotiating bit rates. The following table assumes a set up time of 5 seconds and a constant bit rate of 11Mb/s (maximum 802.11b rate), and as this is theoretical values it remains to be tested in the lab and out in the wilderness.

Encounter Type	Passing Speed	Expected Duration of Communication Opportunity	Potential Total Data Transfer with Wi-Fi (Kilobytes)
Helicopter flying past stationary ground node	150km/h	12 seconds	962,5
Two passing moving snowmobiles	80km/h	18 seconds	1787,5
Two passing moving walkers	8km/h	90 seconds	11687,5
Walker passing stationary ground node	4km/h	180 seconds	24062,5
Stationary encounter (per 10 minutes)	0km/h	600 seconds	81812,5

3.1.6 Performance Monitoring

Applications developed or adapted for use in the N4C environment will also need to be monitored to ensure that they are performing as expected. The exact data that needs to be captured will necessarily be dependent on the nature of the application and will be determined during the development of the applications.

The performance of the DTN communications through each application needs to be monitored including:

- Number of bundles sent
- Time of occurrence, duration, identity of partners and bundles transferred during each communication opportunity
- If possible, geographical location of opportunity
- Parameters of dynamic routing protocols

3.2 USE CASES

The use cases presented here are divided into a number of sections:

- Use cases demonstrating typical structures of behaviour in CCRs as exemplified by the testbed scenarios in the N4C summer tests 2008. The diagrams may at first sight appear to be 'network topologies' but it is important to realize that, unlike the Internet, a CCR is not 'defined' by the topology of its connections. The links between 'nodes' shown in these diagrams reflect the expected opportunities for communication, which the nodes normally had. A CCR is effectively defined by 'membership': a pair of nodes that are members of a given CCR can potentially exchange messages whenever they have an opportunity to communicate. The physical location of the nodes is unimportant as is the means of communication: all that is important is the opportunity. So although a CCR will typically be associated with a physical region and certain static nodes will be fixed in that region for reasons that are important for the functioning of the DTN infrastructure (such as meteorological data collection stations or 'routers' at important path meeting points), many nodes are expected to be mobile and will not necessarily remain in the nominal physical bounds of the CCR at all times. Moreover, by the communications challenged nature of a CCR it is not possible for a node to ascertain that it is 'within' the CCR because it will often not have communications with any other node. All that is possible is to exercise a communications opportunity with a fellow member when it arises.

- Use cases for E-mail in communications challenged regions.

- Use cases demonstrating the various modes of operation of the extended cached web application developed by N4C. Today most computer users are familiar and comfortable with accessing information and applications through a web based interface based on a web browser client. To build on this user comfort level, N4C will endeavour to extend the web paradigm to situations with high elasticity on RTB resulting in potential long delays before delivery of information. This will be done, so far as is possible, by adapting a conventional web browser to manage the user experience of web browsing in a DTN environment.

- Use case for meteorological data delivery. Taking data collected by a meteorological data capture station residing in a CCR and delivering it to clients both in the Internet and elsewhere in the CCR.

Use cases are not presented for the NSIM as it is primarily a tool for development technicians rather than end users.

3.2.1 Use Cases Showing DTN-based CCR Structures

The aim of the first summer tests [N4C-M8.1] was to try and check the legacy hardware and software from the previous test, but it can also be viewed as **three use cases: One use case** was performed in Slovenia, and **two use cases** in the Swedish part of the tests was performed in Lapland's hard to access mountain area focusing on the actual use of various services using the DTN and PRoPHET platform. **The first use case** was performed in Slovenia, and was done in a more controlled environment focusing on actual routing through the DTN and PRoPHET platform. The description of the DTN topology in figure 4 is given in section 1.a) in [N4C-M8.1].

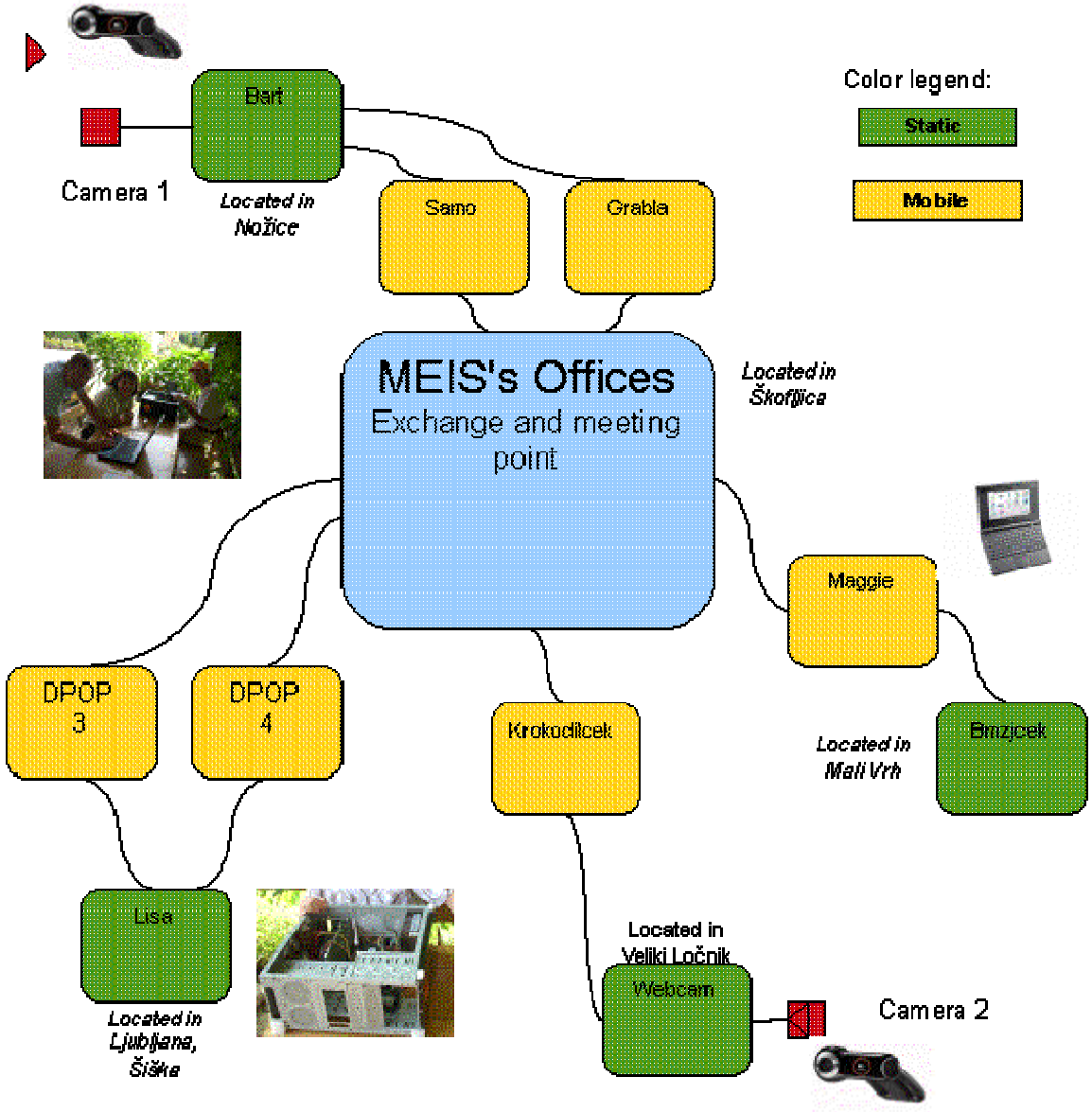


FIGURE 4: CCR STRUCTURE IN SLOVENIA

The second use case took place in the small Sámi village Saltoluokta during the first week of testing. The description of the DTN topology in figure 5 is given in section 1.b) in [N4C-M8.1].

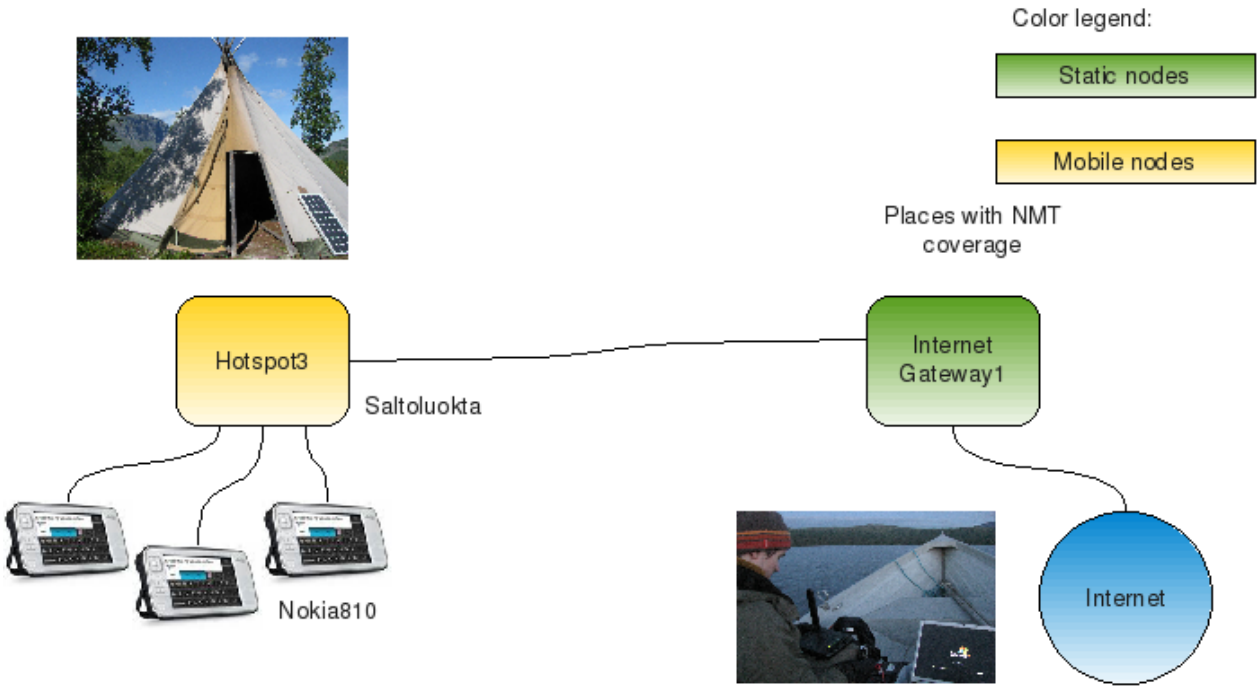


FIGURE 5: FIRST WEEK'S CCR STRUCTURE USED IN SWEDEN

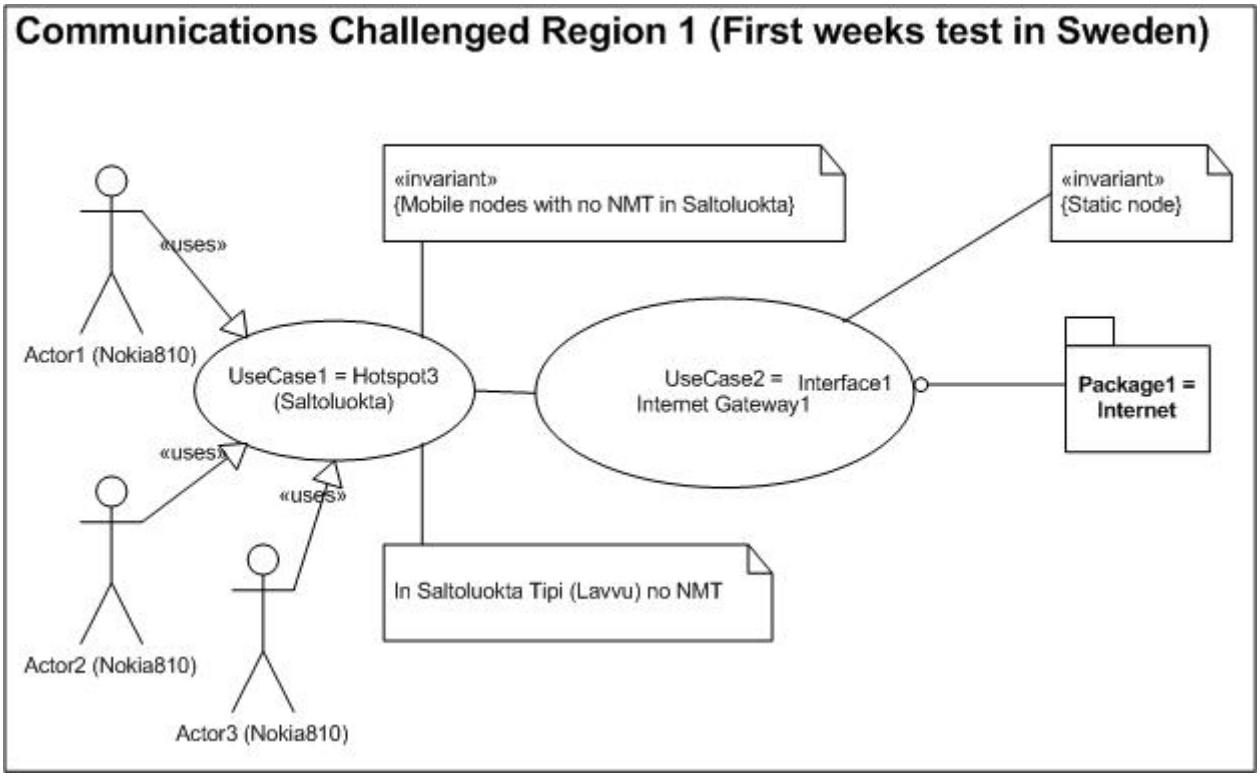


FIGURE 6: USE CASES FOR FIRST WEEK'S TEST IN SALTOLUOKTA

The third use case was performed during the second week of tests at the Helicopter base in Ritsem, at a mountain and in Staloluokta. The description of the DTN topology in figure 7 is given in section 1.b) in [N4C-M8.1].

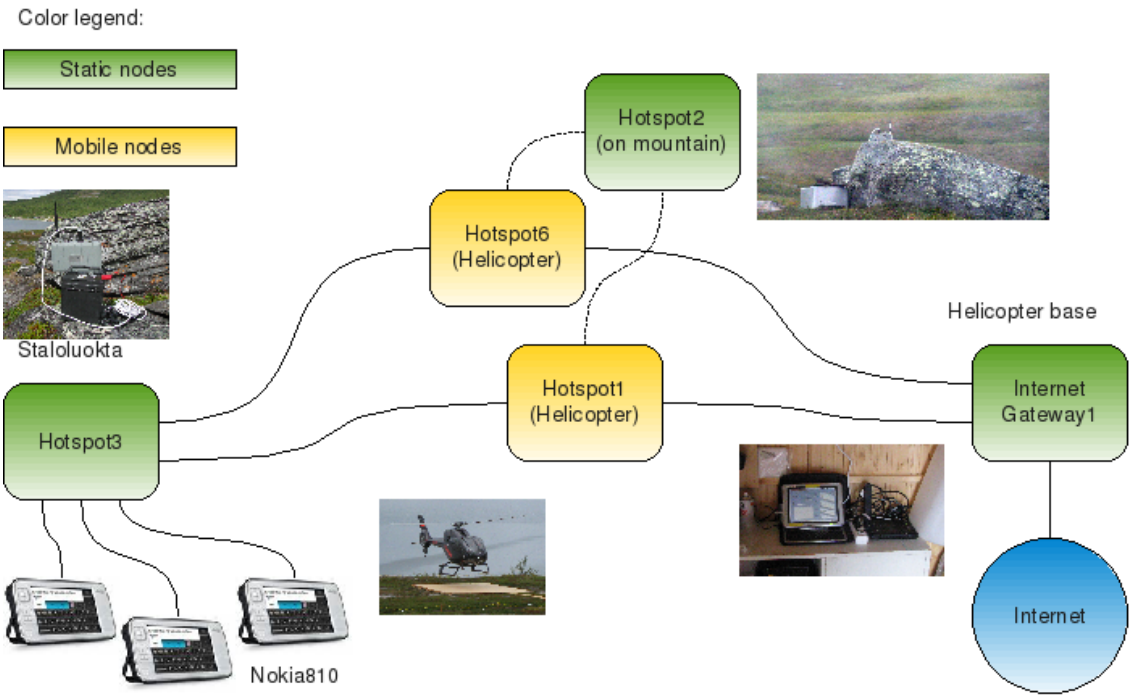


FIGURE 7: SECOND WEEK'S CCR STRUCTURE USED IN SWEDEN

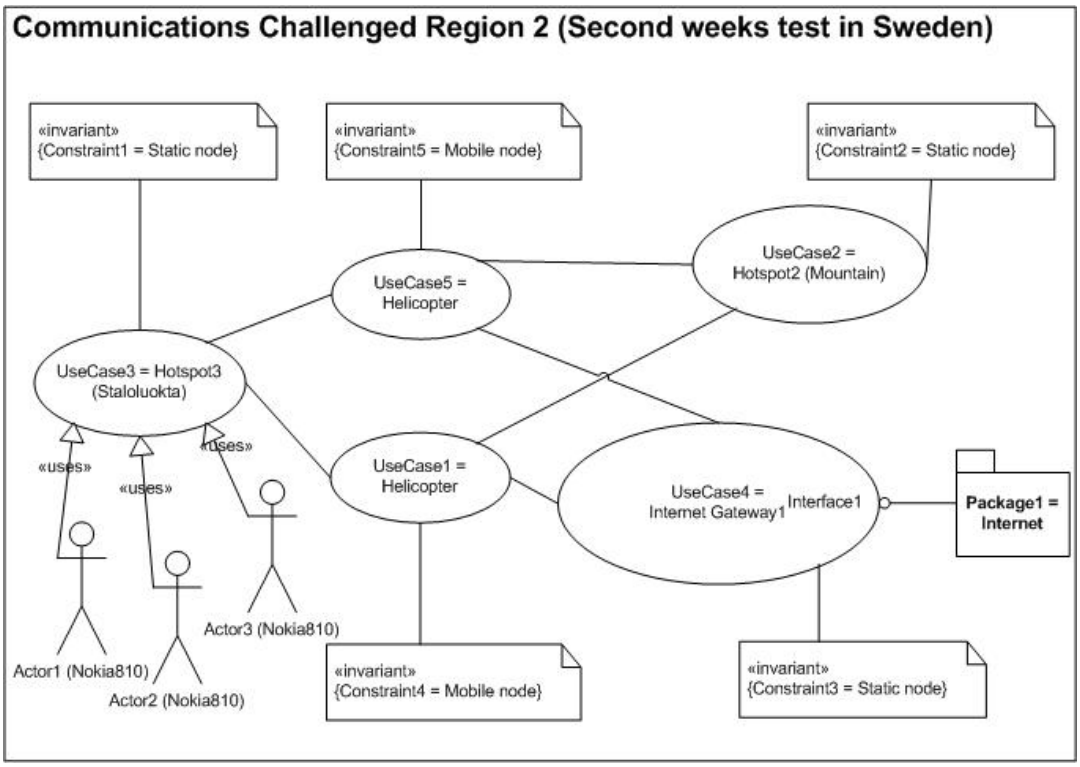


FIGURE 8: USE CASES FOR SECOND WEEK'S TEST IN STALOLUOKTA AND RITSEM

3.2.2 Use cases for the Hiker's Applications Scenario

Figure 9 gives an overview of all the use cases for the Hiker's PDA Scenario.

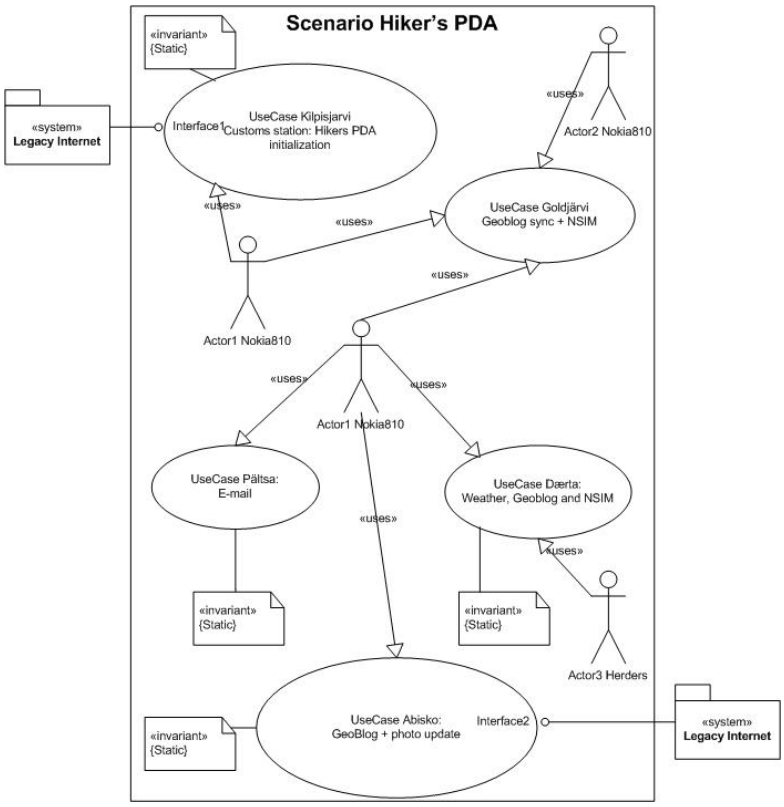


FIGURE 9: USE CASES FOR THE HIKER'S APPLICATIONS SCENARIO

The use cases for the Hiker's applications scenario shown in Figure 9 are described in Appendix A [N4C-HPU]. Use Cases Goldjärvi, Dærta and Abisko are all elaborated during the Norut Summer test 2009, see [N4C-VST]. The use case for the initialization of the Hiker's PDA is shown in Figure 10. There is also a description of the initialization process at
http://wiki.n4c.eu/wiki/index.php/Technical_Page

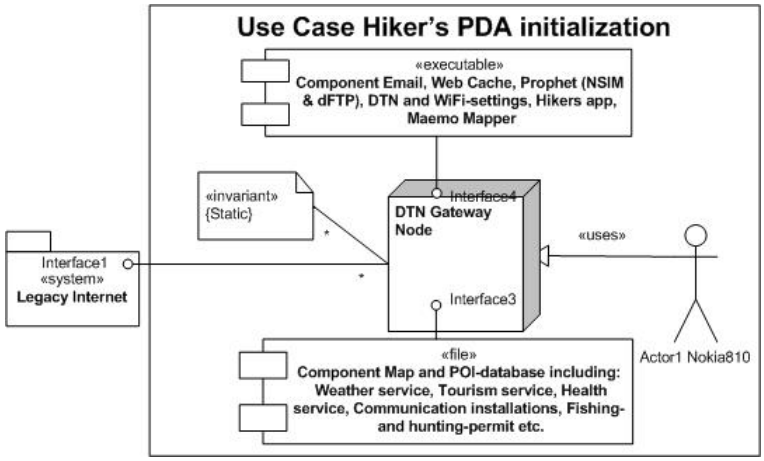


FIGURE 10: USE CASE HIKER'S PDA INITIALIZATION

3.2.3 Use Cases for E-mail

Conventional Internet E-mail is a 'store and forward' application already. Standard E-mail clients will provide all the necessary user functionality without modification. DTN will provide a novel transport mechanism that can deliver E-mails in CCRs that do not have any existing Internet connectivity. Two use cases are envisioned depending on whether the E-mail is delivered all the way to DTN-enabled hosts over DTN or delivered to village gateways which can then be accessed locally by conventional hosts that are not DTN-enabled.

3.2.3.1 E-mail Delivered to DTN-enabled Hosts

Users are given an E-mail account in a mail domain linked to a CCR with which they are normally associated.

E-mail originating in the existing Internet for delivery to one of these accounts is routed to an Internet gateway for the CCR. Each e-mail is mapped to one or more DTN bundle each with a destination EID that indicates a single E-mail account in the CCR domain to which the e-mail is to be delivered. DTN dynamic routing is used to deliver the E-mail to the DTN-enabled host that has expressed an interest in taking delivery of E-mail for the user account.

E-mail originating at DTN-enabled hosts will also be encapsulated into one or more bundles. Each bundle is either destined for another single e-mail account within the CCR or the Internet gateway if the e-mail is destined for accounts not in the CCR mail domain (in this case one bundle can be used for multiple destinations; the gateway will handle despatch to multiple Internet destinations).

Since the DTN

- does not offer guaranteed delivery,
- cannot guarantee to deliver notification messages if these are sent by receiving hosts, and
- may deliver multiple copies of each e-mail

each participating host or gateway needs to maintain a cache of recently sent and received messages in order to allow resending of messages that appear not have been delivered before their expiry time (which should probably be set for a few days in the future) and to suppress duplicates.

3.2.3.2 E-mail Delivered to Village Gateways

To cater for users who do not wish to carry a DTN-enabled host or wish to use an existing conventional Internet host, E-mail accounts can be created in a (alternative) mail domain linked to the villages or camps in the CCR that have a local gateway.

E-mail is transported between the CCR Internet gateway and the village gateways in DTN bundles. At the village gateways e-mail is made available to local clients using conventional e-mail access protocols such as IMAP or POP3 over TCP/IP connections. Outgoing e-mail from hosts connected to the village gateway is handled similarly, using a local SMTP server on the gateway and despatching e-mail to the Internet gateway.

Users can arrange for e-mail to be delivered to one specific or all the village gateways in the CCR depending on their expected travel and living patterns.

Gateways can arrange to batch e-mails destined for the same gateway to reduce the number of bundles sent, but should consider the size of such bundles if some of the e-mails are large. As with the previous case, consideration has to be given to retransmission and duplicate suppression.

3.2.4 Use cases for Cached Web Application

In order to sidestep the difficulties that the HTTP (HyperText Transfer Protocol) used by web applications and the poor user experience that would be delivered when a web client 'browser' and web server are connected over a DTN network that may have a very high upper bound on its round trip time, we propose to provide a local cache adjacent to the browser which can be accessed over a link that offers a low bound on its round trip time such as is the normal expectation for web applications.

To avoid the need for multiple round trips over the DTN network, the local cache would be populated with 'bundles' of content constituting at least sufficient information to display a complete web page. This information would be assembled by a corresponding remote proxy which would access the appropriate web server(s) and assemble the information into a bundle for transmission across the DTN network. A high level view of the components of this proposed system is shown in Figure 11.

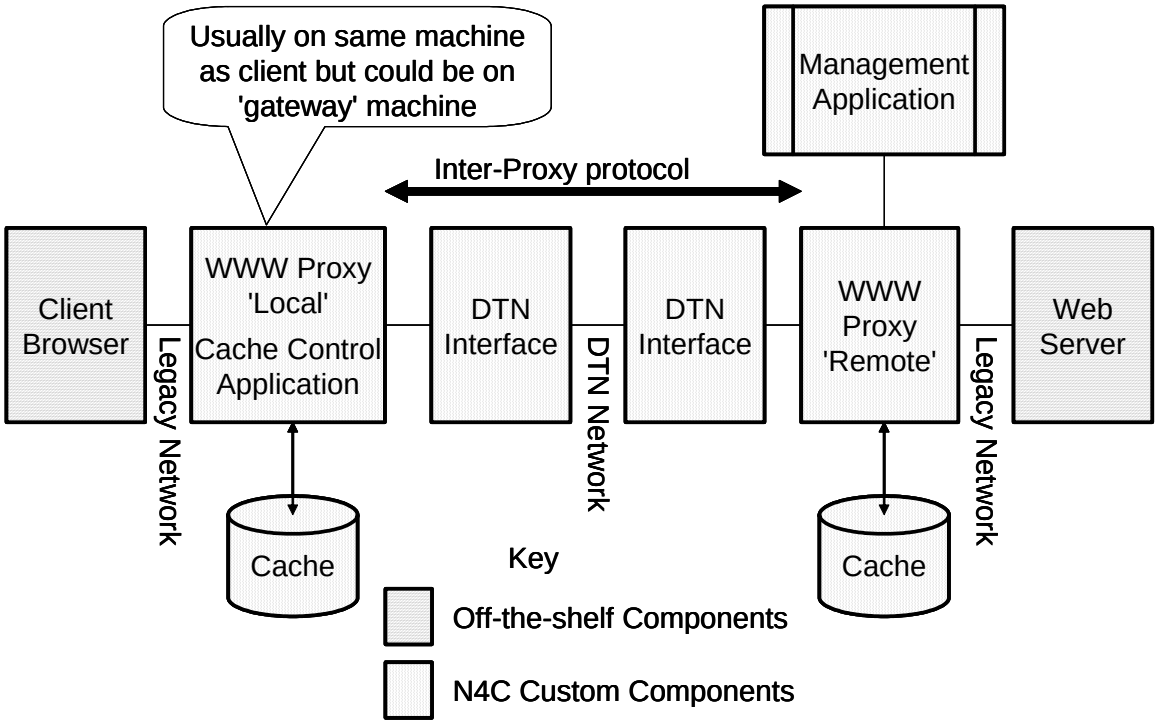


FIGURE 11 WEB CACHING APPLICATION COMPONENTS

The intention is that the client browser and web servers would be standard components - in practice N4C has no control over the web servers and these must be accessed as would normally be done in the Internet. The proxies and control applications are custom developments.

The Cache Control Application runs on the local proxy which serves cached content using the standard HTTP protocol to the clients. Its user interface is a web form application that provides information about the contents of the local cache to the user.

The cache may be populated either in response to direct user requests that are intercepted by the local proxy or as a result of requests instantiated directly on the remote proxy. Locally generated requests are repackaged by the local proxy and passed across the DTN network to be actioned by the remote proxy. The local proxy accepts bundles of information returned in response to requests and makes them available to the client. The Cache Control Application reports the status of each request reflecting if and when the corresponding information bundle is received.

Delivered information can either be public or private. Public information will be made available to any user that accesses the local cache. Private information will be delivered only to the user who requested it. The Cache Control Application manages the privacy controls that are needed to handle the issues discussed in Sections 1.2 and 3.6 To avoid requiring explicit session authentication with user accounts and passwords, thus making the use of the web more similar to that on the conventional Internet, access to private information can be controlled by means of cookies stored with the client browser.

As discussed in Section 1.2, the models used for some web services will not provide a satisfactory user experience when transport across a DTN Network with a high elasticity round trip bound is used. The following sections provide use cases for services that are used to provide close equivalents to the services that users have come to expect from the WWW in the existing Internet. These include periodic refresh of a web (replaced by periodic 'pulling' of the relevant web page controlled by the management application at the remote proxy) and notification of events through a dynamic feed such as RSS (replaced by the event driven 'pushing' of the relevant web page). The service models described here are believed to satisfy a large fraction of the requirements discovered from potential users during the SNC project and others.

The use cases are described in terms of whether the transfer of information gathered by the remote proxy from the remote proxy (connected to the existing Internet) and to the local cache proxy over DTN is driven by a specific user request that 'pulls' information from the Internet to the local cache or by an event generated by an information provider that results in information being 'pushed' out from the remote proxy to the local cache. It is expected that the management application will provide means by which a user can register to have provider pushed information delivered: if this is not provided it would provide a possibility of 'spam' deliveries being made which is clearly undesirable. An administrator will also be able to arrange that some content can be delivered either regularly or on an event driven basis and is then made available publically (e.g., regular weather forecasts or occasional environmental warnings).

A major subject for research and user driven experiment in N4C is the heuristics to be applied in determining what information should be retrieved and incorporated in the bundle resulting from a given request. The vast majority of web sites (and individual pages) will require recursive fetches of information whereby an initial general layout will specify the fetching of additional URLs to provide style sheets, images and other components to make up a completed display page. In many cases this procedure is recursive. In order to avoid near-infinite recursion and building an extremely large information bundle, it is necessary to determine the recursion depth to which the retrieval should go. This is not something that can be set arbitrarily and apply to all pages, or indeed to every path on the same page. Heuristics will be needed. It will also be useful to allow the user to control the retrieval through preferences.

It may well be that it would be desirable to retrieve some or all of the links that appear on a web page as part of the information bundle even though these items would normally not be retrieved immediately when the page is viewed over a conventional web connection. An example might be retrieving a subset of the links pointed to by a search engine output page or some of the items in a bibliography. Again heuristics and user preferences will be needed to control the retrieval.

Many web sites utilize program driven page creation, whereby pages are assembled in real time when a request is made, or consists of client side programs that are downloaded as part of the initial page retrieval. Handling such web sites requires different and novel techniques.

Finally interactive form filling and transactional applications will need special consideration.

3.2.4.1 User-pulled Regular

A user could actively register with the N4C web management application to have certain pages regularly uploaded to the cache or caches nearest where s/he is. Alternatively, this could be arranged by usage monitoring. This service model can be used to emulate regular refreshes of content.

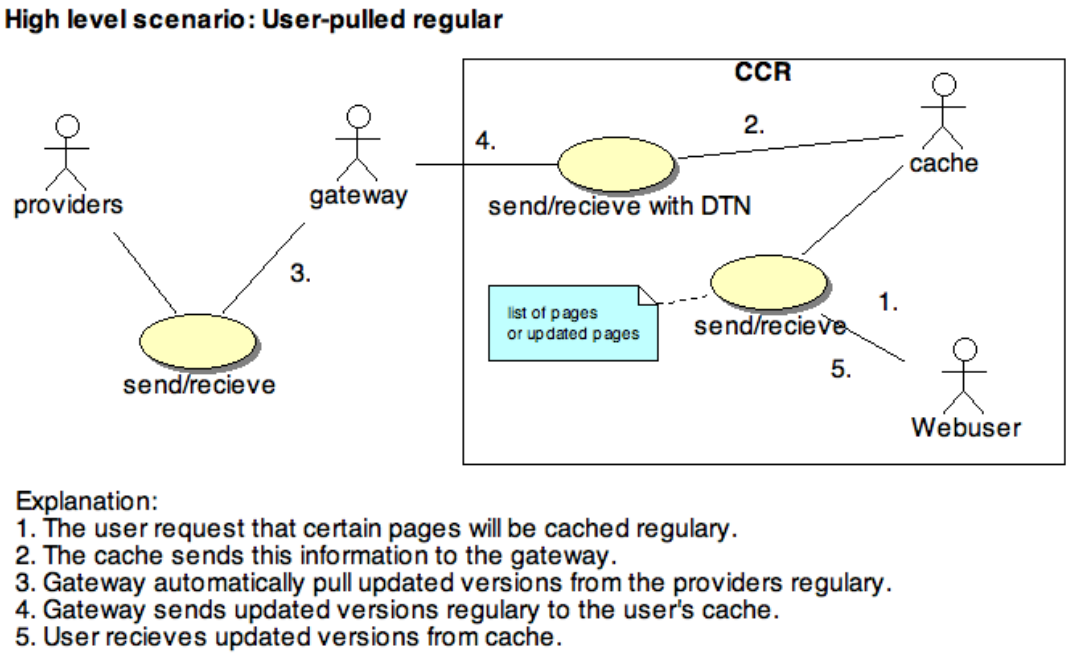


FIGURE 12: HIGH LEVEL SCENARIO: USER-PULLED REGULAR

3.2.4.2 Provider-pushed Event Driven

Cooperating and properly authorized providers that are aware that particular special pages may be of interest on a particular date or over a period, could request that these pages are uploaded in advance to appropriate caches.

One use that has been investigated during SNC is the support of education for users, such as children, who are remote from a physical school. This service model would be a major facilitator for an

educational system. Relevant information pages would be pushed to caches appropriate to pupils that need to access the information in a particular period.

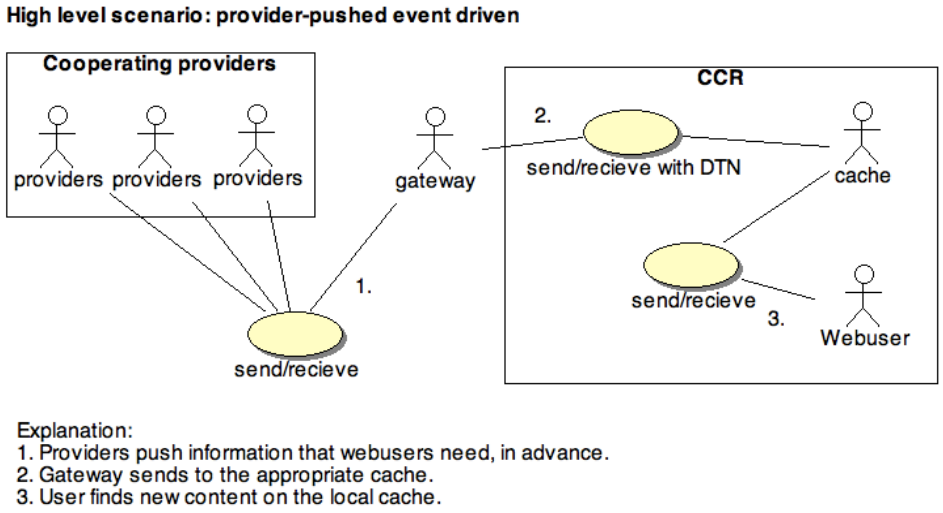


FIGURE 13: HIGH LEVEL SCENARIO: PROVIDER-PUSHED EVENT DRIVEN

3.2.4.3 User-pulled Event Driven

A user expecting to want information over a particular period could request it in advance so that it was ready and waiting. An example of the use of this service model would be 'breaking news' or

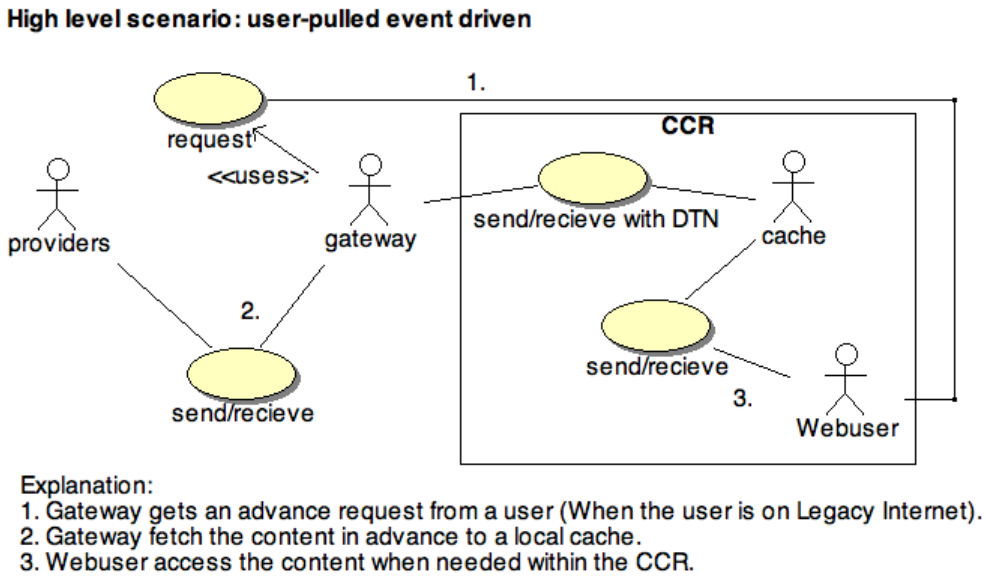


FIGURE 14: HIGH LEVEL SCENARIO: USER-PULLED EVENT DRIVEN

'weather bulletins'.

In order to avoid unwanted spam deliveries, users register their requirements with the management application at the remote proxy. Typically this would involve the management application monitoring an RSS or similar news feed and retrieving web pages when a new item is seen on the feed.

3.2.4.4 Ad Hoc Site Request

A user wanting as much information as possible from a particular site could request that all information in certain categories was pulled from a particular site and uploaded to the nearest cache(s).

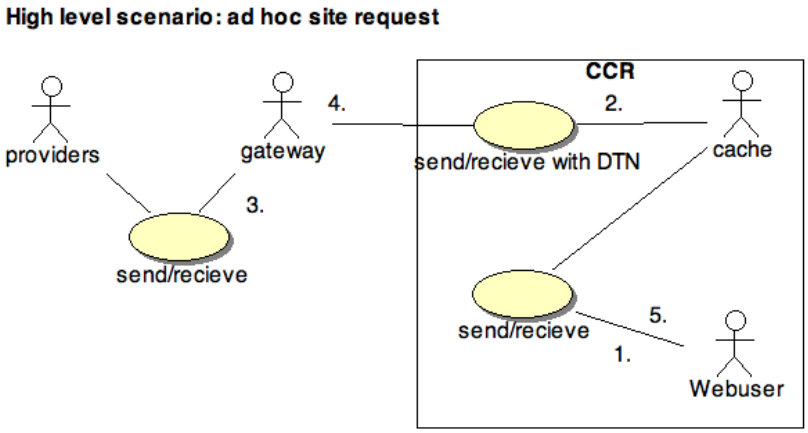


FIGURE 15: HIGH LEVEL SCENARIO: AD HOC SITE REQUEST

3.2.4.5 Ad Hoc Search Request

A user making a search could request a group of most relevant pages was uploaded in one bundle. This would require considerable 'intelligence' and processing to try and widen the search to deliver the most useful information. This is a matter of research.

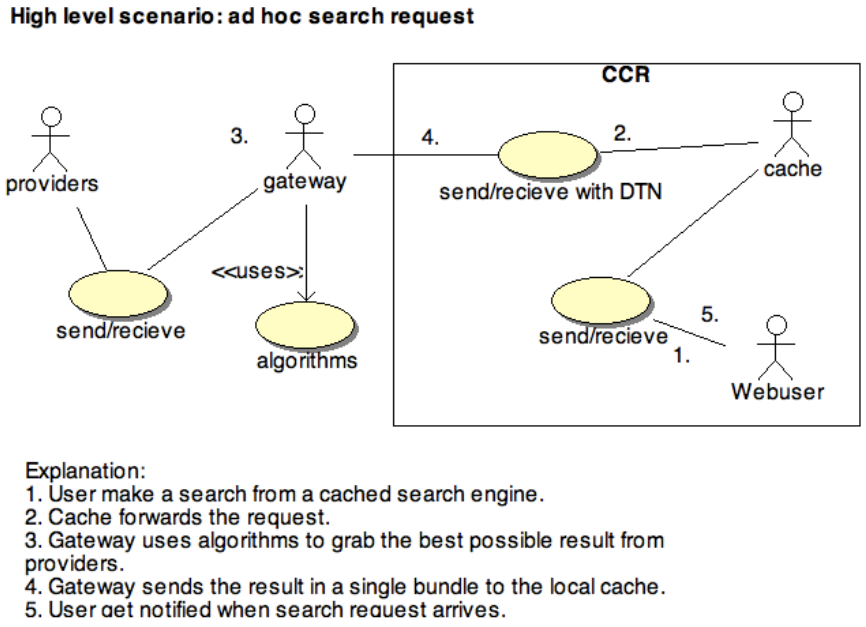


FIGURE 16: HIGH LEVEL SCENARIO: AD HOC SEARCH REQUEST

3.2.5 Use Case for Meteorological Data Distribution

Meteorological data collection stations will be situated at appropriate points in a CCR. The operation of the data collection portion and the data to be collected is based on a format from the Slovenian Agency for Environment. Periodic reports will be encapsulated into a DTN bundle and queued to await an opportunistic encounter with a suitable data carrier that is expected to encounter nodes that will allow the bundle to pass to its eventual destination either inside the CCR or in the CI.

The initial use case envisages data being transmitted purely to the CCR gateway to the CI where it can be passed to an analysis and dissemination station (probably in the CI) for further processing and incorporation into weather forecasts for the wider region.

Additional use cases may involve dissemination of the raw data to multiple nodes within the CCR that can make use of the data directly - this may require multicast functionality in the DTN infrastructure, which is currently not implemented.

3.3 USER COMMUNITY

The primary and initial group for whom the project will be directed are the Arctic indigenous populations, specifically the nomadic Arctic populations. It is also the intent of the project to make the technology available to other nomadic populations.

In the Arctic regions where the project will be deployed, several other groups will be beneficiaries of the infrastructure and of the applications offered in that infrastructure. Some of the other beneficiaries include:

- Tourism service providers and tourists
- Educators and students
- Wildlife surveyors
- Herders and others wishing to track economically important animal species
- Hydroelectric power surveyors
- Media actors, e.g., photographers, needing access from remote areas
- Remote populations elsewhere in the world
- Delay Tolerant and Interplanetary research communities

The Hiker's Apps were designed with three kinds of user groups in mind:

1. Private professional users (business)
2. Governmental professional users
3. Private users.

These three groups can be specified as:

1. Reindeer herders living and working in the Arctic area of Scandinavia and tourist guides who are working (and living?) in the Arctic area of Scandinavia.
2. Nature Park Rangers and the police working in the vast wilderness areas in the Arctic area of Scandinavia.
3. Tourists who are hiking in the Arctic area of Scandinavia.

3.4 ADMINISTRATION FUNCTIONS

Management functions will be required to monitor and configure applications and maintain the membership status of nodes associated with each CCR. Techniques for network and application management are currently the subject of research coordinated by the IRTF DTN research group. N4C partners are participating in this research and it is expected that these applications will utilise some of the techniques under development.

Resource management, especially storage and communication opportunity management, will be a key focus of administration.

Key management for security functions in the DTN will also be required as outlined in [N4C-SEC], which is a work-in-progress document describing DTN security within N4C.

3.5 ERROR HANDLING

This section primarily covers general guidance on application error handling in the context of a DTN-based communication network. Local error handling in each application is specific to the individual application, and should generally follow accepted standards for error handling in GUI-based applications (reporting through message boxes with continuation of the application whenever possible) where an application interacts directly with the user, and logging of problems for server applications also with continued operation wherever possible and automated restart if not.

It is highly likely that applications will be running in isolated nodes that do not have permanent communications to a management station or even a local human operator who can deal with routine problems. It is therefore highly important that applications and infrastructure, especially those running on gateways and routers that do not normally interact with human operators, are designed to recover from all foreseeable errors and continue operation whenever possible after such an error. This may require automated restart of one or more components (including some that were not directly concerned with the error) or even automated reboot of the entire platform using a hardware watchdog mechanism.

Storage management both on a per application and on a overall platform basis will be a key function and applications need to be able to handle lack of storage in a controlled way, automatically freeing up storage as necessary to deal with new requirements.

DTN communication is not reliable and round trip times for communications are not deterministic (even allowing for communications lags measured in hours or days). Thus it is essential that

applications continue to function correctly if a bundle response or delivery report is not received as expected, and such non-responses must not eventually result in storage overflow.

DTN communication may also result in multiple copies of bundles being delivered. In principle, the infrastructure should suppress such duplicates but applications should be aware that there may be circumstances in which multiple copies of bundles may be received at the application level and should deal with the situation appropriately.

3.6 SECURITY

[N4C-SEC] is a work-in-progress outlining our initial ideas for handling DTN security within N4C.

Careful attention needs to be paid to privacy issues. Bundles may pass through and be carried on machines that are not physically secured (e.g., other nomadic hosts) where users must be expected to be able to inspect the contents of the bundle. Users need to be aware of this and consideration needs to be given to providing both infrastructure and application level encryption to offer privacy where users and applications feel this is needed.

The relatively small communities that will be accessing village gateways leads to a privacy challenge when cached web content is accessed from a village gateway cache. If all cached content is made available to other users, the immediate arrival of cached content to a second accessor may reveal usage patterns or social information that the original user would prefer had remained private (e.g., health or medical concerns). Thus a user should be able to designate a particular cached item for private use only a second accessor would have to request another copy and wait for it to be delivered across the DTN. However this could lead to waste of scarce communication resources and possible denial of service attacks. Approaches to the problem have already been discussed in Section 1.2. Other applications should consider whether related privacy concerns may apply.

3.7 HELP

Limited application specific help to assist human users should be available as part of each application. Note that it is not appropriate to use remote web based help systems as the node is unlikely to be able to access this facility when it is actually needed. Help should also be compact and succinct given that limited resources of the expected host platforms.

3.8 INTERFACES

3.8.1 User

3.8.1.1 Hikers, Hunters, Herders and Rangers Applications

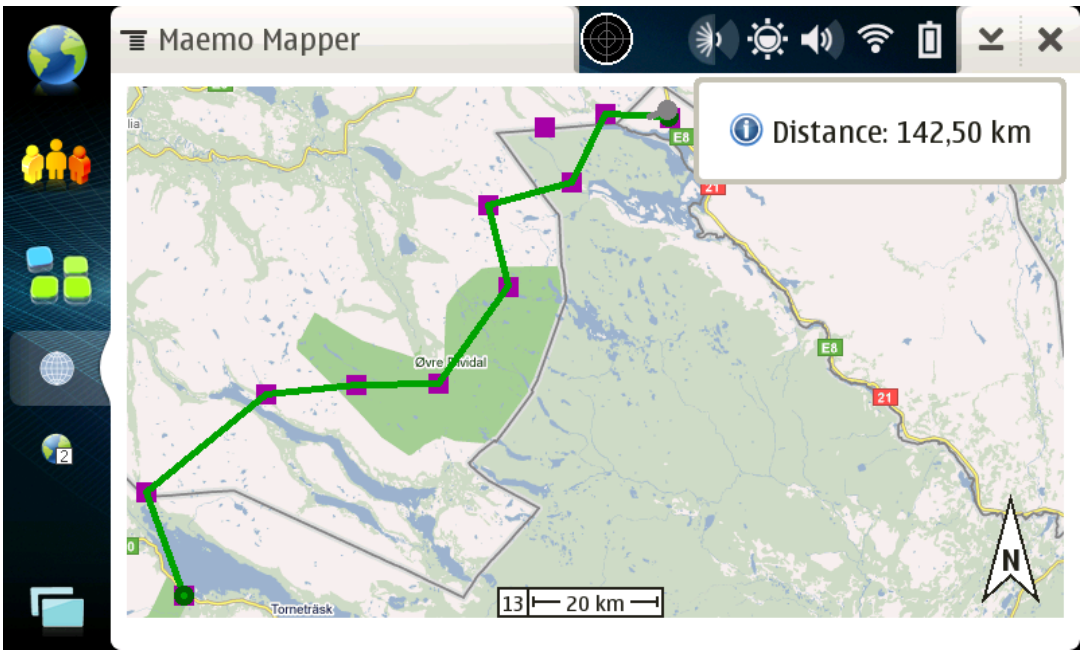


FIGURE 17: MAEMO MAPPER ON NOKIA N810

Figure 17 shows the route for the Hiker's application scenario [N4C-HPU]. Maemo Mapper [3]is an open source geographical mapping application specifically designed for the Maemo platform and the Nokia N900 and N810 form factor. Maemo Mapper is released under the terms and conditions outlined in the GPL.

[3] https://garage.maemo.org/projects/maemo-mapper/
Note: Certain repositories (most notably, the commercial ones) may have license agreements attached with their use. It may be illegal to use a certain repository with Maemo Mapper or under certain conditions. This includes the repositories downloaded via the Download... button. If you are not sure if you are legally allowed to use a particular repository, you should delete it from your list of repositories. The authors of Maemo Mapper cannot be held responsible for your use of a particular repository.

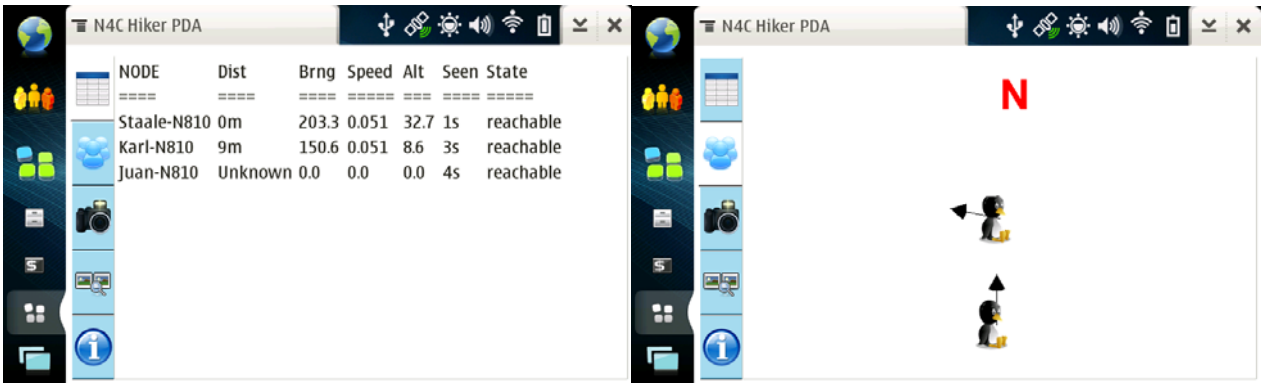


FIGURE 18: N4C HIKER'S PDA ON NOKIA N810

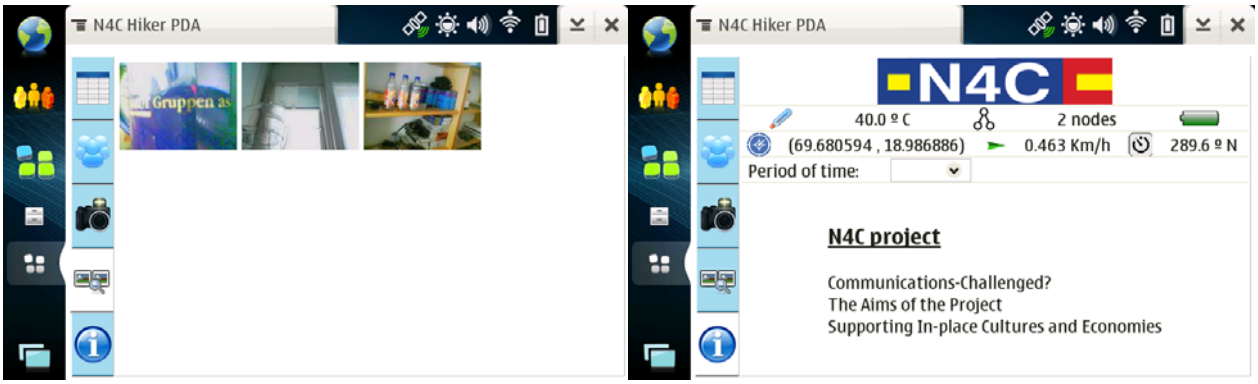


FIGURE 19: N4C HIKER'S PDA ON NOKIA N810

Figure 18 and 19 shows the user interfaces for the N4C Hiker's PDA (Auto Discovery and Photo Sync) application[4] developed for the winter test 2009 [N4C-WTR]. The user interfaces is written in HTML, and the application is written in python. The application was tested on Nokia N810 and Asus Eee PC, according to the N4C Plan for winter test 2009 [N4C-WTP].

[4] http://trac.itek.norut.no/n4c/wiki

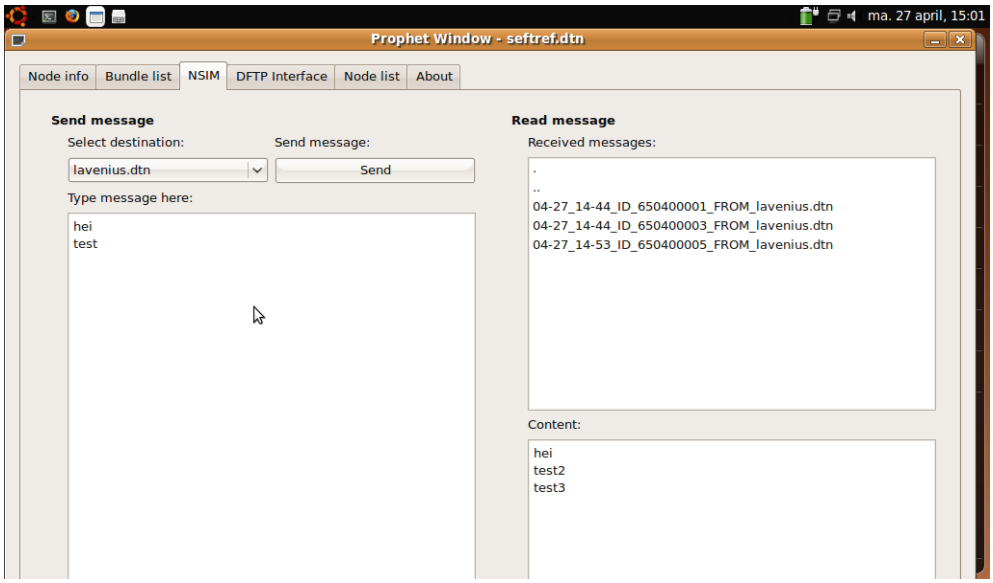


FIGURE 20: PROPHET WINDOW WITH NOT SO INSTANT MESSENGER (NSIM) ON ASUS EEE PC

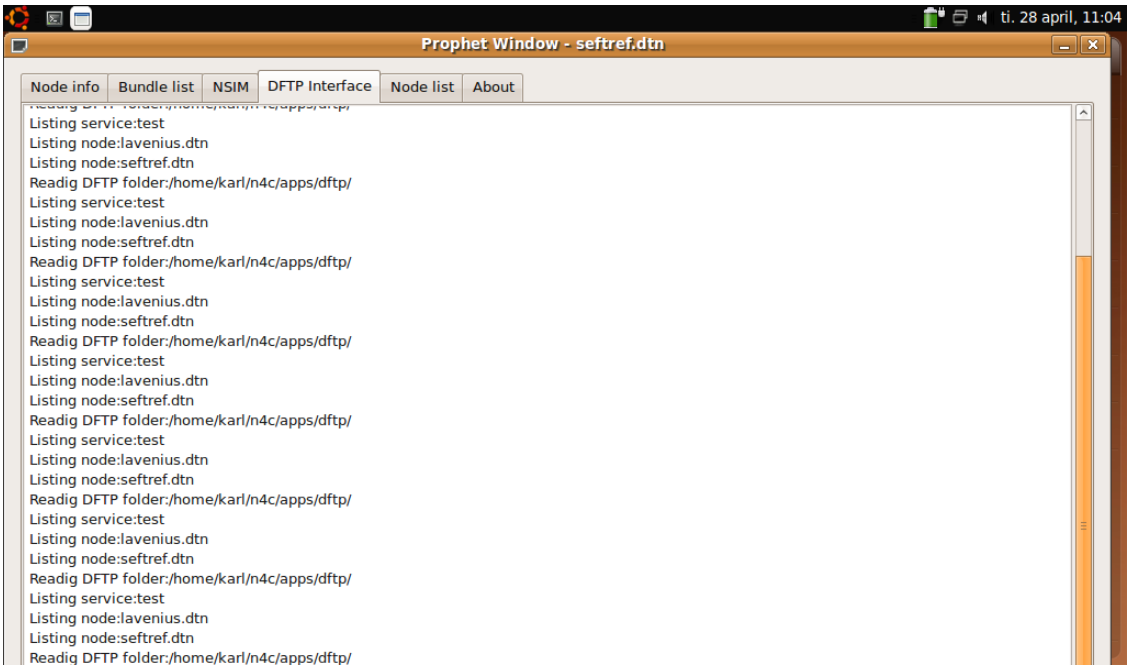


FIGURE 21: PROPHET WINDOW WITH DFTP ON ASUS EEE PC

The NSIM and dFTP applications are a part of PRoPHET[5], and NSIM can be used to communicate with users in the field. dFTP can be used to send larger files (Map database, POI database) to another dFTP server in the local CCR, or via a gateway to Internet.

[5] http://wiki.n4c.eu/wiki/index.php/PRoPHET

3.8.1.2 Web Clients

Web applications will be presented to the user in a standard browser with the addition of a suitable 'plug-in' that can display the status of content requested by the user or automatically transferred to the local cache in response to a provider-push event. The local cache will provide a web-based management function that will allow a user to manage requests made and the contents of the local cache.

A prototype of the user interface of the management function for the cache is shown in Figure 22.

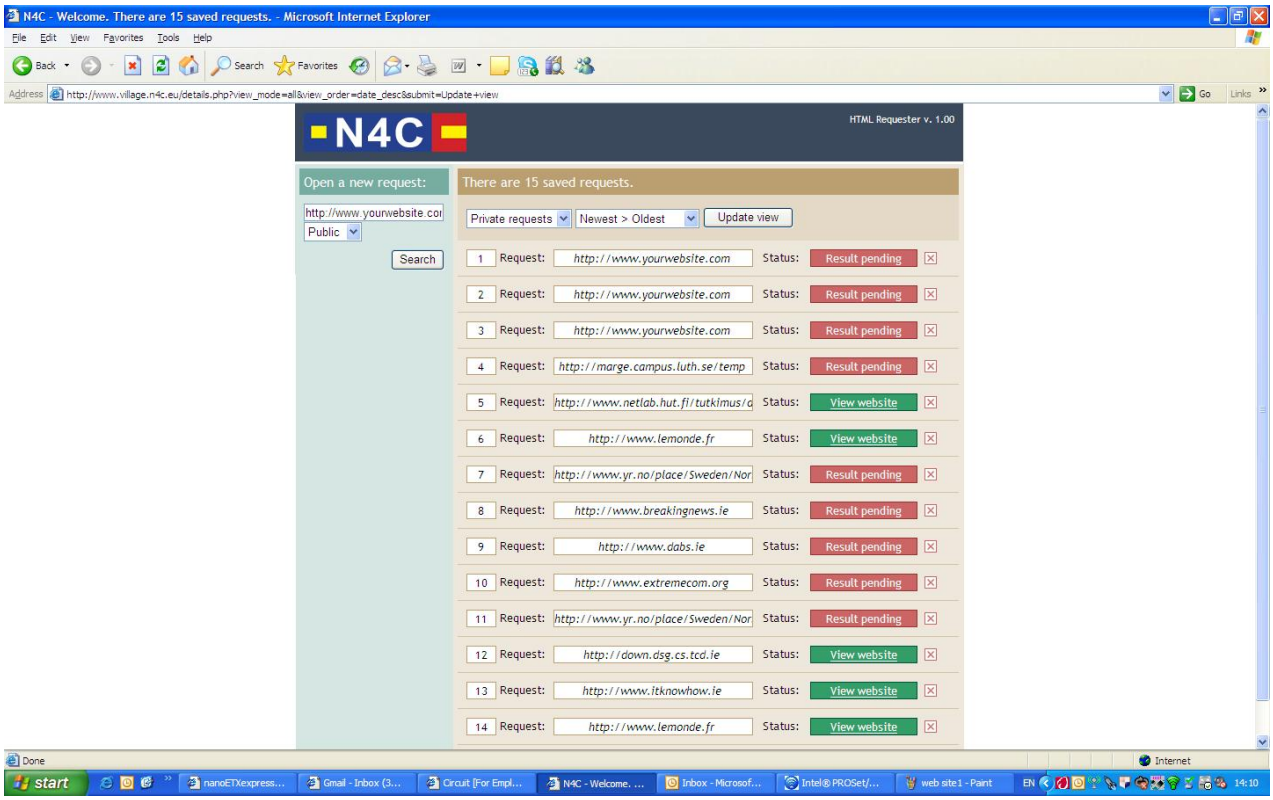


FIGURE 22 EXAMPLE USER INTERFACE FOR WEB CACHE

3.8.1.3 E-mail Clients

Standard conventional E-mail clients will be used.

3.8.2 Software

The Software architecture is divided in four different tiers; see Figure 23. The Application layer called Hiker's PDA contains the applications. The middleware layer relays with the DTN layer which may provide communication to the Internet or to different CCRs. The DTN is on top of the Link layer which is managing the different communications (e.g. WiFi, WiMax and Bluetooth). The implementation of the software platform is based on Python and C++. The hybrid synchronization service in the middleware layer uses XML-RPC for synchronization of meta-data, and http for synchronization of user data. The auto-discovery function uses IPv6 and multicast.

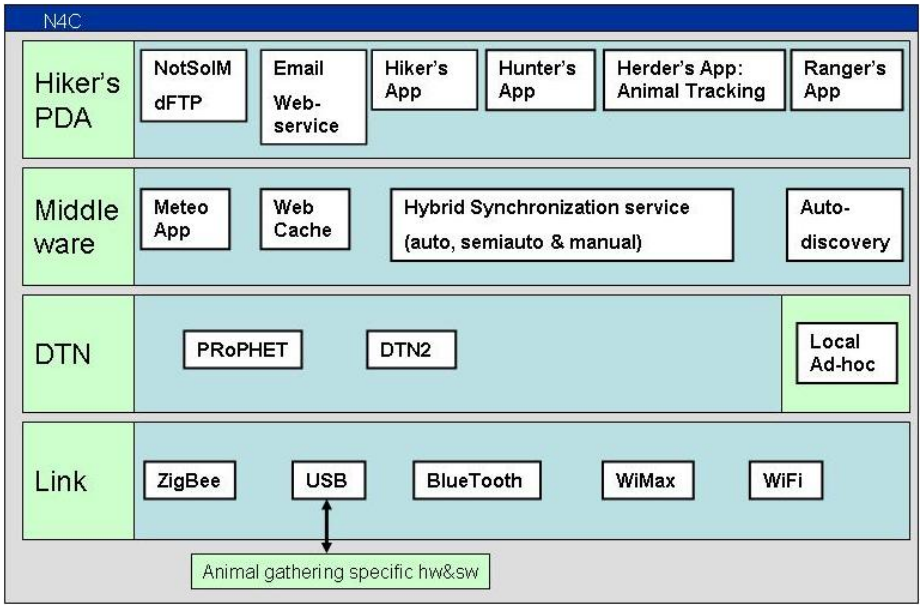


FIGURE 23: N4C SOFTWARE MODEL WITH APPLICATION, MIDDLEWARE, DTN AND LINK TIERS

Figure 24 shows what is inside the DTN2 box in Figure 23, and the description of Figure 24 can be found in [N4C-D2.1].

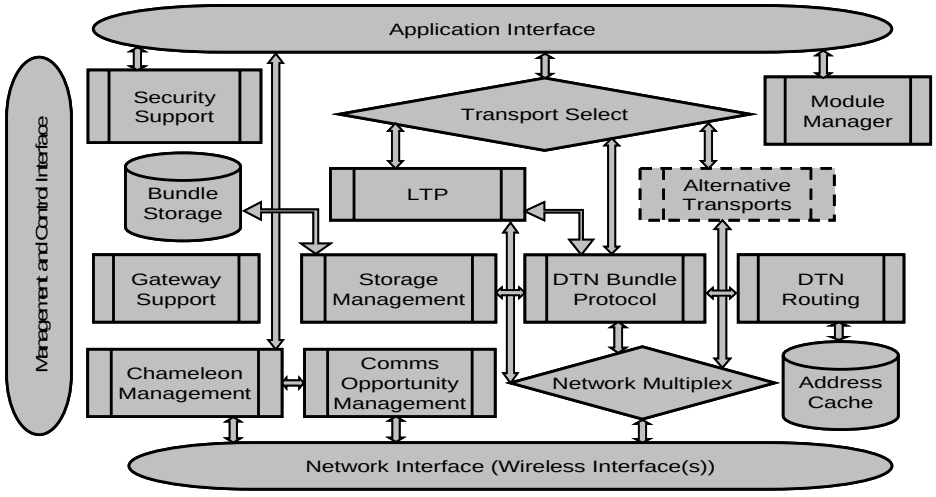


FIGURE 24: DTN NODE SOFTWARE TIER WITH APPLICATION, NETWORK, MANAGEMENT AND CONTROL INTERFACES

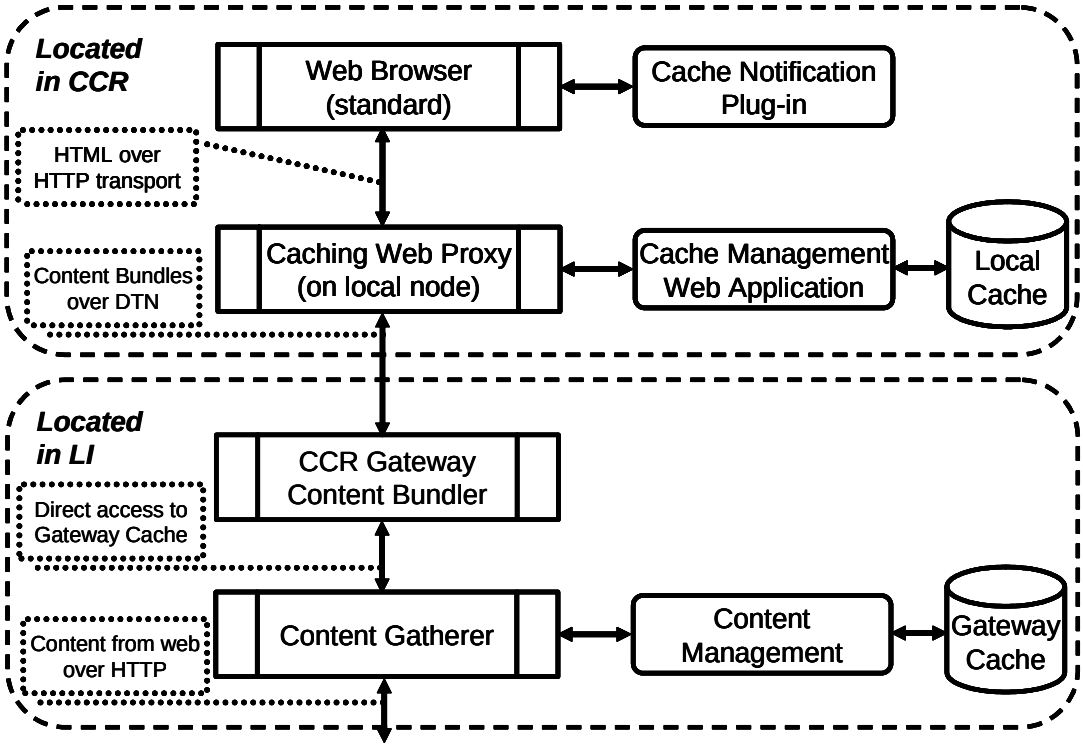


FIGURE 25: WEB CACHING SOFTWARE ARCHITECTURE

Figure 25 shows what is inside the Web service and Web Cache boxes in Figure 23.

3.8.3 Boundary Conditions

At this time no specific boundary conditions have been identified. It may in future be desirable to set limits on the size of bundles that are carried in the system.

Certain system parameters such as bundle lifetimes could be considered as boundary conditions.

3.9 CANDIDATE PLATFORMS

Applications or parts of distributed applications will be implemented on four classes of platforms:

- Gateways attached to the existing Internet,
- Routers and gateways located within the CCRs, primarily static, but maybe mobile,
- Mobile hosts that are DTN-enabled and expected to be nomadic anywhere in the CCR, and
- Conventional hosts that are not (necessarily) DTN-enabled and expected to be used within Wi-Fi range of a gateway in a 'village' area of the CCR.

3.9.1 Internet Gateways

These machines will have mains power and conventional TCP/IP based access to the Internet. The preferred configuration will be a Linux operating system in a low end server configuration machine with at least 1-2GB of memory and at least 100GB of disk storage. These machines will typically be running a mail transfer agent such as Postfix, the DTN2 reference implementation, the Apache web

server, the Equid web proxy and a number of custom applications supporting the N4C applications in the gateways and hosts in the CCR(s) which this gateway serves.

3.9.2 Village Gateways and Routers

These machines will not have mains power in general and will be located within the CCR. Typically power will be supplied by local batteries charged by some local means such as solar energy, wind power or water power. Communication will be primarily Wi-Fi based using both infrastructure and ad-hoc modes. The critical constraint for these machines will be power availability. They will therefore be based on very low power consumption hardware such as the latest generation of Intel Atom processors. Careful attention will need to be paid to the activity patterns of the application parts running on these platforms to ensure that the platform can be placed into as deep a sleep mode as possible when the applications are effectively idle. To this end periodic activities need to be minimized during idle periods to avoid waking up the processor when there is no active work to be done. In particular use of ad-hoc Wi-Fi mode will need to be carefully managed to avoid excessive power drain. Typically they will not be equipped with a permanent monitor or keyboard; control and management would be carried out remotely.

The router being developed in WP5 and associated infrastructure software developed in WP4 is intended to meet these constraints. It is expected that the machines will run a customized version of Linux (currently Ubuntu Hardy Heron Low Power Intel Atom (2.6.24-lpia) branch) which is especially designed to take advantage of the power saving capabilities of the Menlow range of Intel processors, assuming that the board firmware gives access to the capabilities. The machines will require adequate bulk storage (e.g., magnetic or solid state) to store DTN bundles, cached web proxy files, e-mail in transit and similar for the various applications that communicate through the village gateways.

3.9.3 DTN-Enabled Hosts

These machines are expected to be used as mobile, nomadic hosts that will typically accompany human users moving about in the CCR at large, rather than limited to the village areas where they could have Wi-Fi access to a village gateway.

These machines are expected to be compact, lightweight and battery powered with Wi-Fi communications capability and with a keyboard and visual display to provide a human user interface.

Applications are expected to make use of one of the following platforms (in prioritized order?):

1. Nokia N900 and N810 (N800 and 770?) small form factor tablet computers: **Maemo** is a computer architecture platform built on desktop open source components. The platform is based on the GNU/Linux operating system and the Hildon desktop. Comparison of tablet models N810, N800 and 770:
   http://wiki.maemo.org/Comparison_of_Internet_Tablet_Models

2. Asus Eee PC: Operating system: GNU Linux (Xandros distribution). In particular the fully solid state versions of the EEE PC are particularly appropriate.
   http://event.asus.com/eeepc/comparison/eeepc_comparison.htm

3. HTC Hero, Magic (Google 1 Phone): Operating system: Android™[6]. Android relies on Linux version 2.6 for core system services such as security, memory management, process management, network stack, and driver model. The kernel also acts as an abstraction layer between the hardware and the rest of the software stack.
   http://www.htc.com/www/product/g1/specification.html

4. iPhone: Operating system: iPhone OS 3.1
   http://www.apple.com/iphone/specs.html

5. USB stick: Bootable and good for winter test? Easy to carry and exchange with others.

3.9.4 Standard Hosts

Interchange of E-mail and cached web content between village gateways and hosts located adjacent to the gateway requires only a 'standard' (non-DTN-enabled) host, communicating over infrastructure Wi-Fi. Normal Internet E-mail clients and web browsers will provide the required interface.

3.10 INTERNATIONALISATION

The applications developed during N4C are considered to be prototypes which will be implemented with display of text in English only in a UK locale. No explicit measures will be taken to facilitate display of text in alternative languages, adaptation to alternative locales or other mechanisms needed to adapt the application to use in other environments than one where UK English is the norm.

3.11 PORTABILITY

Although we may only be supporting one platform initially, we almost certainly will want to be able to port developments to other platforms using Qt[7] or some other cross-platform application framework.

The use of cross-platform scripting languages such as Python should also be considered.

3.12 EXPANDABILITY

The main areas of expandability to be considered are:

- Larger numbers of users in a given CCR: This is primarily a matter of infrastructure resources.

Operation in regions with several overlapping CCRs: Individual hosts need to be able to operate with several different e-mail addresses and DTN EIDs.

[6] http://code.google.com/android/what-is-android.html

[7] **Qt** [cute] is a cross-platform application framework. Using Qt, you can develop applications and user interfaces once, and deploy them across many desktop and embedded operating systems without rewriting the source code. http://qt.nokia.com/

3.13 SUPPORT & MAINTENANCE

[N4C-M8.1] lists accessibility of log files during summer test 2008, and has recommendations for developers from technical and application teams.

3.14 CONFIGURATION MANAGEMENT

[N4C-CR] is a work-in-progress describing TCD's proposal for a code repository for the N4C project. Mercurial [MER] will be the core of the N4C version control system (VCS). TCD will act as the project librarian for these code repositories and host the master copies. There is also a description of the configuration management process at http://wiki.n4c.eu/wiki/index.php/Technical_Page

3.15 DOCUMENTATION

The Gant diagram for WP3 is based on the N4C Work planning and timetable, the tasks, deliverables and milestones for WP3 in [N4C-DOW]:

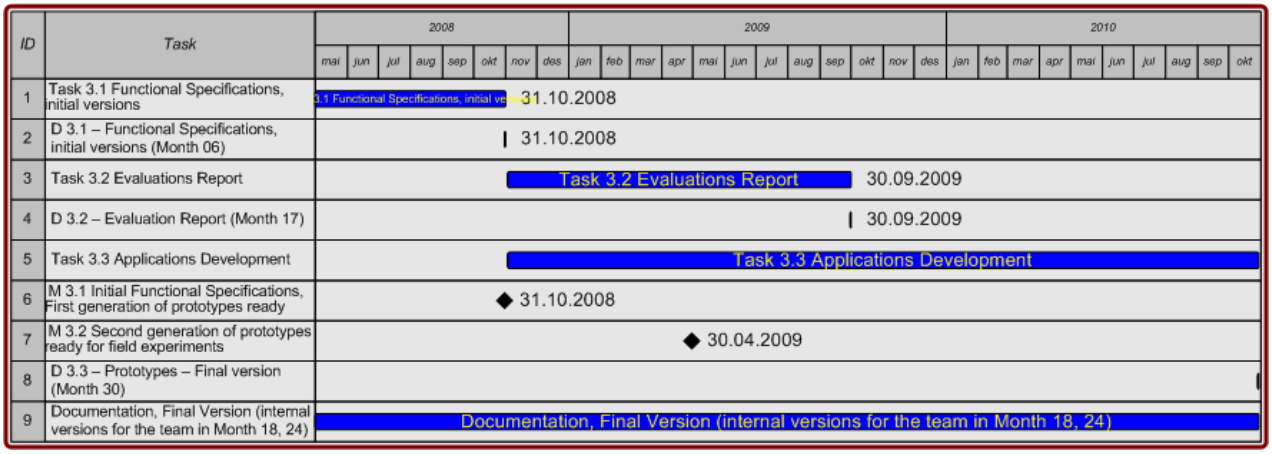


FIGURE 26: GANT DIAGRAM FOR WP3

This document, D 3.1 Functional Specification, is a "living" document, which can be seen in the Gant diagram:

- Initial version submitted in Month 06.
- Internal version in Month 18.
- Internal version in Month 24.
- Final version is scheduled to be submitted in Month 30.

The Allocation of Effort for WP3 is given in the following table [N4C-WP3-1]:

Task #	Task Title	Output Type	Effort per Partner						
			LTU	TCD	Norut	ITTI	MEIS	Tannak	Folly
1	Per Partner Effort Totals		20	12	16	2	9	4	4
2	Hiker's Personal Digital Assistant	Functional Specifications, initial versions			2	0,25		0,25	
3	Web Caching	Functional Specifications, initial versions	2			0,25		0,5	0,5
4	Meteorological and Environmental Data Capture	Functional Specifications, initial versions		1		0,25	1	0,25	
5	Hiker's Personal Digital Assistant	Evaluation Report			2			0,25	
6	Web Caching	Evaluation Report	2					0,5	0,5
7	Meteorological and Environmental Data Capture	Evaluation Report		1			0,5	0,25	
8	Hiker's Personal Digital Assistant	Prototype – Final version			10	0,25		0,5	
9	Web Caching	Prototype – Final version	14			0,5		1	2
10	Meteorological and Environmental Data Capture	Prototype – Final version		9		0,5	6,5	0,5	
11	Hiker's Personal Digital Assistant	Documentation, Final Version			2				
12	Web Caching	Documentation, Final Version	2						1
13	Meteorological and Environmental Data Capture	Documentation, Final Version		1			1		

The smallest time unit is 0.25 months (i.e., approximately a week).

4. PERFORMANCE/RESEARCH INDICATORS FOR WP3 REVIEW

For WP3 the Description of Work states that quantitative review indicators are to be suggested with D3.1. The indicators the Consortium suggests are as described in the table "Review indicators for WP3".

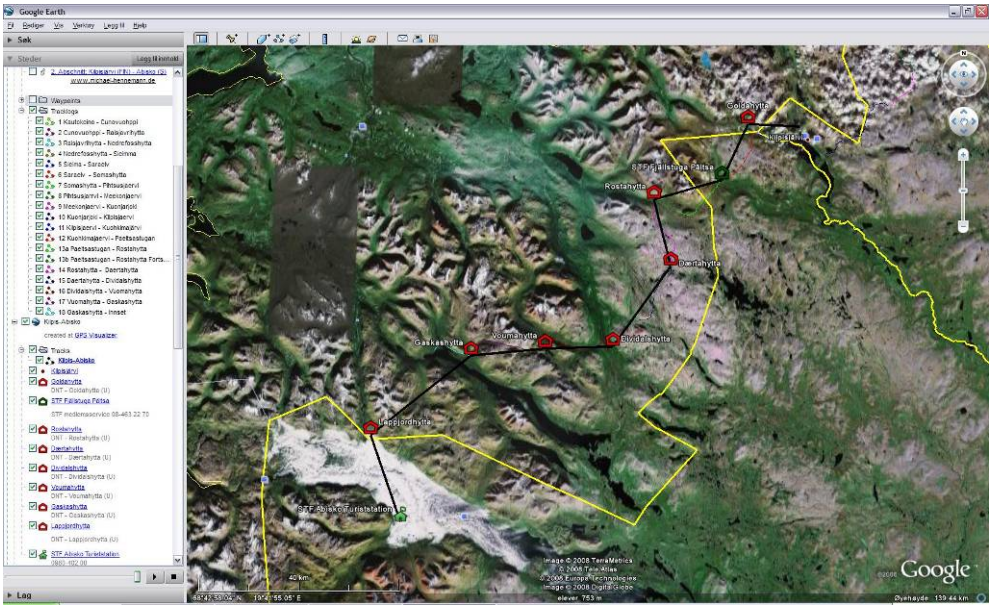
Review indicators for WP3		
WP	**Indicator**	**Time schedule**
WP3	Functional Specifications	One (1) in Period 1
WP3	A beta version of E-mail and Not So Instant Messenger	Two (2) in Period 2
WP3	A beta version of Web cache	One (1) in Period 2
WP3	A beta version of Hiker Application	One (1) in Period 2
WP3	A final version of E-mail and Not So Instant Messenger	Two (2) in Period 3
WP3	A final version of Web cache	One (1) in Period 3
WP3	A final version of Hiker Application	One (1) in Period 3

APPENDIX

This scenario: Hiking the North Calotte Route gives an overview of how an application for hikers, out in the wilderness, could be used. It is the basis for developing the UML scenarios given in section 3.2.2 Use cases for the Hiker's Applications Scenario.

A. SCENARIO: HIKING THE NORTH CALOTTE ROUTE

Let me introduce two old friends who are ready for an adventure into the wilderness of northern Scandinavia. Our backpacks are filled with warm clothes, some dried food, a lightweight tent, a sleeping bag and the survival equipment: a knife, a box of matches, medical equipment, a fishing rod and a cell phone.



The plan is to hike along the North Calotte Route from Kilpisjärvi at the border between Finland and Norway, going southwest along the border between Sweden and Norway and ending up at Abisko in Sweden, where there is easy access to public transportation. There are several cabins along the route where we can stay over night. Weather permitting; we will sleep outdoor for three-four nights. Most of the cabins are un-manned, so we have to carry sufficient food for one week. But the trout in the lakes have a quantity and quality beyond any imagination, and we hope for some really nice outdoor meals during our hike. And now is the season for picking the gold of the mountains: cloudberries; fresh, sweet and full of accumulated sunshine!

We set out from the Finnish customs station at Kilpisjärvi. There we pick up updated paper maps and the keys for the cabins (run by the Norwegian Tourist Association). The customs officer, Mr. Iiro Rantala, tells us that there is no mobile phone connection along our route, so we can surely switch off the phone. However, there are some other hikers out in the field, and if we want to get in touch with them and with the outside world, we can borrow something he call a *"Hiker's PDA"* that *might* give us some communication out there. No guaranties, though! The PDA has GPS and camera, and to provide for power, a lightweight battery charger powered from energy from any fireplace, is included. The use of this equipment is free of charge; but we have to deliver it back after our trip, and we have to accept a clause where we agree to "carry" information out to some locations in the wilderness (see DTN).

Iiro explains the basic ideas and how stuff works, and downloads the PDA with four applications:

E-mail and web cache: The PDA is set up as a DTN node. It means that it will carry e-mail and have web-cache for ordinary - but delayed - internet access. The latest weather forecast for the area is a '*must*'. We pick the Swedish weather service since it is said to be the best along the Swedish-Norwegian border area. We also google for the best fishing and cloudberry locations, but we just get some vague answers like: "There is plenty of berries and fish in the area, just go and find out yourself. Have a nice trip! Best wishes from the Wilderness Ranger Service."

The download system keeps track of all Hiker's PDAs out there. We cannot see where they are, but we can see that 10 units have been deployed from Kilpisjärvi Customs Station, 10 units from Abisko Tourist Station and 15 units from Dividalen Camping.

NSIM: Not so instant messaging - mostly used to communicate with other people out in the field, either directly or via occasional other "carriers".

Maemo Mapper with maps of the relevant area containing points of interest (POIs), for instance description of cabins, tracks, good camping sites with safe fireplaces, bridges or crossings for steamy rivers and some fixed communication hotspots.

Geoblog: a special blog containing field observations that are 'close' in time and space. Users may record their own field observations or photographs in the blog together with the GPS position. When random users are within communication range, their PDAs will synchronize geoblogs so that the registrations are exchanged and made visible in the map.

And then we are off, well prepared for one week in the wilderness.

Day 1: We walk over the mountain called Halti and follow the path to the triple point border between Finland, Sweden and Norway. Out in a small lake there's a yellow cairn made of concrete, and it is possible to walk around this being simultaneously in three countries. Astonishing! We simply must take some photos with the PDA camera (annotated with the GPS coordinates) to show to our colleagues back home; they think we are out in the middle of nowhere - which we in fact are – but still we are more international than ever.

This is the first day of our vacation. Our rucksacks are very heavy and we are not used to long hikes like this. Isn't there a nice place for setting up the tents? We turn on the PDA and use the map to search for a nice spot. Yes, the map shows a recommended camping site some kilometres away. Near a small river where there maybe are some trouts? We go for it. Then a message pops up on the display saying that there is updated information in the Geoblog. Wow, our PDA is synchronizing with another PDA in a position straight across lake Goldajärvi. It is just 500 meters away (line of sight), but it's a long walk around the lake. The Geoblog information turns out to be very useful: it says that the bridge crossing the Ice River is destroyed. And we had counted on that bridge! Perhaps the guys across the lake have more information for us? We try to send an NSIM message asking for guidance, and after a while we receive a more detailed description and two photos: one showing a bunch of reindeer and the other from the river with no bridge at all. Plus that they are French and enjoy Arctic nature.

Reindeer, well well. Interesting enough, but more than hundred of them are surrounding us right now. The bridge, however, here we have some upcoming problems. Where can this big river safely be crossed?

We postpone the decision until next day. From the PDA log we can also see that the French have downloaded the "fresh" weather forecast from our PDA. Not so important today, the weather is quite nice, but still it is good to know that our PDA can give something in return …

Day 2: After a good night's sleep in the tent we prepare for a typical hikers breakfast, mostly made of dried food. Nice and nourishing food, but one week of this will almost turn us into dehydrated species as well

We eat the breakfast and start walking in the direction of Pältsa, the cabin on the Swedish side of the border. The track follows some impressing moraines left behind as the ice withdraw from the area a long, long, long time ago.. Not many people have seen this with their own eyes, so we must take some photos for the blog.

We arrive Pältsa around noon. It's nice and modern, and the name is given by the mountain close to the cabin. In contrast to the unmanned cabins on the Norwegian side of the border, there is a cabin host there. His name is Kaj Swensson. What his tasks are, we really don't understand, but he is there, that's for sure. And unlike us, he is not there for pure pleasure. He is out there because of work, quite alone in the wilderness, so he surely wants all information he can have from the outside world. We are not surprised when he turns on his PC and asks if we would be so kind as to fire up our PDA!

Seconds later all e-mails to Kaj is uploaded from our PDA to his computer. Plus the web cache from our PDA. And Kaj is happy. This man turns out to be a devoted chess player, and he is waiting for results, analysis and comments from the international chess tournament in Biel, Switzerland. The information, of course, has been cached from www.bielchessfestival.ch and has now literally been carried to him by us. Being a devoted fan of the young Norwegian chess player Magnus Carlsen, Kaj immediately starts analysing some of the games from the chess tournament in Switzerland. He shows us some results:

	Standings after round 10		1	2	3	4	5	6	Points	Soberg
1.	GM Leinier Dominguez	CUB	**	½ 1	½ ½	1 0	½ 1	½ 1	6.5	29.50
2.	GM Evgeny Alekseev	RUS	½ 0	**	½ 1	1 0	½ 1	1 1	6.5	26.75
3.	GM Magnus Carlsen	NOR	½ ½	½ 0	**	1 ½	½ ½	1 1	6.0	25.00
4.	GM Etienne Bacrot	FRA	0 1	0 1	0 ½	**	½ 1	1 ½	5.5	24.25
5.	GM Alexander Onischuk	USA	½ 0	½ 0	½ ½	½ 0	**	1 ½	4.0	17.50
6.	GM Yannick Pellet	SUI	½ 0	0 0	0 0	0 ½	0 ½	**	1.5	8.00

"You know", he says, "earlier I felt very isolated staying out in the cabin for a couple of months with very little updated information from my family and from the society. But now this way of life far away from civilisation suits me quite well, provided I can receive and send such information once in a while. With these devices working so well, I am very happy staying out here for a long time. No cars, no shops, no time registrations, no stress. But still, I am also partly in touch with society, and that is really my preferred way of living."

We can also make use of these services. So the Geoblog uploads the photos of the triple point border, the moraines and some cloudberries. Hopefully these photos will be available on the Internet within some days, if other travellers, herders or rangers happen to pass by the Pältsa cabin in the coming days.

Our PDA also downloads some e-mail and web pages headed for reindeer herders in the vicinity of Dærta, which is one of the cabins on our route. These mails did not originate from the cabin host Kaj, but they were "carried" by some other hikers coming from Rostajärvi, and they were not headed in the direction of the herders. Therefore, the stuff was "stored" on Kaj`s computer until somebody like us could carry it further.

We also send an e-mail to the Norwegian Tourist Association with information about the destroyed bridge across Ice River, hoping that this info will be published on their web-site as soon as possible. For our own planning, the broken bridge is a fact we have to accept; we must find another route. Instead of going in the direction of the Rosta cabin we go directly to Dærta, thus avoiding the damaged bridge. No problem, we have plenty of time and there is a good path going directly to Dærta. The only problem is that we have to wade the river at a place where the river is shallow, wide, flows quite gently and …. very very very cold. But we are real wilderness hikers, aren't we?

So we say goodbye to the host and we start walking again. It is really good to be out in the wilderness. When we come to the point of crossing the river, we cross it. Simple as that. We just cross it.

And afterwards we warm ourselves by a fire that we made at a suitable fireplace. Then we make some really good coffee on the fire. Life is good! And so are we!

On our way to the Dærta cabin we pass the highest point on the route at Bossir. It is more the 1000 meter above sea level. Near by the big cairn at the top there is also a meteorological station that records continuous measurements of temperature, air pressure, humidity in the air, etc. When we turn on our PDA, data from the station are automatically downloaded into the Geoblog.

At the end of the day we reach the Dærta cabin, tired, hungry and happy. There is plenty of wood in the shed and we carry some of it inside and get the fire going in the oven to get some heat in the cabin (still north-Norwegian summer). We prepare for cooking on the gas system and we try to switch on the PDA. But alas, no power left, flat battery! The PDA is almost as tired as we are! Then we remember the mobile charger. It exploits the difference between the hot airstream coming up from the oven and a cold reservoir, based on a thermo-electric effect called Seebeck or Peltier. We put it on the oven as described, prepare our "menu de la dia" consisting of the very familiar dried food, eat and finally go to sleep.

Day 3 and 4:

We are now at the Dærta cabin, and we decide to stay one extra day. It is far, far out in the wilderness, almost as far as we can get away from civilisation. And we have heard rumours about big fishes in the small lakes near by, even if the ranger service didn't want to tell us anything about that. Yesterday's dried food dinner was OK, no doubt about that. But what about a big fat fresh trout…… There is a saying "never sell a bear's skin before it has been shot", but still - we cannot wait to pull the big ones out of the water.

Before we go out we turn on our PDA. The batteries are now fully loaded and are almost as energetic as we are. Right away the PDA recognizes the reindeer herders' computer only 500 meters away, and the postings to them are transferred immediately. We receive an acknowledgement for successful transmition. Our geoblogs are synchronized, and this time there is interesting information about an area where there has been some wolverine observations. The herders also send us an NSIM message asking us to tell them if we see any wounded reindeer.

Now, back to the fishing. According to tradition we will not tell exactly how many and how big trouts we caught; let's just say they were very many and very big. In fact we caught some of the bigger fish ever taken in this area, we believe. So in the evening we walk back to the cabin and prepare the best meal ever; fried tout, fried trout and fried trout. No need for vegetables, potatoes, cream. Just plain fried trout. And afterwards, cloudberry naturel. Sweet and juicy as the sweetest dream. What did we say yesterday? Life is good and so are we! Tonight it's even better!

(FYI: if you think the above trouts don't look very big, we had to shrink the picture to make it fit on one page!)

Before going to bed that evening, we turn on the PDA. There is a message from the herders. They ask again if we did see some wolverines? We answer very quickly that we didn't and then we have an internal argument between the two of us whether that was a good or a bad thing.

Day 5,6,7,8:

For us, this has been "days of wine and roses". Well, physically not very relaxing. Hard to walk over such long distances and hard to carry heavy rucksacks. But mentally we have really had a nice and relaxing vacation. Lots of experiences. Lots of observations. Lots of photos. And occasional communication with other people in the field, both by using GeoBlog to share relevant information that is near us in time and location, NSIM to communicate directly and DTN to access Current Internet services.

When we finally arrive Abisko in Sweden by the end of the week, we take a good bath, have some restaurant food (not as good as the trout at Dærta), and then we sit down at the hotel's internet computer. Before we start to upload photos to our personal web-site, we check to see if any of our messages from the field Geoblog and field e-mails have arrived. Guess what: The damaged bridge, the cloudberries, the trouts, and the triple point border. It's all there. And not just that. There is a greeting from the host at Därta. There are some thanks from the Norwegian Tourist Association for reporting the broken bridge. There's a message from the herders that the wolverine have left the area. And there is a comment from Anette, a friend of us. She has made a nice melody following the slide show of photos. "On the sunny side of no street! " That was precisely what we had experienced.