Summary of the third and final year May 2010–April 2011

Remote and otherwise communications challenged areas often have specific infrastructural constraints and other obstacles for communications. The aims of the FP7 ICT project Networking for Communications Challenged Communities (N4C) has been to extend Internet access to people, businesses and authorities operating in remote locations. For this purpose N4C has focused on the most challenging scenarios with populations and local industry in remote and topographically complex areas, exploring models for deployment and business in the context of current debates on knowledge society inclusion.

The central idea of N4C has been to drive the evolving Delay- and Disruption-Tolerant Networking technology (DTN) towards practical usage. The strategy has been to combine this emerging future internet protocol set with mobile computers used as data mules and off-the-shelf wireless technology to provide carriers, including upgrading of WiMAX solutions for challenging scenarios. As lead concept, nomadic solutions were the aim. At the peripheries data transport would be dependent on data mules but it would be robust and independent of conventional infrastructure. The idea was to deliver technology that does not require heavy investments in infrastructure but, can operate opportunistically, with smaller, movable masts, portable data mules and, generally light and portable equipment. To tackle this challenge with unconventional solutions, a consortium covering several European regions and with a strong representation of SMEs was created.

ACHIEVEMENTS: A MAJOR STEP FORWARD

As the project ends, it is with satisfaction that we present results confirming our success in fulfilling the N4C goals. We can now present DTN access solutions and applications that have proven stable and run autonomously for several months in real situations. Environmental measurement nodes using DTN for transfer of data in critical situations for the nuclear industry and, results in the WiMAX area are already available on the market. DTN test beds in remote locations were built for the project, and as a sustainable result the Slovenian Kočevje test bed is suggested for the FIRE federation.

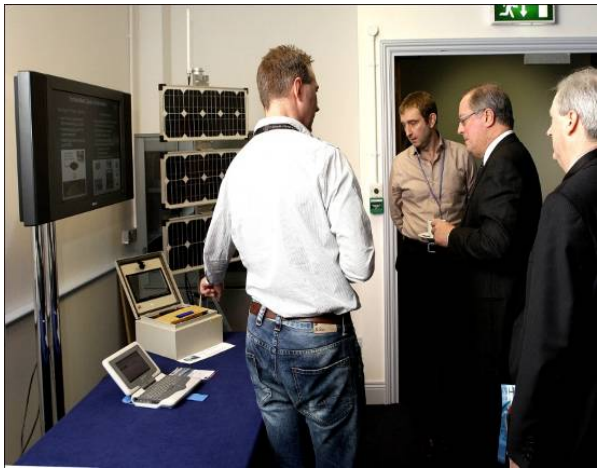
Communication technologies we use daily are dependant on electrical power. In an urban European setting this is not an issue. Setting up networks beyond the conventional infrastructure and electrical power grid however, implies limited or no access to this commodity. To handle such situations in an efficient and environmentally friendly way N4C developed strategies for power harvesting, and made power management intrinsic in software as well as hardware solutions. Problem areas were also identified, where power saving strategies, are presently not available but should be researched.

Figure 1. Wind generator and solar panels for power harvesting. N4C summer tests 2010 in Staloluokta, Swedish Lapland.

APPLICATIONS AND COMMERCIAL RESULTS

Services drive the uptake of networking technologies. Generic services were researched in several work packages and with open source software. The N4C theme 'Pervasive applications', focused on remote areas and challenging scenarios. The **Hikers' Personal Digital Assistant** was developed by Norut, for use with DTN and contains selected and tailor made functions such as blog function, 'Send Message with own location', and download of 'Point Of Interest'. With assistance by Power Lake AB (PLAB) an exploitation plan was developed for the applications.

In-situ measurements of climate and pollution data are not sufficiently collected from sparsely populated areas. In N4C the transport of such data has been addressed with DTN. In comparison to GSM, DTN needs less infrastructure and electrical power to operate. An **Environmental Data Capture** suite was developed and tested by MEIS. A Meteorological station with increased autonomy providing measurements in critical situations AMS-CS was developed for DTN and is now rolled out to the nuclear industry and generating revenues. The meteorological station AMS-DTN and a Symbinode based u-GaRaMo gamma dose rate measuring device are also close to market.



An N4C spin-off is **Tolerant Networks Ltd**. with current engagements on an ESA DTN study contract. This company will offer a range of services, as advice on the **Village router**. This durable router was designed by Intel and Trinity College Dublin (TCD), from commercial off-the-shelf equipment. The design is fully described in a public N4C deliverable and, there is also a possible market for providing mounted routers as service.

Figure 2. The N4C Village router on display at the Intel Open Innovation Lab. From left David Boundy and Brian Quinn from the Intel N4C team, Intel CEO Paul Otellini and Martin Curley, Director Intel Labs Europe.

Air-interface technologies and animal tracking

With the support of Universidad Politécnica de Madrid (UPM), Albentia Systems has achieved two unique implementation of WiMAX technology one using multiple antennas and another for mesh connectivity. This can be used for repeaters to increase the coverage of WiMax especially where terrain limits line-of-sight operation, and also to gather distributed information in large areas. A pilot WiMAX repeater network has been deployed in the south of Spain, to provide broadband access for real users. The deployment has run for over six months and as N4C ends it continues working. An *ad-hoc* WiMAX network organizer was introduced, as generic entity for DTN and multi hop strategies. The combination of WiMAX and DTN was tested at the SmartBay test bed in Ireland with results confirming the relevance of DTN for challenged scenarios. Mobile nodes for animals were researched by UPM, with kinetic mechanisms replacing batteries. Real life tests performed with Tannak AB in parallel to their system Herdview were successful. The next step is refining the mechanical design of the kinetic generator.

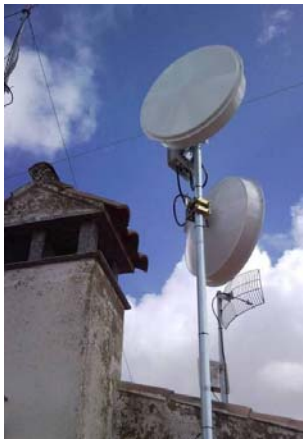


Figure 3. Repeater installation, Spain

RESULTS IN THE DTN AREA

In the DTN area the N4C results include scientific advancement, standards development and, results exploitable in real deployments. N4C DTN networks and applications have run autonomously for several months and from this base, the consortium offers free access to software and instructions for setting up a DTN network, and basic services. The range includes two different DTN implementations (the Grašič Prophet and, the DTN2 reference implementation), with e-mail and cached web delivery for both options. Other achievements include SMS service, Podcast and more. Main contributors in the DTN research was Luleå University of Technology (LTU), TCD, Folly Consulting Ltd and MEIS. The system integration teams from Instituto Pedro Nunes (IPN) and ITTI Ltd carried out independent validation and, made the results available through integration and simulation platforms, with installation packages, deployment strategies and documentation. On http://wiki.n4c.eu developments are posted. Code and results are also found via www.n4c.eu, Sourceforge and other. The impact from N4C will include several PhD theses and, the DTN research is taken further in the FP7 SAIL project. Transfer of Innovation is covered in the Leonardo da Vinci project 'e-Learning DTN'.

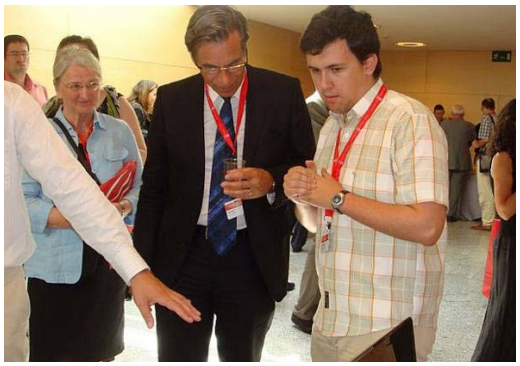


Figure 4. Paulo Freitas, IPN, and Barbro Fransson, PLAB presenting an N4C demo for Head of Unit Mr. Per Blixt in the Barcelona FIRE meeting 2010.

Elwyn Davies (Folly) led the N4C System architecture work. The N4C concept originally formed in close relation to the IRTF Delay Tolerant Networking Research Group and, the involvement has remained. N4C has maintained the DTN2 reference implementation, and contributed to several experimental RFCs such as the PRoPHET Routing Protocol, the Bundle Security Protocol Specification, and more. Also the relation to real use situations is typical. The N4C architecture is from start a response to a request from Sámi reindeer herders, for access to Information and Communications Technology. The technical challenges are however of such a kind that extensive work is needed, before a team can present accomplishments realistic enough to be fed back and assessed by users. Before presenting core technical results, it is necessary to design and establish interfaces that are meaningful in relation to the target use situations and not least that, allow others than the research team members themselves to develop a view on the value of the new technology. Reaching to this point is a major achievement.

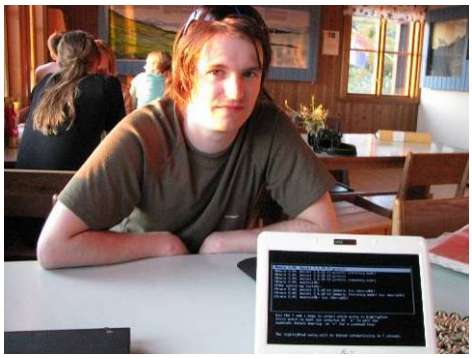


Figure 5. User assessments take careful preparations. LTU PhD student John Näslund, on site in a Lapland tourist station to give instructions and follow up user feedback.

N4C TEST BEDS AND REAL LIFE TESTS

Particular impact is expected to emanate from the dynamics achieved by the N4C real life tests. Test beds were built in Slovenian Kočevje and Swedish Lapland, with slightly different scenarios. Throughout the project, tests embedded in end-users' every-day activities were regularly performed in these sites. The tests have given opportunities to document interaction with target end users and provided unique experience from building and running DTN systems in real situations. The time spans during which the test beds were active, the numbers of tests and the range of applications tested, the genuine traffic, and user input represent a considerable achievement. MEIS was lead for

the real life tests, developed the Slovenian test bed and is hosting the N4C offer to the FIRE federation. In Sweden LTU set up tests using nomadic routing, while Tannak hosted the teams from Spain, Ireland, U.K. and Norway for tests with different scopes. Log files and analysis scripts from the real life tests are now publicly available for use by the global scientific community. As real traces from DTN traffic have been a scarce commodity, this is a notable N4C result.

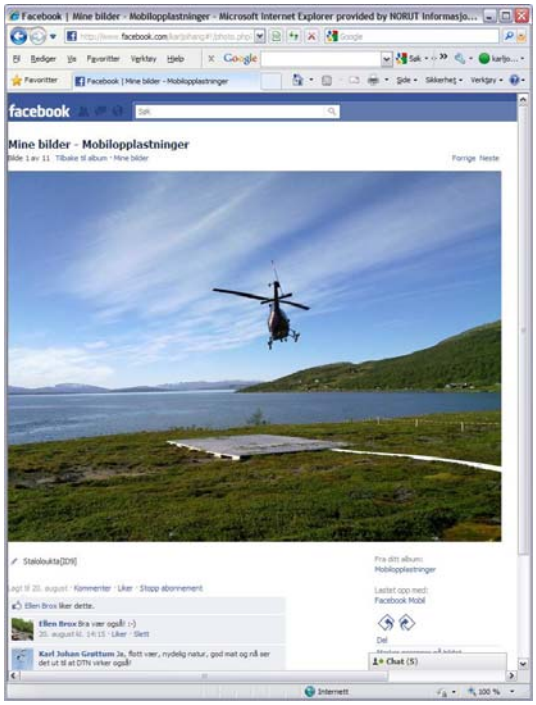
SOCIAL SCIENCES IN N4C

Technical progress needs informed strategies to result in inclusion. To promote equal access, research on the implementation context and issues of gender and culture supported the N4C technical strand, with LTU and PLAB as main contributors. The N4C business and implementation models lead to theoretically based analysis of problems connected to remote and rural areas, the use of open source, the realization of sustainable innovations, and other.

Figure 6. Maria Udén, Yngve Sundblad, Kurt Aagaard Nielsen and Avri Doria on location in Luleå for the conference Future Internet Learning from Experience

DISSEMINATION

The N4C dissemination includes presence in TV, radio and press. The newsletter has been distributed with totally six issues in English and selected issues translated to Portuguese and Slovenian. The monthly web traffic analytics show that in May 2011 www.n4c.eu had 500 visitors from 50 countries. A permanent N4C exhibition was featured at the Intel Open Innovation Lab in Ireland, with 3000 customer visits per annum. In Period 3 the participation in FIRE and FIA events included two demonstrations and a presentation in the Budapest FIA meeting. The N4C conference 'Future Internet Learning from Experience' was arranged as an on-line event and included a keynote by Vinton G. Cerf. Among the audience was official representation from the Swedish Sámi Parliament and the Swedish Ministry of Agriculture.



THE N4C CONSORTIUM

Coordinator: Luleå University of Technology, Sweden; Spain: Albentia Systems S.A. and Universidad Politécnica de Madrid; Ireland: Intel Performance Learning Solutions Ltd. and Trinity College Dublin; Norway: Northern Research Institute Tromsö AS (Norut); Poland: ITTI Ltd.; Portugal: Instituto Pedro Nunes; Slovenia: MEIS d.o.o.; Sweden: Tannak AB and Power Lake AB; United Kingdom: Folly Consulting Ltd.

Figure 7. Test results in the final year. Photo sent to Facebook mobile upload from Staloluokta 17.08.2010, appearing on Facebook 20.08.2010. Sent by Karl Johan Grottum, Norut, using the Hiker's PDA and the NSIM email service for DTN developed by Samo Grašič, LTU.