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Winter test report 2011
(Swedish test field)

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1. INTRODUCTION

This document describes the DTN (Delay Tolerant Network) set up and the subsequent results from the last N4C winter test that took place in the mountain Arctic area in the northern parts of Sweden. The winter test was conducted by researchers from Luleå University of Technology (LTU) in February 2011.

The main objective of the winter test was to perform a temperature and power supply test of the DTN outdoor node that was designed by the researchers of LTU for the last N4C summer test. In doing so the intention was to detect potential flaws in the hardware design.

An additional objective of the winter test was to gain practical experience of how the deployment of the equipment would endure the harsh winter conditions of the Arctic climate in the northern parts of Sweden. The software configuration of the tested DTN outdoor node remained the same as it was in the previous summer test.
2. WINTER TEST DESCRIPTION

The used equipment

The DTN station that was designed and used by the researchers of LTU in the last summer test was build around the Cambria embedded network board that is based on the Intel® IXP43x series Xscale CPU [2] with a 802.11b/g mini-PCI radio card. In addition to the internal antenna we also mounted N-type connector for connecting an optional external high gain antenna. The power to the board was supplied from a 12V/100Ah gel lead-acid battery that was charged with the 60W solar panels and/or the 90W wind-charger from Rutland Ltd [4]. All the components, including two separated solar/wind charge controllers were embedded in the rugged water proof Pelican box with a lock (Figure 1).

![Figure 1: The open DTN station](image)

Included in the same box was a wireless receiving unit of the Davis Vantage Pro2 weather station and the ICE.Net NMT modem that we used for the Internet connectivity. The power supply of the modem was connected through a power switch with a timer that was set to turn on the power for one hour every day at noontime. The intention was that the main Cambria board should be on all the time.
Network Topology

The network topology was intentionally kept very simple, because the network performance was not in the scope of this winter trial. The outdoor DTN station was connected to the gateway through the VPN (Virtual Private Network) connection that used Ice.Net NMT modem for the Internet connectivity. The relatively high power consumption of the NMT modem and limited power resources, forced us to limit the online connectivity to only one hour per day. Theoretically this was supposed to give us enough time to transfer all the collected data to the gateway and perform needed service of the DTN node through the available SSH service that run on that node.

![Diagram of DTN topology](image)

**Figure 2: The used DTN topology in winter-test**

This winter test topology was part of the concurrent interconnected winter test that was pursued in collaboration with the Slovenian partner MEIS d.o.o. More details about this test is available in the milestone report M8.6 - Winter tests 2011 report [3].

Deployment

We used the mountain peak Aratjákkå as the location of our winter test. Aratjákkå is to be found in the Artic mountain area of Sweden, and although its peak offered powerful winds it was still relatively accessible. Taking our point of departure from Aluokta: the nearest village that lies across the river, we went by snowmobile to the mountain peak Aratjákkå, a journey that took us approximately two hours.
The equipment was deployed on the 9th of February. In order to avoid snowstorms and extreme temperatures the exact day of the deployment was chosen only a couple of days before. Although the intention was to deploy the equipment on a slightly warmer and sunnier day – on the morning of the 9th of February the thermometer showed around -20 degrees C in the valley – the weather conditions turned out to be very fortunate. We were able to work in daylight and the ice on the river was thick enough for us to safely pass the river with the snowmobile.
The equipment was brought to the mountain peak Aratjåkkå by using a sledge that was attached to the snowmobile. In order to reach the peak, we had to leave the heavily loaded sledge when the terrain became too steep. After we had reached the peak and found the optimal location for the placement of the outdoor DTN node, we returned to pick up the sledge.

![Figure 5: The place where we assembled wind-charger](image)

Due to strong winds (sometimes more than 12m/s on top of the mountain peak Aratjåkkå) and before we reached the peak, we decided to pre-assemble the wind-charger and the weather station on an area that was less exposed to the stormy conditions. We also used the snowmobile to make a tightly packed track of snow that would be robust enough to pull the sledge on. Our initial plan was to finish the set up of the wind-charger, the solar panel, the DTN node and the weather station within less than one hour, but due to the strong wind and also the cold climate it took us more than two hours before we had completed the set up.
Although we detected some problems with the wind charge controller, we were forced to retreat in the evening (I guess you mean dusk and not dawn…) when the temperature hit –12 degrees C. Our efforts were however rewarded the next day, when we received magnificent images (I guess that there was more than one image…) of the valley from the DTN node’s web-camera.
3. **THE WINTER TEST RESULTS**

**The Running services and node's uptime**

Due to the faulty wind charge controller the only power source that we could harvest came from the rather weak Arctic sun. According to our expectations this would allow the DTN outdoor node to run for approximately five days. The DTN outdoor node was accurately running without any interruption for five days. After that the node revived only during noontime and, as could be seen on the temperature log graphs that we received from the station, only if the day in question was particularly sunny.

![Figure 7: The received temperature log graph from our winter-test DTN node](image)

Looking at the web-cam images that we received on the 11\textsuperscript{th} of February we noticed that the wind was picking up. On the same image we also spotted an unidentified object at the bottom left corner. The shape of this object did not match any of the gears that we had left on the peak. After the 11\textsuperscript{th} of February, the node's daily uptime was getting shorter.

![Figure 8: The Web-cam image with an unidentified object](image)
The power supply issues

Once we had mounted, secured and connected the wind-charger to the DTN node we cut the strings that prevented the wind turbine to get into spin, whereupon the strong wind and the slightly drained battery immediately engaged the charge controller into full charging mode. After approximately ten minutes the battery was fully charged and the wind charge controller let the wind-turbine to a free spin, something that was amplified much due to the occasional gusts and the lack of load on the wind-charger. As a result, and despite the fact that the power rate of a charge controller was supposed to handle the maximum output current from the wind-charger, the wind-charger output voltage and the momentum of the wind-turbine got so high that when the charge controller was engaged again, it blew off the main controlling MOSFET transistor of the charge controller. Unfortunately, we did not bring a backup charge controller, but returning to Luleå we ordered a new charge controller that was designed particularly for the wind-charger operation.

When we returned to replace the burned charge controller ten days later we discovered that pieces of the wind-turbine and of the wind-charger was scattered in a radios more than 10 meters around the peak. Besides, pieces of the wind-turbine had hit the solar panel and damaged its protective glass. The broken glass of the solar panel dispersed the light and significantly lowered the power output which resulted in the short daily updates of the DTN station. Other pieces of the wind-turbine had hit the weather station and torn it apart from the pole onto which it was attached. One piece of the wind-turbine had also smashed the solar radiation sensor and the rain bucket. Hence, it turned out that the object that we could not identify on a web-cam image was in fact part of the weather station.
Although we contacted Rutland Ltd [4], the wind-charger manufacturer, regarding this issue we could not find the reason for this failure. Up until this day, we can only assume that the wind-charger was designed mainly for marine type of scenarios and was therefore not designed to manage temperatures below -20 degrees C nor was it intended for exceptionally windy conditions.

![Smashed protective glass of the solar panel](image)

**Figure 10: The smashed protective glass of the solar panel**

### Snow drift issues

In addition to the exploded wind-turbine we had problems with the snowdrift. Although the node itself was mounted in a waterproof plastic box, we had to drill small cable hole for plugging in the solar panel and the wind-charger. Drawing on the experiences from the previous summer tests where we found the nodes to be unplugged from the power supply we decided to place the power connectors inside the locked box this time. A hole was drilled on a bottom of the box to prevent water from entering the box without using any seals. This approach was successfully used during the N4C summer test of 2010, but during this winter test we discovered that the strong wind turbulences brought snow inside the box through the gaps and holes, regardless of their location or inclination. Luckily, the Arctic weather conditions also prevented the snow from melting and cause electronic breakdowns.

Not only was snow and ice found inside the box, the inside of the protective enclosure of the webcam was also packed with the snow. The camera was mounted on a big rock and the wind that was blowing mostly from the other side of the rock caused strong wind turbulence in the area around the camera and brought lots of snow. Although the snow did not cause any technical disruptions it completely blocked the camera's view. In retrospect, it would have been better to mount the camera so that it was directly exposed to strong winds. The snow would then easily have blown away.
Figure 11: The snow and ice found inside the box

Figure 11: The web-camera packed with snow
Practical deployment issues

During this winter test we naturally anticipated the cold to be one of the most obvious climatological issues. But as it turned out, the combination of strong winds and the cold was even more problematic and especially on the mountain peak Aratjåkkå or when we reached open areas. The pre-assembling of the equipment that could be pre-assembled (such as adding blades on the wind-charger and mounting sensors on the weather station) took place in a forest at the foot of the mountain, something that served facilitative toward the set up procedure. Assembling everything on the peak, and judging from the strong winds, we would have needed another day to finish the set up.

Needless to stress, but appropriate clothing is pivotal when working in Arctic conditions, and an efficient way of dressing is to use layers. We were dressed with more than four layers of clothes. It is wise to avoid cotton underwear, because it is a good absorber of sweat and that can significantly decrease the isolation properties. It also helps to wear two types of gloves. Thin gloves with fingers will protect the hands when precise work such as screwing needs to be done and fingerless gloves on the top will keep the warmth during the rest of the time. It is also wise to take care not to touch any metal material without gloves. Special precautions should also be taken when handling with gas or any liquid fuels in cold conditions since spillover the hands or any other part of the body can cause frost bites, due to fuel's very low freezing point.

*Figure 12: The laptop’s keyboard packed with snow*
Another problem that was related to the cold were the plastic cable ties that we had used extensively in all the previous summer tests. Due to the cold the normally flexible plastic ties stiffened and snapped immediately when we tried to tighten them. We also failed to secure cables with the power tape, because the glue became so stiff that it did not want to glue to any material. As it turned out it is always handy to have some thin metal wire or rope in your pocket when working in such conditions.

Yet another practical issue concerned the loss of the Nokia N900 that we used to test the DTN node’s connectivity. On our way to the mountain peak Aratjåkkå we tipped over with the snowmobile and lost the Nokia N900, and although we spent at least one hour searching for it, we could not find it; the snow was deep and partly loosely packed together, which obstructed the search. Hence, rather than keeping electronic devices in the pockets, it is wise to carry them on a necklace under the jacket. In doing so, you will also extend the battery life of the electronic devices, which also was an issue with our cameras. We barely managed to take ten pictures with one set of fresh batteries when working on the mountain peak.

Loosing the handy Nokia N900, we had to use our laptops for testing the connectivity on the field. In order to protect ourselves from the wind we squatted behind the big rock that we also used as an anchor for the wind-charger mast. Due to strong turbulences behind the rock the laptop's keyboard was however packed with snow in less than five minutes. Fortunately this did not affect the Internet connectivity. Before we restored the laptops in our bags, and in order to prevent any damage from the melting snow, we cleaned the keyboards and removed the batteries.

4. CONCLUSION

Although this test period came to an end earlier than we anticipated we did reach our objectives for this winter test. Valuable experiences were gained from the practical work; for a remote Arctic deployment in the winter the wind power is a good alternative to the solar power. However, more carefully chosen locations and a higher level of maintenance are needed. As proven in this winter test, any potential flaw or imperfection in the design and the assembly of a product that is likely to be left unnoticed during warm summer conditions is likely to fail in harsh cold environments. Further winter DTN deployments therefore require a redesigned DTN power supply with a stronger charge controller and a different type of wind-charger.
5. REFERENCES


