Terrestrial application of DTN for reindeer tracking in Sweden

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Background

- **Initiated and coordinated by Dálvvadis economic association , Jokkmokk, Sweden**
- **4 Sami villages, 192 companies, 30 000 reindeer, 115 000 acres**
- **Partners: Sirges, Tuorpon, Jåhkågasska Tjiellde, Udtja sami villages and Luleå Technical University**
- **Platform was developed together <u>with</u> the reindeer herders**

Reindeer herding

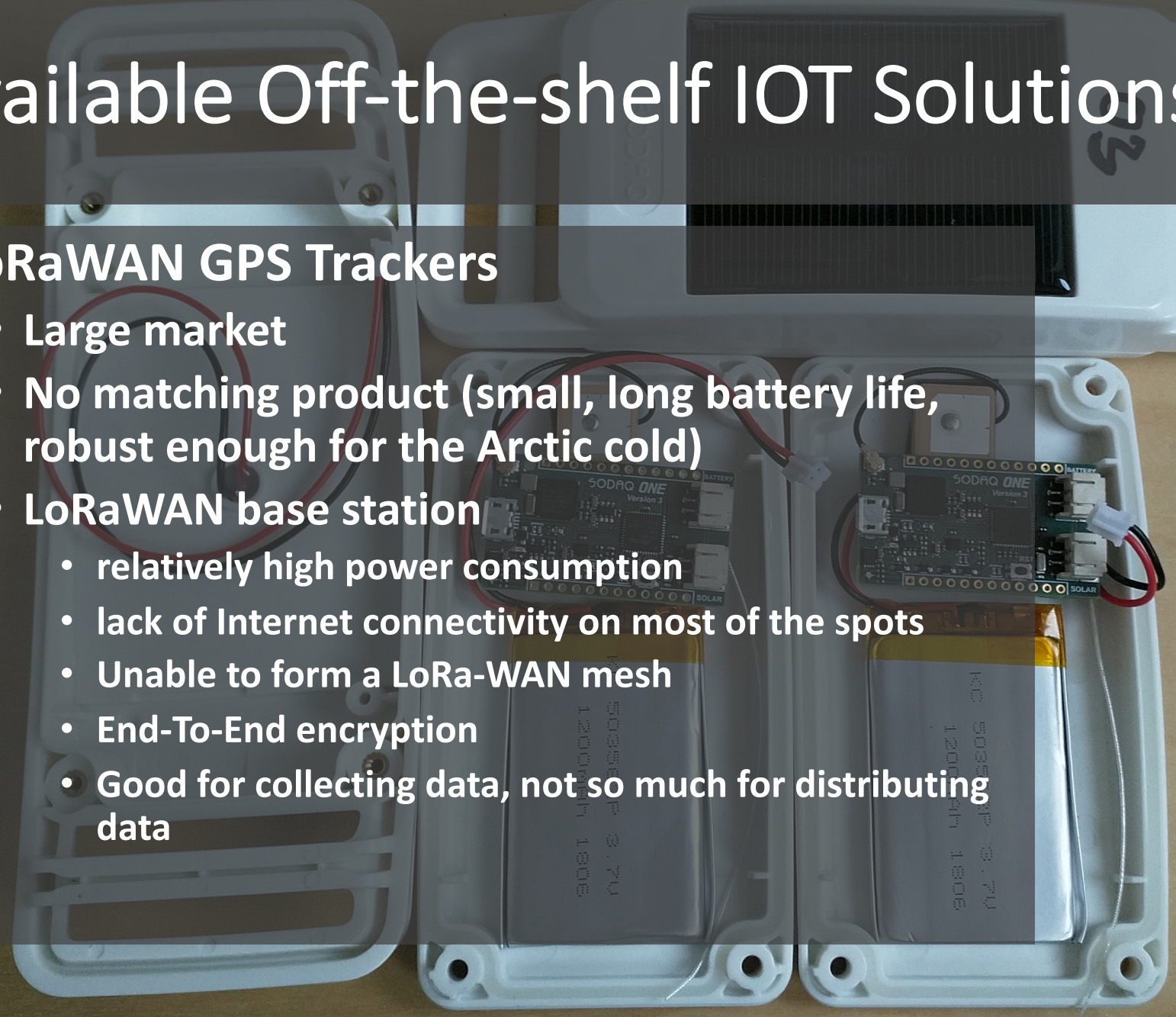
- Reindeer in Sweden graze freely in nature
- Vast grazing area without any infrastructure (Padjelanta and Sarek National Parks)
- Herds are gathered once/twice per year
- Polar summer and winter (above the Arctic circle)
- Harsh and hard to access terrain
  - Summer time: several days walk or helicopter flights
  - Winter: snowmobiles
- Early adopters of new technologies

Available off-the-shelf IOT Solutions

- **GSM GPS trackers**
  - Require mobile coverage
  - Short battery life
  - Subscription fees
  - Poor coverage drains batteries
- **Satellite GPS trackers**
  - Expensive (500-800 eur + subscription)
  - Low update frequency
  - Short battery life
  - Satellite signal issues (large antennas, forest)
  - Polar regions remains a challenge

Available Off-the-shelf IOT Solutions

- **LoRaWAN GPS Trackers**
  - **Large market**
  - **No matching product (small, long battery life, robust enough for the Arctic cold)**
  - **LoRaWAN base station**
    - **relatively high power consumption**
    - **lack of Internet connectivity on most of the spots**
    - **Unable to form a LoRa-WAN mesh**
    - **End-To-End encryption**
    - **Good for collecting data, not so much for distributing data**



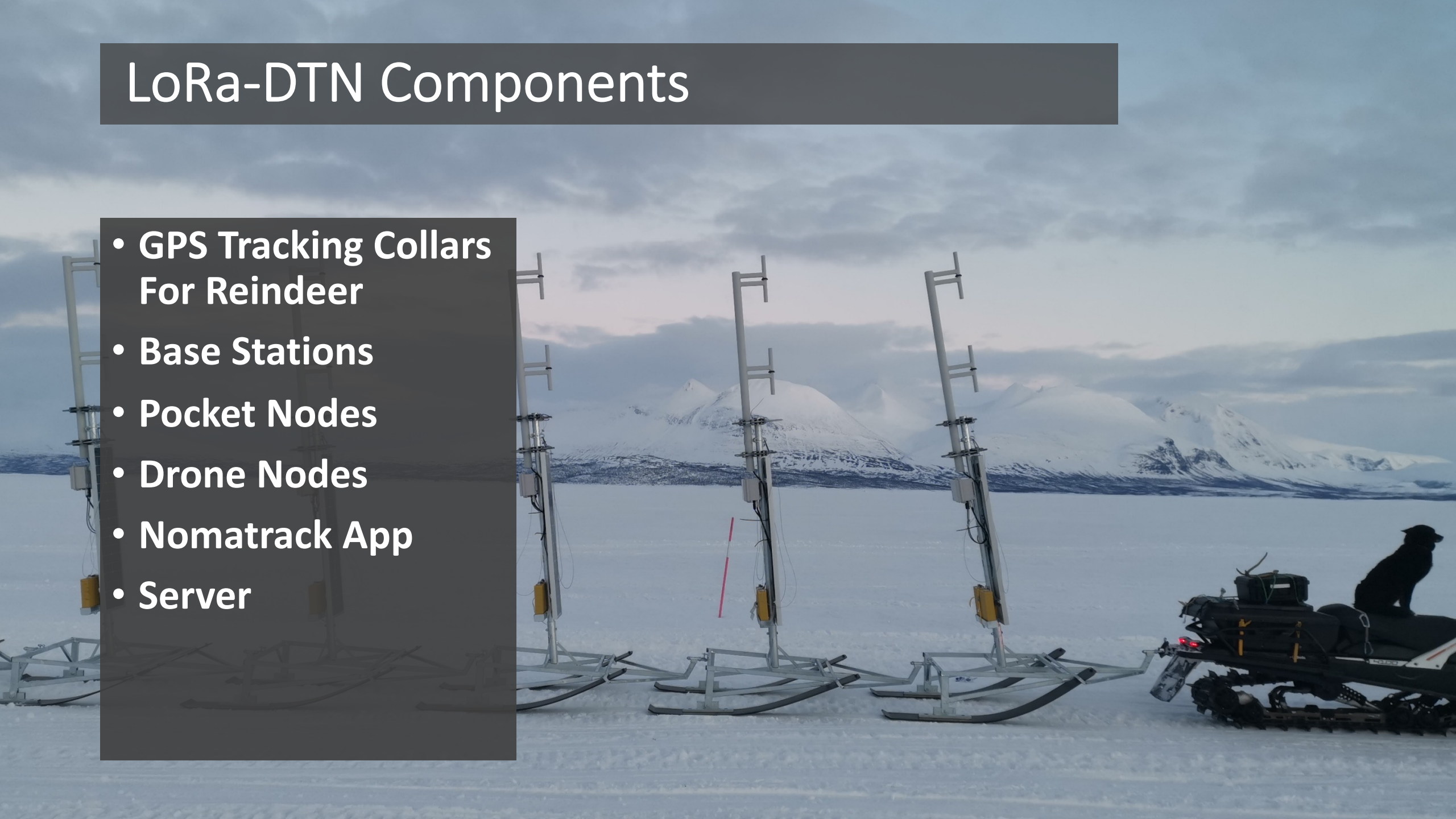
Settling for a Tailor Made Solution

- **No suitable solution available on the market**
- **Requirements**
  - **Low power consumption, solar driven**
  - **Long battery life (more than 1 year)**
  - **No license fees**
  - **Ability to track herds and exchange SMS on the field (even when offline)**
  - **Fully functional mobile app in offline mode**
  - **Frequent GPS position updates (from 1 pos/day to 4 pos/hour)**

Solution: Custom built platform

- Using 433Mhz LoRa radios
- Adopting Delay Tolerant Network architecture
  - Used previously in the N4C project
  - Designed for space communication. Can handle disruptions and delays in network links
  - Store-And-Forward principle
  - Bundle Protocol too heavy (in terms of data overhead and running code)
    - Duty Cycle (On-the-Air)
    - Tx Power consumption
  - Header size only 12 bytes (min 65 for BP)
- Synchronized Network (using GPS)
  - 4 communication opportunities every hour
- Two modes:
  - M/S (with power constrained devices)
  - PtP (other nodes in the network forming DTN/Mesh)
- Implemented as an Arduino Library

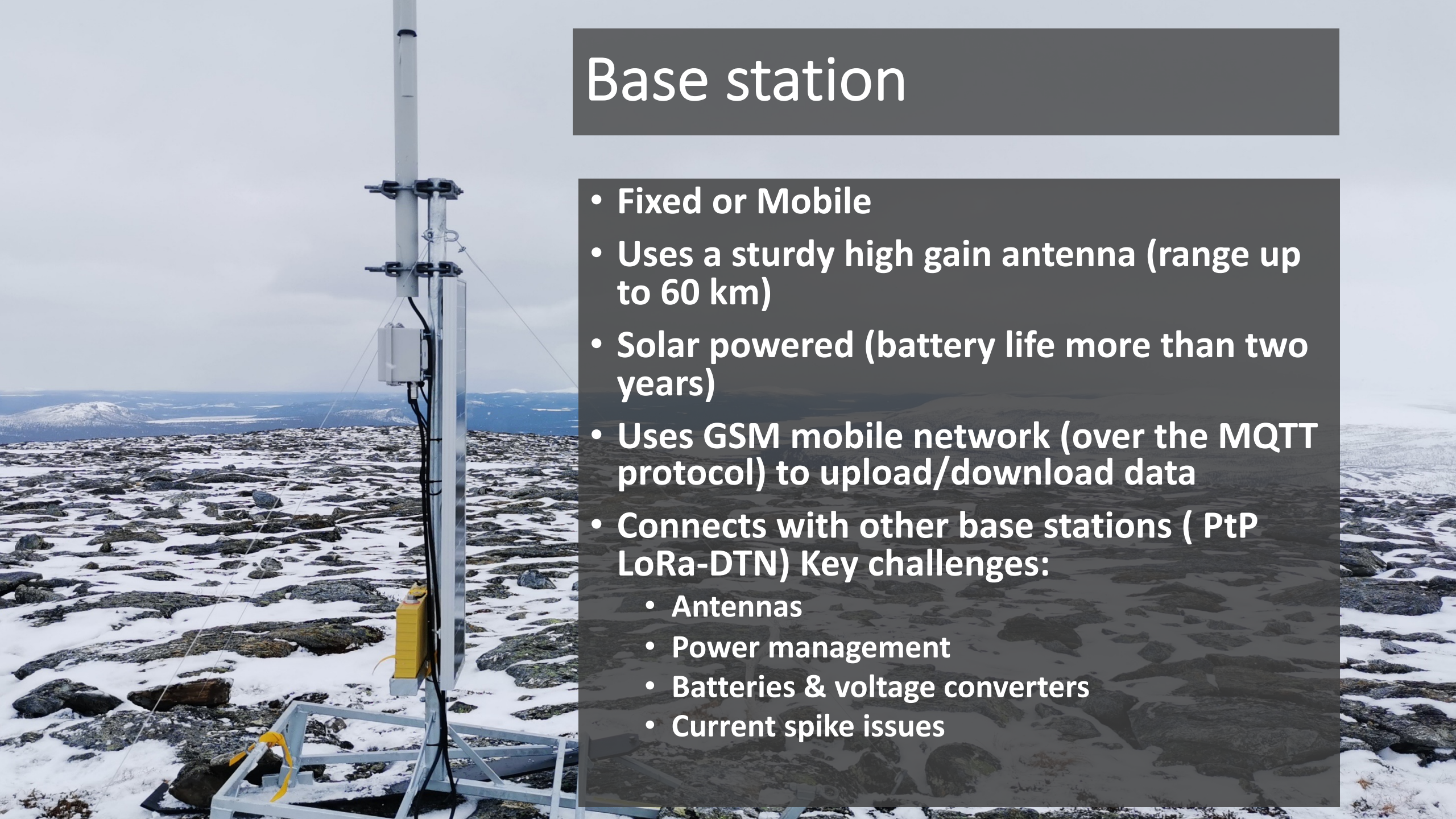
LoRa-DTN Components



- **GPS Tracking Collars For Reindeer**
- **Base Stations**
- **Pocket Nodes**
- **Drone Nodes**
- **Nomatrack App**
- **Server**

Reindeer GPS Tracking collars

- Long battery life (non-rechargeable) between 2 to 5 years
- Using M/S mode, transmits positions only when it is in range of a base station/pocket node (beacon)
- GPS Update time can be adjusted from 15 minutes to 1 per day (over beacon)
- Weight approx. 220 grams
- Key challenges:
  - Battery life (power management)
  - Antenna
  - Waterproof
  - SAMD21 Sleep Bug



Base station

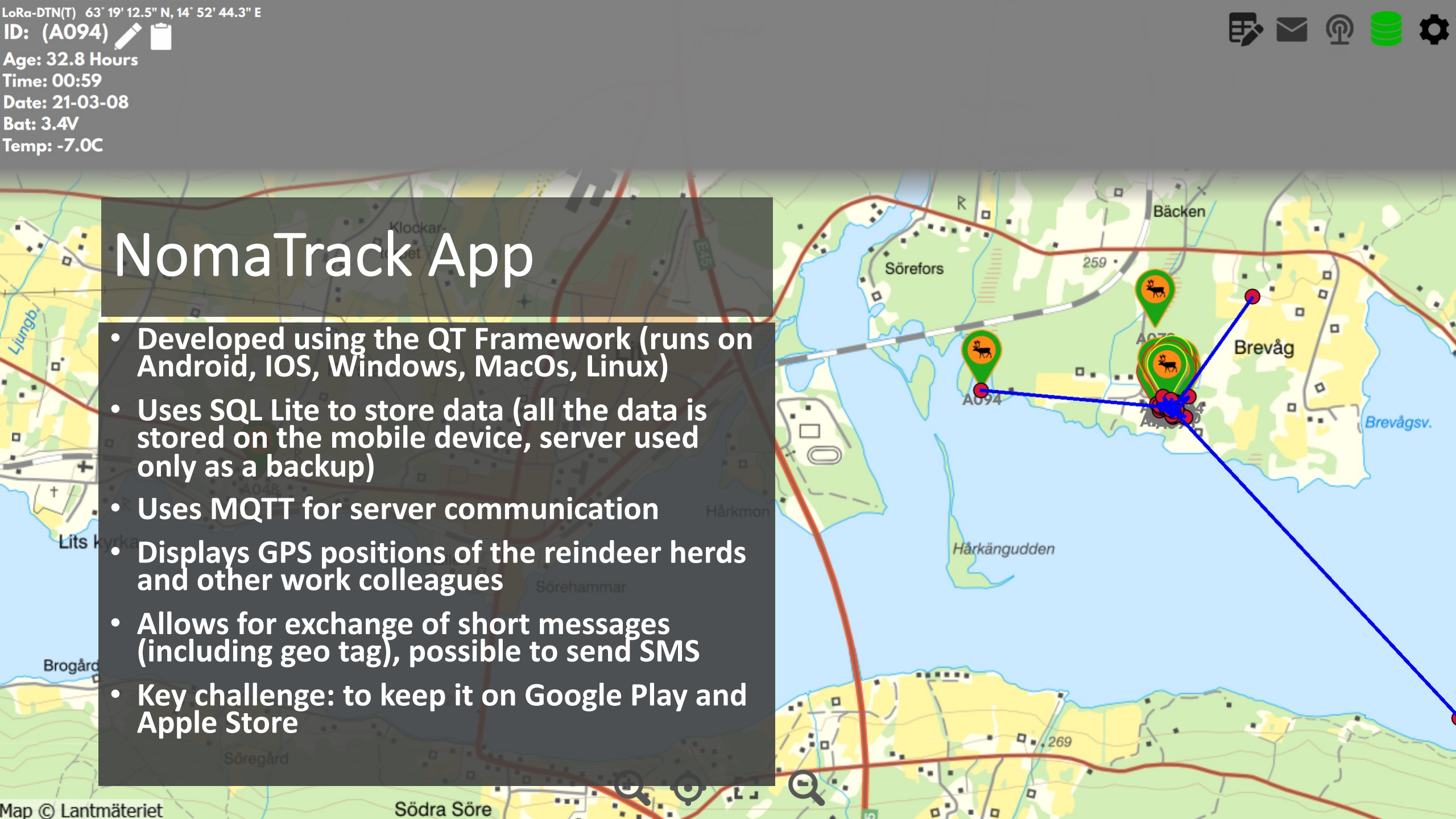
- Fixed or Mobile
- Uses a sturdy high gain antenna (range up to 60 km)
- Solar powered (battery life more than two years)
- Uses GSM mobile network (over the MQTT protocol) to upload/download data
- Connects with other base stations (PtP LoRa-DTN) Key challenges:
  - Antennas
  - Power management
  - Batteries & voltage converters
  - Current spike issues

Pocket Node

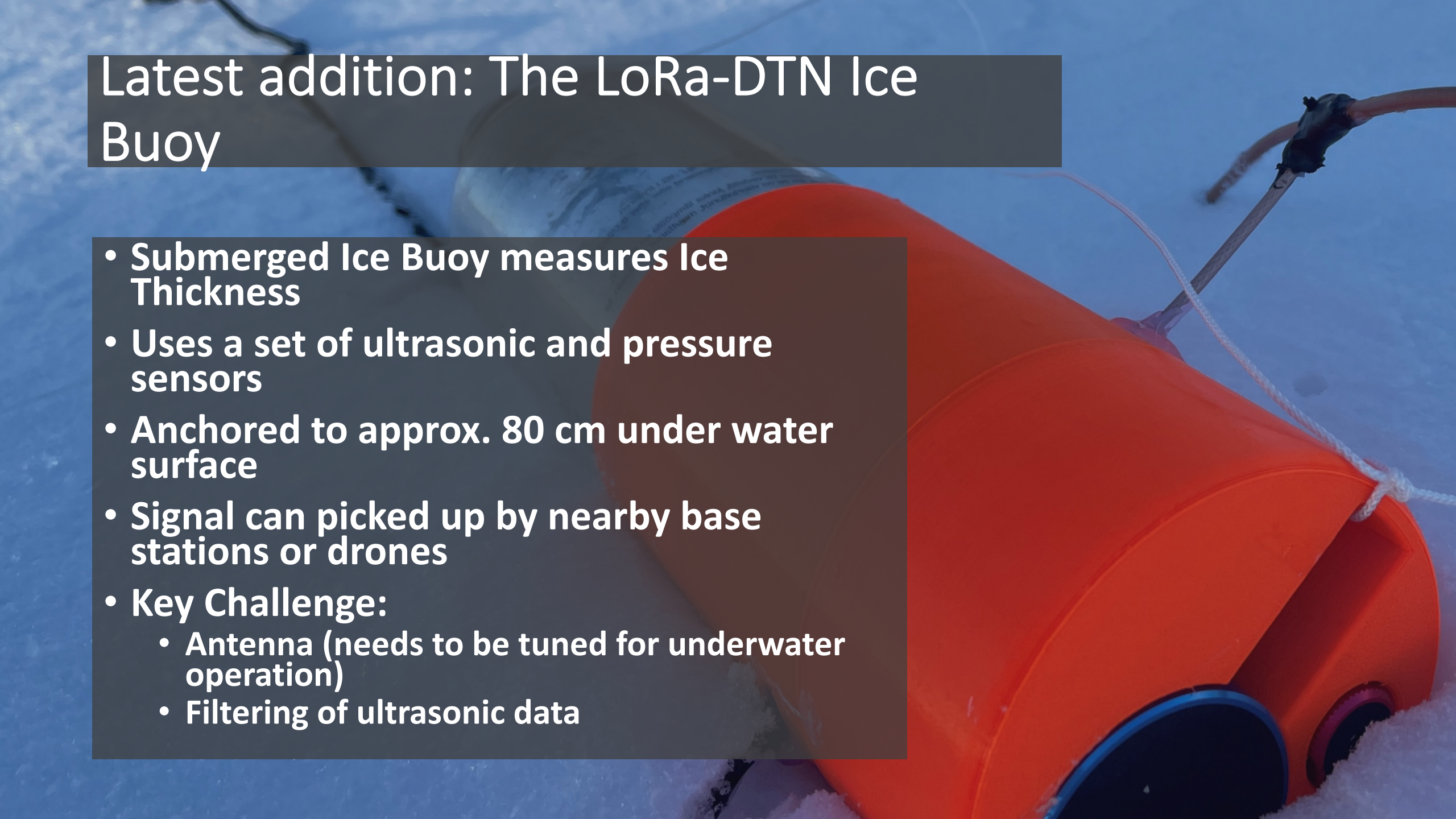
- Designed to be carried around while working in areas without mobile coverage
- Interfaces the LoRa-DTN network and Nomatrack App over the Bluetooth
- Based of NRF52 chipset, built-in GPS
- Same function as base station (supports M/S and PtP Mode)
- Challenges
  - Size
  - Antenna
  - Battery life (more than 24h at room temperature, 2h max at -25, not possible to charge)
- Can be attached to the drone and used as base station in order to collect GPS positions

Drone Node

- Drones have become an essential tool for searching and monitoring herds (large economic impact)
- Can be used as a hovering LoRa-DTN base station
- First prototype: An attachment for the DJI Mavic 2 Enterprise
- Currently: Hanging a Pocket-Node to the drone
- Coverage around 30 kms (on 120 m height)
- Key Challenge:
  - Interference with DJI signal


LoRa-DTN(T) 63° 19' 12.5" N, 14° 52' 44.3" E
ID: (A094)
Age: 32.8 Hours
Time: 00:59
Date: 21-03-08
Bat: 3.4V
Temp: -7.0C
NomaTrack App
• Developed using the QT Framework (runs on Android, IOS, Windows, MacOs, Linux)
• Uses SQL Lite to store data (all the data is stored on the mobile device, server used only as a backup)
• Uses MQTT for server communication
• Displays GPS positions of the reindeer herds and other work colleagues
• Allows for exchange of short messages (including geo tag), possible to send SMS
• Key challenge: to keep it on Google Play and Apple Store
Bäcken
Sörefors
259
Brevåg
A094
Brevågsv.
Hårkängudden
Hårkmon
Sörehammar
Lits kyrka
Brogård
Söregård
269
Södra Söre
Map © Lantmäteriet

Latest addition: The LoRa-DTN Ice Buoy



- **Submerged Ice Buoy measures Ice Thickness**
- **Uses a set of ultrasonic and pressure sensors**
- **Anchored to approx. 80 cm under water surface**
- **Signal can picked up by nearby base stations or drones**
- **Key Challenge:**
  - **Antenna (needs to be tuned for underwater operation)**
  - **Filtering of ultrasonic data**

Tannak INT service

Telespor INT service

FindMy INT service

FollowIT INT service

NomaTrack server side

GPS trace processor

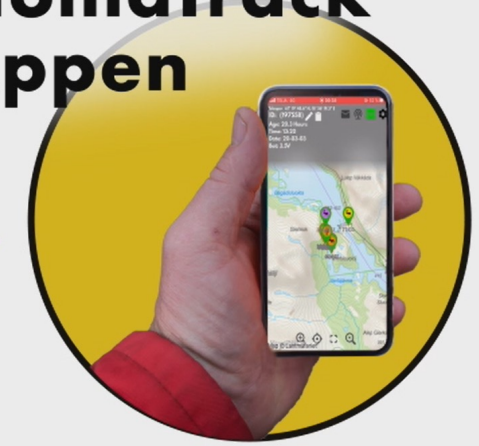
Data-bas

NomaTrack DTN Halsband

Fast/Mobil Basstation

Pocket-node

NomaTrack Appen



Additional challenges

- Timing issues (despite GPS time)
  - Initial plan to use Time-Division Access method dropped
    - Issues with timing due to high temperature fluctuations and software issues
  - Slotted Aloha used instead (more robust, easier to implement)
    - Issues with “random” function
- Assuring backward compatibility (for already deployed equipment)
- Base stations placements (high peaks vs. low peak methods)
- Overcharging of Base Station Batteries (fixed with different power management, allowing for Instant Retransmissions)
- Expensive maintenance
- Adopting plans to weather conditions and reindeer
- Ice damage
- Handling equipment in the cold (charging various equipment)
- Issues plastic mounts/cables

Work in progress

- **Adopting the DTN Bundle Protocol v7**
  - **Already implemented LoRa Convergence Layer for ION DTN implementation**
  - **Connecting the LoRa-DTN network to the Interplanetary Special Network Interesting Group's operational DTN network**
  - **Ping a reindeer from Space**
- **Building the DTN-Of-Things Stack (ION-DTN, MQTT, Arduino Sensors)**
  - **Implementing a lightweight DTN Sensor Arduino Library**

Final remarks

- Developing a distributed application to counter the prevalent trend of
- centralized Internet services is challenging.
- The reward? A service that's notably more resilient.
- A bottom-up approach and local governance proved essential for the success of the LoRa-DTN platform.
- Due to its niche market and remoteness, it's often not economically viable for external actors.
- Different Sami villages have adopted their own unique deployment strategies


Thank you for your attention!
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