Electronic Communications of the EASST
Volume 080 (2021)

Conference on Networked Systems 2021 (NetSys 2021)

MoleNet: An Underground Sensor Network for Soil Monitoring

Jens Dede, Daniel Helms and Anna Förster

4 pages

Guest Editors: Andreas Blenk, Mathias Fischer, Stefan Fischer, Horst Hellbrueck, Oliver Hohlfeld, Andreas Kassler, Koojana Kuladinithi, Winfried Lamersdorf, Olaf Landsiedel, Andreas Timm-Giel, Alexey Vinel
ECEASST Home Page: http://www.easst.org/eceasst/ ISSN 1863-2122

MoleNet: An Underground Sensor Network for Soil Monitoring

Jens Dede[1], Daniel Helms[2] and Anna Förster[3]

jd@comnets.uni-bremen.de
dhelms@uni-bremen.de
anna.foerster@uni-bremen.de
Sustainable Communication Networks
University of Bremen, Germany

Abstract: With the increasing digitalization worldwide, the demand of information also increases in all areas. *MoleNet* is a low-power sensing platform which is easy to assemble and use. It offers several options to monitor, for example, the soil moisture and temperature and visualize the data. Several researchers from different countries are currently working and improving *MoleNet* for different applications. This demo shows the main application of MoleNet: Monitoring soil conditions in a remote area, transmitting the data and visualizing the current status.

Keywords: sensor network, underground communication, WUSN, soil monitoring

1 Introduction

MoleNet [ZDG+16] was originally developed for monitoring reforestation projects in developing countries. Here, a long time monitoring of the soil properties in remote areas is required. The special requirements 1) long battery lifetime (i.e., several years), 2) inexpensive devices, 3) easy to build, set up, and maintain and 4) data transmission between the buried nodes was not achieved by existing systems. Therefore, we decided to develop a new system tailored to those needs. In the beginning, our focus was mainly on the subsurface communication challenges [HSW+20] and the soil water content [AS06]. Meanwhile, the use cases of MoleNet evolved, and the system was also evaluated for additional projects like, for example, for monitoring fish tanks [QZF20] or finding trapped miners [ZFMC18].

In this demo, we show data from one of our currently running field tests where the soil is monitored at a local farm.

2 System Overview

MoleNet is based on standard technologies and can be adapted easily. Figure 1 shows the principle setup of a MoleNet measurement site. (1) is the sensor network itself containing the MoleNet nodes with different sensors attached. Those nodes are battery powered and communicate using 433MHz radio technology. Depending on the setup, the nodes can be buried and operate several month to years without maintenance or battery changes. (2) shows the MoleNet base station. Here, also data can be collected like from an optional weather station (3). The main task of the

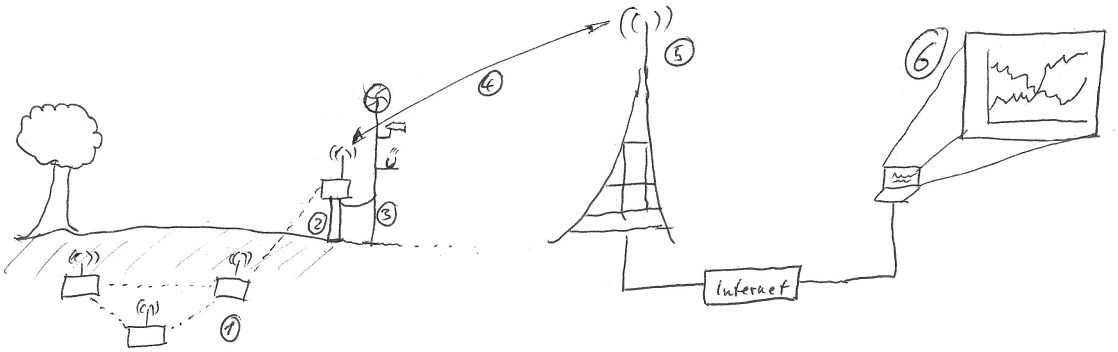

Figure 1: The Infrastructure of the demo setup: The measured data is transmitted from the MoleNet nodes to the end-user device.

MoleNet base station is to receive the data from the nodes and forward it to the Internet. For that, the collected data is sent via long-range communication technologies (4) like a cellular network, WiFi, or LoRaWAN to the corresponding infrastructure, or more precisely, to the base station of the service (5). From here, the data is sent to one or several Internet services for storage, further processing and user access (6).

3 Sensor Node Hardware

MoleNet is an open-source project and available on github[1]. The design is based on Arduino[2] with the focus on very low power consumption. Arduino ensures that a complete ecosystem of documentation, tutorials, drivers, and libraries can easily be integrated. Especially for beginners in embedded programming and system design, MoleNet offers a good starting point for low-power open-source hardware. For the same reason, we decided to focus on easy-to-solder standard components.

Figure 2 shows the PCB of a node. The main parts are (1) the microcontroller, which is running the program itself, (2) an RTC (clock) module ensuring precisely timed measurements and wakeups, (3) a radio module for the communication with other nodes and the base station, (4) a flash memory for data storage, (5) a connector for the sensors and (6) the antenna.

The current system operates at 433 MHz but can be adapted easily to other frequencies or even communication standards.

MoleNet is optimized to a low power consumption between two consecutive sensor readings. For most applications, only a few measurements per day or even less are required. This allows to shut down the system, including most peripheral, and only keep the RTC module running. After a certain period of time, the RTC wakes up the system, starts the measurement, saves the data on the flash memory, starts the data transmission, and returns to the deep sleep mode. In another configuration, the node enters the deep sleep mode after saving the data and transmits the data

[1] https://github.com/ComNets-Bremen/WUSN
[2] https://arduino.cc

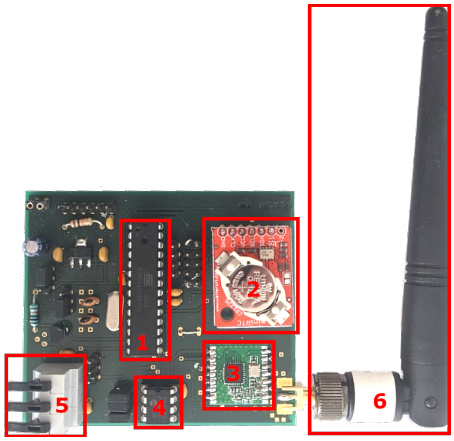

Figure 2: A MoleNet sensor node.

only once a day, further decreasing the power consumption.

4 MoleNet Applications

Even if the main application area of MoleNet is soil monitoring, we have already used it for various other applications and further are in planning. The MoleNet platform is very well suited for challenged environments in general, where communications at higher frequencies are impossible. We have used MoleNet for fish tank monitoring in Namibia [QZF20], where the sensor nodes are deployed on the edge of the fish tanks, with sensors hanging into the water and monitoring salt levels, dissolved oxygen, temperature, and pH values. In South Africa [ZFMC18], we have used MoleNet to develop a system for localizing trapped miners after a mine collapse. Here, no sensors were used at all, and only the radio signal strength was utilized to localise the sensor nodes, carried by miners.

5 Planned Demo

For the demo, we plan to show live data from two sources: Soil measurements from a field in northern Germany and live data collected at the venue. The data will be transmitted using the system as shown in Figure 1 and displayed on a webpage similar to Figure 3. The impact of rain on soil moisture and the power consumption of the system will be demonstrated.

6 Conclusion and Future Work

MoleNet offers an inexpensive, easy-to-build, use and maintain low-power sensor node platform. It is flexible to use and offers a good starting point, especially for newcomers in embedded hardware and programming.

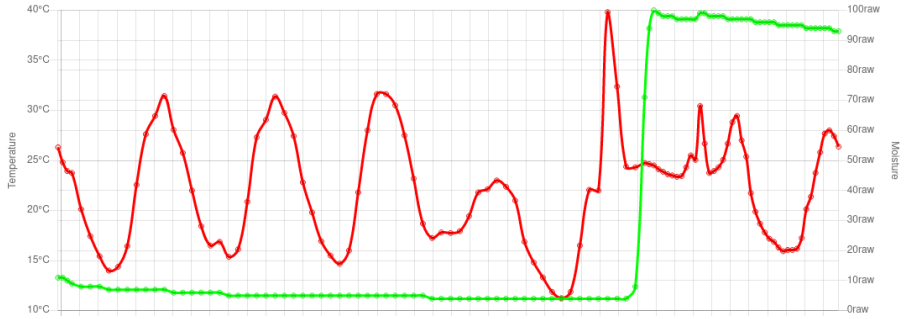

Figure 3: Example data from a measurement: The air temperature above the surface (red) and the raw values of the moisture sensor (green) are shown.

Due to the variety of different users and applications, their expectations and requirements of the project, the future work is manifold. One focus is to extend the MoleNet nodes to a more modular system: Adding new sensors with different hardware interfaces is currently simplified. Regarding the hardware, we are evaluating the recent developments in chip design and plan to adapt the system to newer generations of low-power microcontrollers. Furthermore, in the near future, tutorials and videos will be made available on our youtube channel to foster the usage of MoleNet in education. Everybody is invited to contribute to the MoleNet project on github or on the project webpage: https://www.molenet.org.

Bibliography

[AS06] I. F. Akyildiz, E. P. Stuntebeck. Wireless underground sensor networks: Research challenges. *Ad Hoc Networks* 4(6):669–686, 2006.
doi:10.1016/j.adhoc.2006.04.003

[HSW+20] H. Huang, J. Shi, F. Wang, D. Zhang, D. Zhang. Theoretical and experimental studies on the signal propagation in soil for wireless underground sensor networks. *Sensors* 20(9):2580, 2020.
doi:10.3390/s20092580

[QZF20] K. Qayyum, I. Zaman, A. Förster. H 2 O Sense: a WSN-based monitoring system for fish tanks. *SN Applied Sciences* 2(10):1–12, 2020.
doi:10.1007/s42452-020-03328-3

[ZDG+16] I. Zaman, J. Dede, M. Gellhaar, H. Koehler, A. Foerster. Molenet: A new sensor node for underground monitoring. *IEEE SenseApp*, 2016.

[ZFMC18] I. Zaman, A. Förster, A. Mahmood, F. Cawood. Finding trapped miners with wireless sensor networks. In *2018 5th International Conference on Information and Communication Technologies for Disaster Management (ICT-DM)*. Pp. 1–8. 2018.
doi:10.1109/ICT-DM.2018.8636376