Deliverable

D2.4 : Field ready internal next generation sensors

Deliverable information	
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Summary

QuakeSaver developed two kinds of connected smart seismic sensors for monitoring within the RISE project: (1) A cost-effective and highly sensitive seismometer for monitoring buildings and seismicity at local, regional and global scale. (2) An affordable, integrated MEMS accelerometer for monitoring strong motion and the structural health of high-rise buildings.
The sensor software platform is connected to retrieve information in real-time and configure the sensors remotely. Furthermore, the developed sensor software serves as a foundation for RISE partners to access the computing capabilities of embedded devices to extract meaningful high-level data products from the sensor time series, through an extensible software plugin mechanism.

1 Smart Seismic Sensor Development

Within the RISE project, QuakeSaver developed two affordable smart seismic sensors: (1) a highly sensitive short-period sensor real-time building monitoring for seismic monitoring of seismicity at local, regional and tele-seismic distances. These sensors are designed to be deployed indoors and in harsh outdoor environments. (2) A compact sensor for indoor installation equipped with a low noise MEMS accelerometer for building monitoring.

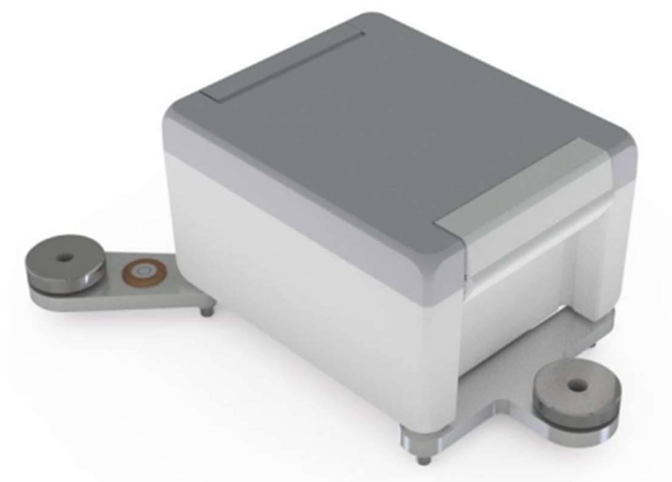

Fig 1: QuakeSaver highly-sensitive short-period + accelerometer HiDRA smart seismic sensor for use in harsh outdoor environments, following IP65 standard.

Key features of the short-period QuakeSaver HiDRA sensor (Fig. 1) are:

- 3-component short-period seismometer with a cutoff frequency f_c of 0.5 Hz.
- Ultra-low noise 24-bit ADC (RMS ~2 counts; 139 dB) with variable sampling rate of 50 Hz, 100 Hz and 200 Hz and analog pre-amplification 1x, 2x and 4x.
- Low noise 3-component 20-bit MEMS accelerometer with variable sampling rate from 50 Hz, 100 Hz and 200 Hz and configurable range of 2 g and 4 g (optional).
- Flexible power supply from 9 to 18 V.
- Hygrometer, barometer (atmospheric pressure) and thermometer for continuous system and instrument health monitoring.
- Time synchronisation via NTP and/or external GNSS antenna.

Fig 2: QuakeSaver MEMS accelerometer. (left) The bare-bones compute unit with Ethernet port for scale. (right) The sensor unit enclosure for indoor deployment in buildings.

Key Features of the QuakeSaver MEMS (Fig. 2) sensor developed in the RISE project:

- Low noise 3-component 20-bit MEMS accelerometer with variable sampling rate from 50 Hz, 100 Hz and 200 Hz and configurable range of 2 g and 4 g.
- 5 V Power supply over USB. Power consumption ~1 Watt.
- Connected via WiFi and Ethernet.

Advances in sensor, communication and embedded computation technology allowed the development of low-cost sensors. The evaluation and testing of QuakeSaver MEMS sensors was undertaken with RISE partners at ETH Zürich.

2 Sensor Software Development

Within the RISE project we developed a flexible software architecture which is empowering the sensor instrument to process the data “on-the-edge”. This innovative approach opens new ways for data handling and real-time processing of the data for swift integration into exposure maps and RLA models. Simple data products for example are Peak-Ground-Acceleration and Velocity (PGA/PGV), instrument intensities (e.g. spectral intensity of JMA Shindo).

We now rely on cooperative development and research with RISE partners to fill this ecosystem with meaningful data processing modules e.g. analysis of dominant frequency of a building, tailored to the demands of stakeholders.

Next to the real-time processing capabilities the QuakeSaver sensors implement well-established data exchange protocols for streaming the seismic data in real-time to central data centers.

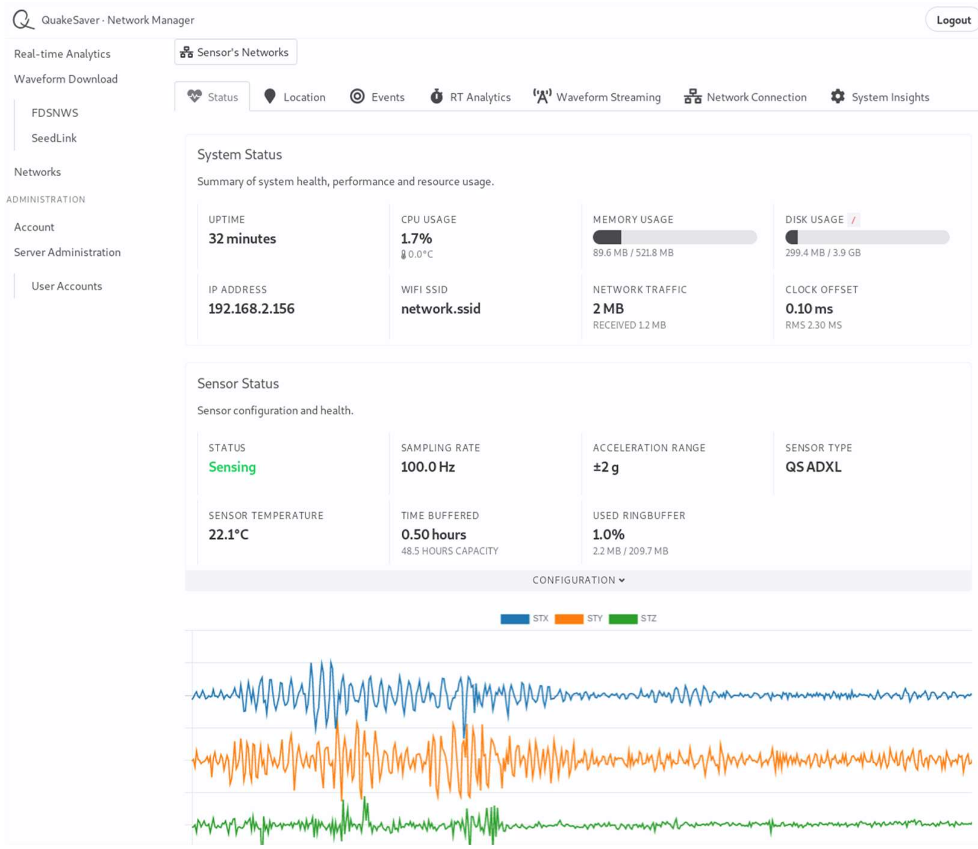

Fig. 3: Sensor user interface to configure and monitor a sensor in the field.

The increased numbers of sensors and ever increasing amount of sensor data demand sophisticated software solutions to manage the growing fleet of seismic sensors. This developed backend allows to manage a fleet of QuakeSaver sensors in a modern and reliable fashion. Intuitive and powerful user interface are accessible from any device and in any browser. Sensors can be grouped into virtual networks and configured remotely in bulk or individually.

The digital twin of each sensor provides a detailed reflection of all parameters and continuous data analysis such as network aggregated PGA. Data products are graphically presented as maps, lists and accessible as descriptive GeoJSON for seamless integration in any GIS software. This enables a continuous overview and health monitoring of your entire network within a glimpse.

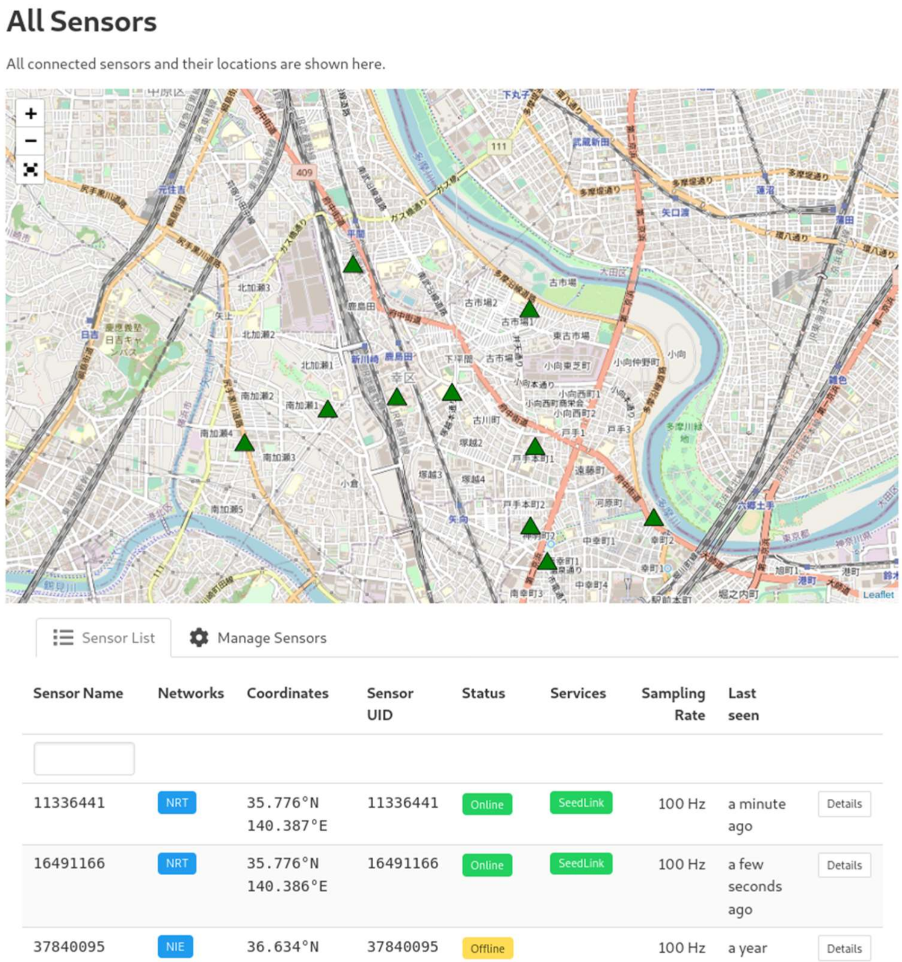

Fig. 4: Network management of sensor fleets through an intuitive browser interface. Sensors' digital twins can be managed and monitored remotely.

Preliminary Network Deployment

As of Q2 2021 first batches of QuakeSaver MEMS were shipped to RISE partners in ETH Zürich, ISTerre Grenoble, University of Montenegro and University of Istanbul. The deployment of more QuakeSaver HiDRA sensor nodes will follow in 2021.

The RISE project will now see a growing number of smart and cheap seismic sensors which can be exploited for real-time risk assessment.

Challenges and Further Work

The two sensors are currently under evaluation by QS as well as project partners. A recently conducted study showed that the more sensitive integrated sensor has a low amplitude noise signal at 1 Hz which becomes apparent only in extremely quite environments. This issue will require modifications in the PCB design to decouple the power supply from the analog sensor front-end carried out by QS contracted electro-technical engineer. Further modifications of the PCB are required to integrate an industrial compute platform designed for large scale applications.

A major unforeseeable challenge has been the global chip crisis, which is a direct result of the corona virus pandemic. This crisis has led to significant shortages of electrical parts. Across many industries the demand and supply chain has collapsed.

Due to shortage of critical electrical components (e.g. MEMS accelerometer, analog-digital-converter, industrial SD cards and more) the production of more seismic sensors will be delayed until the market has recovered. Some expert estimate that the crisis will be overcome in mid-2023[1]. We are eagerly working to find alternatives for unavailable components, redesigning PCBs and taking other measures to mitigate the effect of the ongoing crisis in the best interest of the RISE project.

Our further work will engage cooperation with RISE partners to research and develop on-device algorithms to deliver meaningful real-time data products into the exposure and hazard modeling communities.

Further development of the software stack will be needed to guarantee a redundant, high availability and robust infrastructure that will scale for global application of the developed system. Funds allocated in the amendment will be dedicated to employ a professional full-stack software developer.

We will open-source the developed sensor software under free licenses (e.g. GPL) to empower and drive the sensors capabilities further.

[1]https://www.techtimes.com/articles/260243/20210514/global-chip-shortage-persist-until-2023-demands-pc-slightly-soften.htm