IBTP Koschuch e.U.

Rockfall Detection System

RDS 22

Rev. 1.1

www.ibtp-koschuch.com
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Sensor

More and more protective nets and barriers are being built to protect roads, railroad lines, and infrastructure from rockfalls, avalanches, and debris flows. The IBTP Koschuch Rockfall Sensor System is designed to detect and measure those events directly at the structure. The system allows the measurement of an event's intensity and disclosure of its triggering location, which provides the possibility of a targeted and timely inspection of the affected areas afterward and hence a quick check of the functional capability of protected facilities and the detection of further rockfall hazards. This ensures optimal maintenance of the facilities and reduces the risk of possible subsequent destructive events that occurred rockfalls may trigger.
Several systems were built and evaluated for this purpose. The final design consists of a digital-output three-axis low g MEMS accelerometer in combination with a miniature-sized circuit board containing a Cortex processor, a LoRa connection module, and a crypto chip. The device power is supplied with a 6V-2W PV panel and a 4000 mAh supported battery, ensuring the device is energy self-sufficient. The accelerometer sensitivity is +/-16g in each of the three axes and is featured by various built-in motion detection modes and user-adjustable thresholds. Thanks to a modular design, additional sensors can be integrated into the system efficiently to measure other favorable quantities such as ambient temperature, humidity, and pressure. They are mounted inside a 120×80×50 mm³ outdoor waterproofed and UV stable plastic box. This box can be mounted with some cable ties on every rock fall barrier without any other tools.

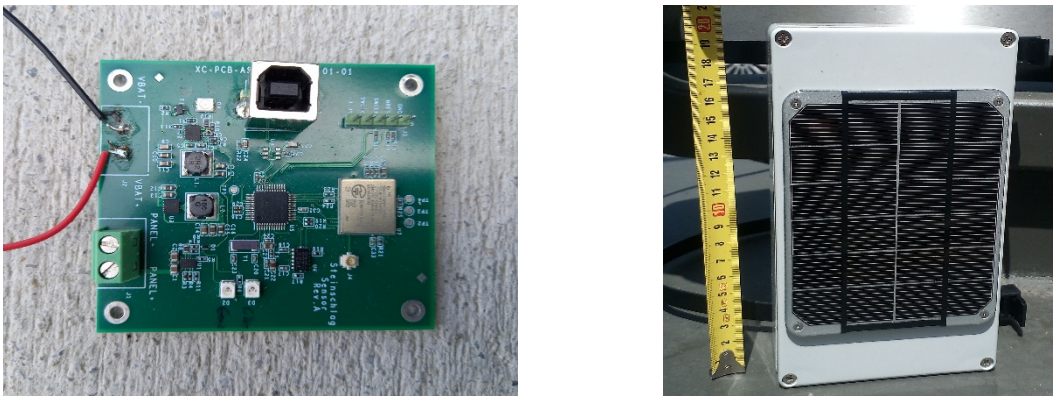

Figure 1 A digital three-axis shock sensor mounted on a printed circuit board (left) and the plastic box containing PCB, sensor, and supported battery plus the PV panel installed on the surface of the box (right).

Sensor Specifications

Digital Three-axis Shock Sensor

Low power consumption	23 µA
operating temperature range	-40°C to +85°C
End-user resolution	8 bit
supply voltage range:	2.0 V to 3.6 V

Circuit Board

Microcontroller	SAMD21 Cortex®-M0+ 32-bit low power ARM
Radio module	CMWX1ZZABZ
Board Power Supply (USB/VIN)	5 V
Secure Element	ATECC508
Circuit Operating Voltage	3.3 V
Digital I/O Pins	8
DC Current per I/O Pin	7 mA
CPU Flash Memory	256 KB (internal)
QSPI Flash Memory	2 MByte (external)
SRAM	32 KB
Clock Speed	32.768 kHz (RTC), 48 MHz
USB	Full-Speed USB Device and embedded Host
Antenna gain	2 dB (bundled pentaband antenna)
Carrier frequency	433/868/915 MHz
Working region	EU/US

Waterproof UV-resistant PV Panel

Maximum output voltage	6 V
Maximum output power	2 W

Li-Po single cell battery

I/O Voltage	3.3 V
Input Voltage (nominal)	5 V
DC Current per I/O pin	7 mA

Data Transmission

The measured data are forwarded via **Lo**ng **Ra**nge **W**ide **A**rea **N**etwork (**LoRaWAN**) connection standard to a mobile gateway. A gateway can support several devices, varying between 10 to 30 devices, depending on the gateway model. The distance to the gateway can be 2-3 km. In our test installations (currently 6 locations), it has been shown that it makes sense to mount the sensors at the top of every second post of the protective barrier. In this way, the magnitude and position of an impact can be accurately determined across the entire network. The sensor reports wakeup measurements every 12 h (it can be adjusted before installation) as a sign of functionality or to assess the status of the network. In case of an impact larger than the preset threshold, the sensor records a configurable number of measurements and sends the data immediately.

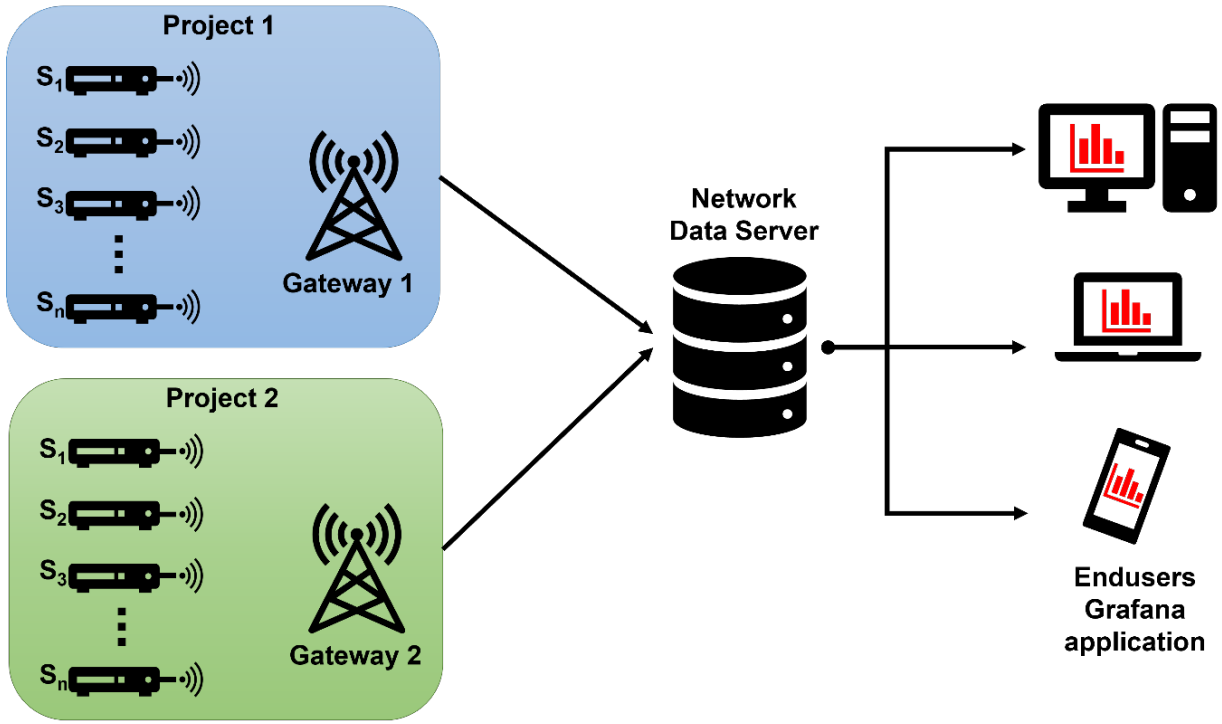

Figure 2 Schematic view of the Rockfall Detection System using LoRaWAN connection standard.

Data Monitoring and Visualization Software

After a measurement ends, the data are sent immediately over the gateway to a server and are stored in a database. The database can then be visualized via **Grafana**, a multiplatform monitoring tool with web interface visualization. All locations and sensors are accessible here and anyone with authorization can view the data or make their own visualizations (Grafana dashboard). The data are used to determine the number of events or the location and intensity of an impact. In addition, Grafana generates automatic alarm SMS/Email for different thresholds using the database analysis. Herewith the customer is informed immediately about significant events.

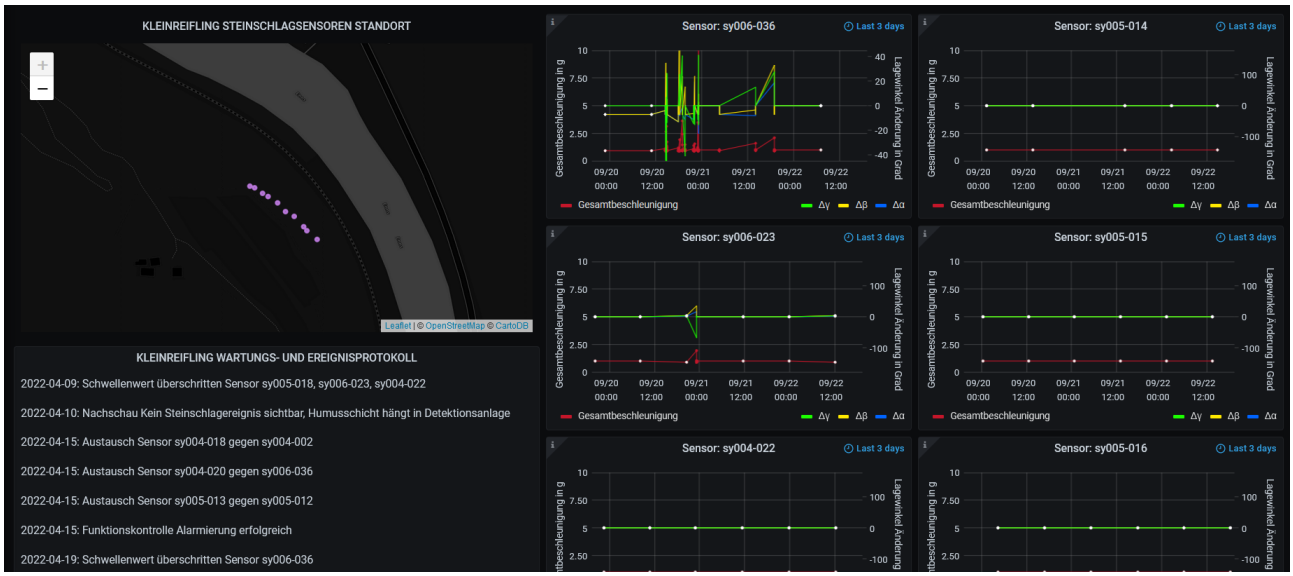

Figure 3 View of a Grafana dashboard for a rockfall project showing an aerial map of location of installed sensors (left panel) and magnitude of measured acceleration along with rotation around cartesian axes respect to the latest wakeup outside the visualized time interval for each sensor (right graphs). The white points are the wakeup measurements.

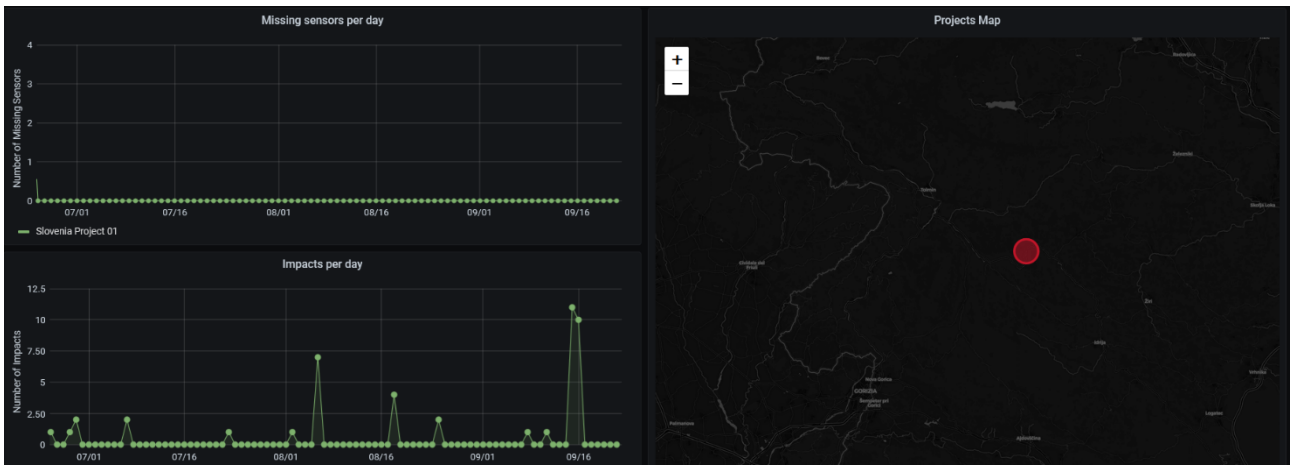

Figure 4 Another example of a Grafana dashboard showing status of a project. It consists of two graphs, number of missing sensors per day (top left panel) and number of impacts per day (bottom left panel), following by aerial view of the project in a map panel (right panel).

We currently have running projects at six sites. We are already beyond the prototype stage and using the system as a product. From the data obtained, we have created a robust monitoring system that can still be further developed and adapted according to customer demands.

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