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A new data logging system for monitoring of concrete structures

1 Introduction

There are different reasons (e.g. costs, limited service life) why concrete structures are not repaired during a longer period. For such structures and other constructions, where rapid deterioration can occur, monitoring systems can give reliable information on different durability parameters and structural changes.

TFB Diagnostic Systems, a company of the TFB group, is specialised in monitoring systems for structural application and special laboratory equipment for concrete durability testing.

In 1998, a monitoring system composed of a field logger and special sensors has been developed for corrosion and humidity monitoring in concrete structures (Fig. 1). Since its launch, the system has gained a solid reputation with customers for its accuracy and robustness in long term field monitoring.

In 2005, the logger has been upgraded with a wireless communication module as an alternative to the original RS-485 bus. At this time, wireless communication was used in the local field network for sending the logger data to an on-site central unit PC. The main advantage of this system was the avoidance of long cables through the structure. The trade-off was a maximum transmission distance of about 100 meters, compared to over 1 km with a cable bound RS-485 network. The central unit was a full, industrial grade Windows® PC which forwarded the collected data over a GPRS or ethernet network to the end user.

The main weaknesses of this system were the restrictive data transmission from the logger to the central unit and the cumbersome and sometimes unreliable central unit.

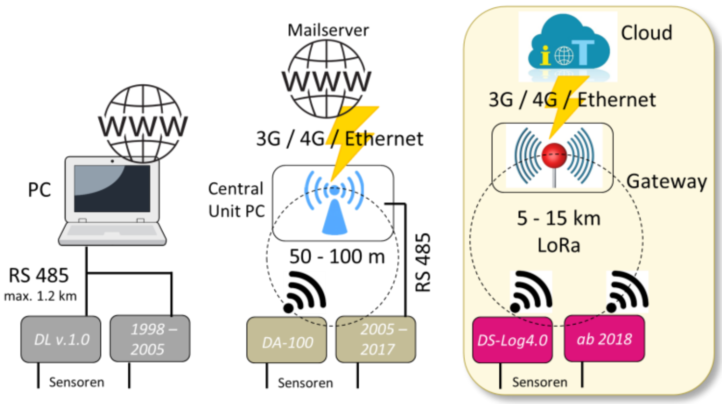

Fig. 1: The three generations of the data logging system

In 2018, TFB Diagnostic Systems redesigned the complete system in order to improve it in several aspects:

- Wireless, long distance and autonomous data transmission into the IoT-cloud, without the need for a local central unit
- Real-time data visualisation on the Web (cloud based), with the possibility to add personalised data analysis routines and alarm values.
- Battery powered, several years of autonomy
- Complete electronic redesign of the measurement circuitry with modern, high precision components
- Addition of thermocouple, Pt1000 and universal voltage and current inputs to make the logger even more versatile

2 The Internet of Things (IoT) / LoRaWAN

The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions (definition Wikipedia). The IoT is nowadays considered as a major opportunity for many consumer, commercial and industrial applications. Among these, structural health monitoring has a large potential.

Being one of the preferred transmission protocols for IoT devices, LoRa is a wireless low-power wide-area networking (LPWAN) for low bandwidth, battery powered devices such as sensor systems. It operates in a sub-gigahertz, licence free band (EU: 868 MHz, US: 915 MHz) which makes it particularly efficient to penetrate buildings and civil structures. Typically, its transmission distance ranges from 2 km (urban), 15 km (suburban) up to 40 km (rural, free line of sight). Compared to other common wireless protocols such as Wifi or Bluetooth, LoRa has a much longer range while consuming less power than the 3G / 4G network.

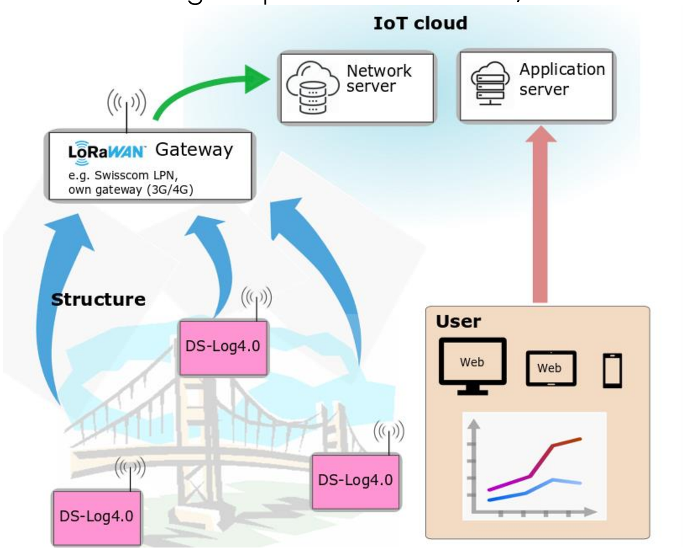

Fig. 2: IoT cloud integration of the DS-Log4.0

In many countries, there are public LoRaWANs operated by a telecom company (In Switzerland, Swisscom operates its LPN). Where there isn't such a commercial network, everybody can build its own LoRaWAN or contribute with an own gateway to a community-based network (e.g. The Things Network, Loriot, etc.).

3 DS-Log4.0 – a new data logger system

Building on its successful predecessor, the new DS-Log4.0 logger can measure the following parameters:

Parameter	Range	Int. resistance
Corrosion potential	-1 … +1 VDC	100 MOhm
Corrosion current	-1000 … +1000µA	≈ 0 Ohm
Temperature (TC, Pt100, Pt1000)	-50 … +250 °C	--
Impedance (@1kHz)	1 Ω … 1 MΩ	--
Voltage (universal)	0 … +45 VDC	280 kOhm
Current (universal)	0 … +100 mA	1 Ohm

For each parameter, 8 independent channels are available. All 48 inputs can be logged concurrently. There is also a 3.3 V output as a power supply for active sensors.

While logging, the device stores the data with a timestamp on the internal SD-card and sends it simultaneously to the cloud over the LoRaWAN, making the data available at any time. A logging interval between 1 and 9999 minutes can be set.

The device also has a Bluetooth LE interface for local wireless data readout and configuration. It can operate at temperatures between -20 and 50 °C and the enclosure is watertight (IP67). The lithium battery typically lasts for 3 to 5 years, depending on the logging interval.

Fig. 3: DS-Log4.0

4 Applications

The logger system lends itself to field use on remote sites without access to the power grid and/or communication network as well as laboratory use. Combined with the special corrosion and humidity sensors from TFB Diagnostic Systems, it is the ideal solution for long term corrosion monitoring in concrete structures. Without being exhaustive, other interesting applications may include multi-channel temperature monitoring (e.g. for the maturity method or hydration heat monitoring of concrete elements) and deformation/displacement monitoring (potentiometric sensors).

Geotechnical or environmental monitoring applications where analogue sensors with a voltage or a current output are used will also work.

5 Conclusion

The new DS-Log4.0 data logging system pushes the convenience of structural monitoring further. Thanks to the new LoRaWAN compatibility, it is easier to install, to maintain and to use than the previous system. The IoT cloud integration makes the data visualisation and analysis much more user friendly and less time consuming.

The following citation from "Challenges and opportunities in corrosion of steel in concrete", Prof. Dr. Ueli Angst, Materials and Structures 51:4 (2018) highlights well the need for new monitoring systems that are convenient and cost-effective for large-scale implementations:

"Embracing the technology of structural health monitoring by installing durability sensors on structures, combined with semi-automated analysis of the large amount of produced data, presents a major opportunity for refined condition assessments of structures, but also gaining experience with modern systems in different exposure conditions."

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Impressum

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