Data Packets in SHM Systems

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Abstract. To improve robustness of SHM systems each sensor, datalogger, host controller and other devices of SITIS:Sprut system use unique electronic device identification. Those identification tags together with sensor data, timestamp and checksum form the basis of universal packet. Each data packet consists of the header with sensor and datalogger tag, datalogger time, the sensor data and the packet checksum. The packets are stored in internal memory of each datalogger, and then can be sent, stored or managed in the other devices and server software via wired or wireless network.

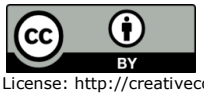
1. Motivation

This year the SITIS company is 10 years old, employing more than 40 employees, half of them - developers. SITIS specializes in developing software for computer simulation and mobile applications [1] for the Civil Engineering industry. First time we are interested in the topic of structural health monitoring in 2007, when one of our customers has mounted system of the vibrating wire (VW) strain sensors on high-rise building. The client asked us to survey 120 embedded VW strain sensors using a manual datalogger and provide weekly reports. Almost immediately, we were faced with two problems.

The first problem - 120 sensors were installed on four floors, with 30 units per floor. To survey all the sensors of our employees had to pass on a certain route, as if you do not know the order of the survey (ie what the sensor reads the first, what - the second, and so on), it then impossible to determine which sensor is associated with this data. Thus, if an employee accidentally strayed from the known route, and this was often because access to some of the sensors was not possible due to the construction work, so the post-processing and interpretation of the data was much more complicated.

The second real problem was also associated with the identification sensors. In each column was installed on 4 sensors, respectively from one point have been laid 4 cables. The ends of the cables were marked for identification, but when one of our staff once again came surveying, he found that the cables are cut and there is no mark! We were able to identify the sensors by comparing previous testimony and new, but in general this is not always possible.

Thus, about half a year of work on this project, we realized that Russian culture construction and operation of buildings requires the most robust SHM systems, eliminating the influence of the "human factor" in the collection and processing of data. In early 2008, we analyzed the market of vibrating wire sensors and realized that there is no system to solve our problems. But, there is a standard IEEE 1451.4, which describes the necessary technical solutions and many companies [2], [3] offer sensors and datalogger with TEDS [4] technology. Therefore, beginning in 2008, we started developing its own system SITIS: Sprut, we set the main goal of design - to minimize the manifestation of the human factor. Below described the structure of the SITIS: Sprut SHM Network and key features, the most important of which is universal data packet.



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2. Key-features of SITIS: Sprut SHM system

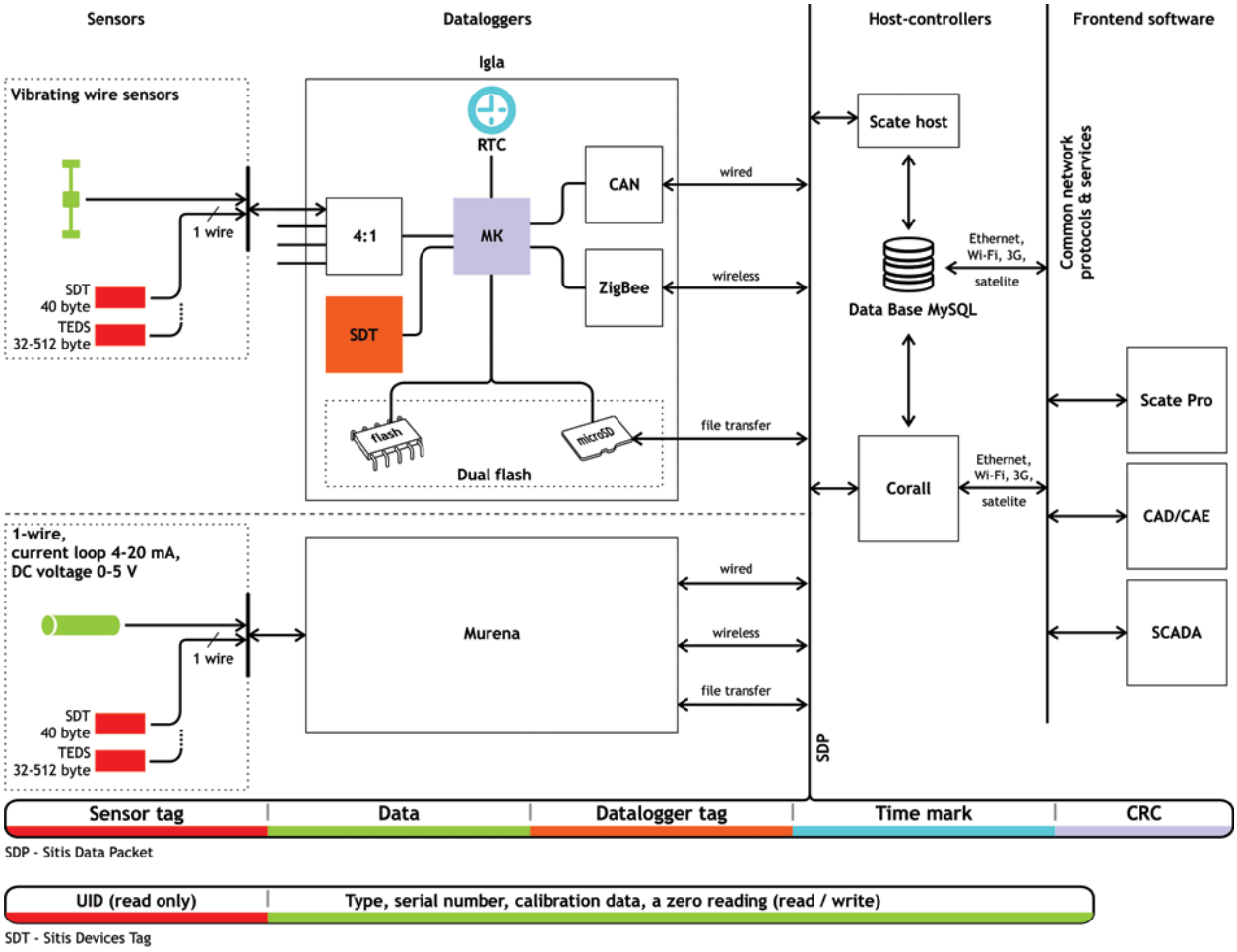

Figure 1. The general scheme of data processing and communication of SITIS: Sprut SHM network.

2.1. SITIS Data Packet

A key feature of the SITIS: Sprut SHM network is SDP - SITIS Data Packet. Any SHM data intended for transfer, reading, storage and processing contains a set of required attributes: a unique identifier for the data source and data receiver, the date and time of packet formation and checksum. Such packet structure allows to understand at any stage of packet usage: which sensor the data belongs, when they are received, which device got the measurement and whether the information is reliable (**Fig. 2**).

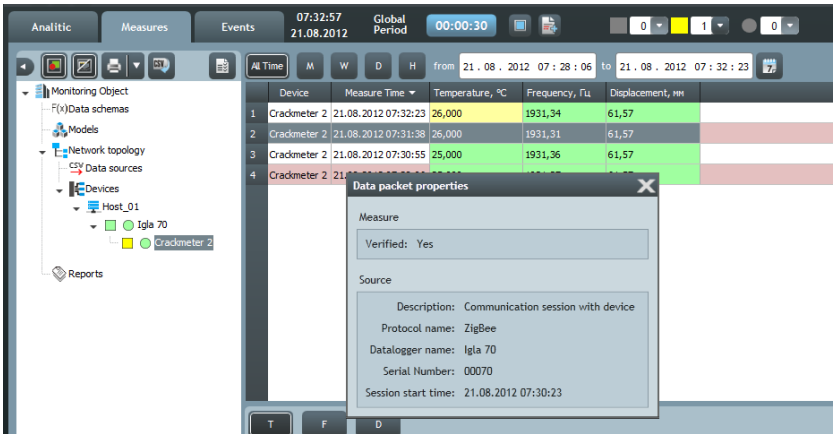

Figure 2. PC software “Scate Pro” allows to control the properties of each data packet.

2.2. Smart tags

A second key feature of SHM system SITIS: Sprut is the automatic identifier at each source of data which allows to unambiguously identify it at any moment of time. There are two types of tags used in the system: hardware tags (SITIS Devices Tag – SDT, **Fig. 3**) and software tags (UUID [5], **Fig. 4**) for any custom data in SHM system. A hardware tag contains the type of device, serial number and calibration data assigned at manufacture. SDT tag is based on the non-volatile memory with rewritable data, except the memory area which contains UID, this area is accessible only for reading. Along with the SITIS tags, all the dataloggers can be used to connect smart sensors of IEEE 1451.4 standard, model 2, which contain the electronic data sheet (TEDS).

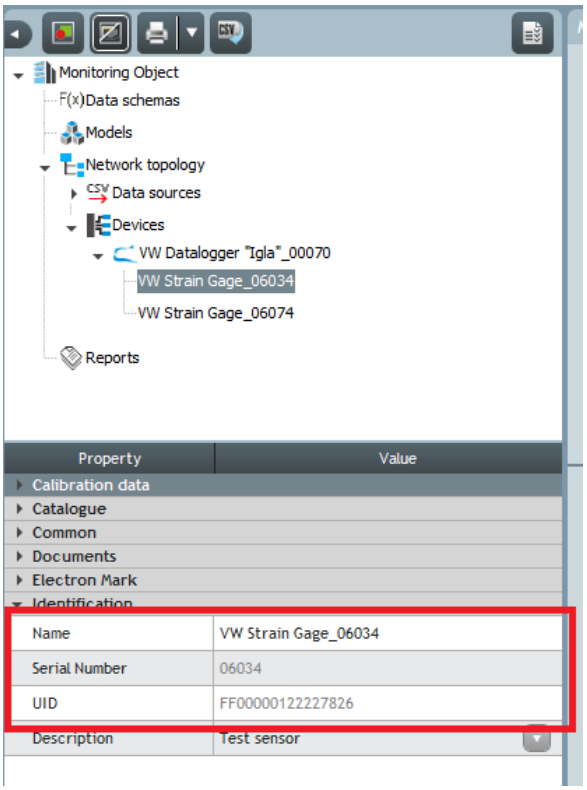

Figure 3. Hardware tag sample based on SDT.

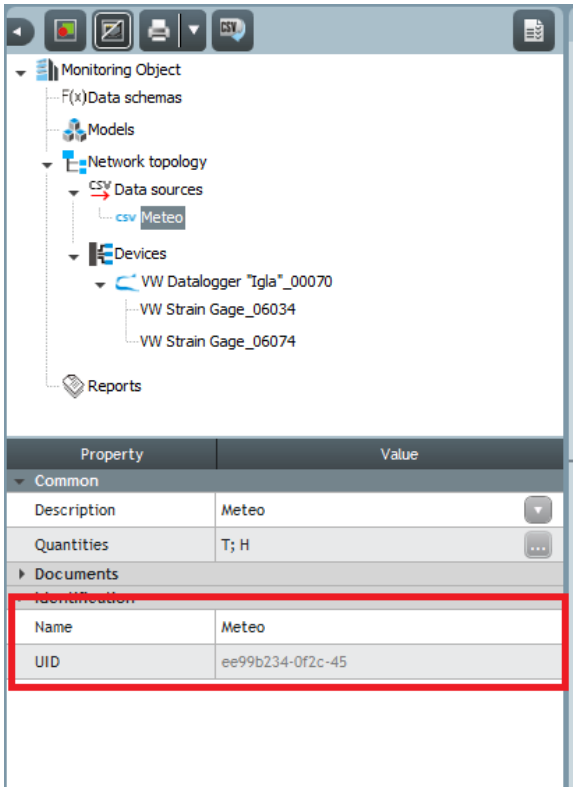

Figure 4. Software tag sample based on UUID

2.3. "Black box"

SITIS: Sprut dataloggers are designed for surveying sensors, storage and transfer of measurement results. Each datalogger has a built-in power supply and a real-time world clock which is automatically synchronized when connected to a reliable time source (GPS, SNTP). A datalogger operates as a "black box" which saves the results of measurements and events to non-volatile dual backup memory. One built-in battery (6AA) is enough for 2.5 years of operation at surveying of 4 sensors once in an hour. A datalogger can function offline or as a part of wired (CAN) or wireless (ZigBee) SHM network managed by host-controllers.

3. Conclusion

According to feedback from our customers, the use of a universal data packet to store and transmit information allowed to save them a lot of time. For example, in static tests of a new bridge in Vladivostok, one of our customers has been expected to use the wireless network from 40 dataloggers Igla and 160 VW Arc-Weldable strain gauges. However,

already during the test, it turned out that two of the 40 datalogger should be put out of reach of wireless radio network. But since each datalogger writes all sensor data to the internal memory microSD card as a standard packet, the client was able to easily collect the data over a wireless network, and part of data was transferred into SHM database via files on memory card. Also during the test one datalogger has failed due to a fall of stone. But due to all SITIS: Sprut sensors, datalogger and software is designed to provide "Plug and Play" principles, to remedy the situation the client have to make only two steps: connect the new datalogger instead of the failed and turn the power on.

At present (August 2012) our company have already more than a year to sell our sensors, dataloggers and software. SITIS: Sprut system with hundreds of sensors and datalogger fully assembled on 15 objects: buildings, bridges and even missile launch platform.

4. References

[1] GeoCam, http://sitis.mobi/geocam/android
[2] HBM Inc., http://www.hbm.com
[3] National Instruments Corp., http://www.ni.com
[4] IEEE 1451.4 Standard for A Smart Transducer Interface for Sensors and Actuators—Mixed-Mode Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats
[5] RFC 4122, A Universally Unique IDentifier (UUID) URN Namespace.