

New Generation of the Health Monitoring System SMS 2001

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ABSTRACT

The Structure Monitoring System SMS 2001 (applied for patent) represents a modular structured multi-component measurement device for use under outdoor conditions. Besides usual continuously (static) measurements of e.g. environmental parameters and structure related responses the SMS is able to register also short term dynamic events automatically with measurement frequencies up to 1 kHz. A larger range of electrical sensors is able to be used. On demand a solar based power supply can be realized. The SMS 2001 is adaptable in a wide range, it is space-saving in its geometric structure and can meet very various demands of the users.

The system is applicable preferably for small and medium sized concrete and steel structures (besides buildings and bridges also for special cases). It is suitable to support the efficient concept of a controlled life time extension especially in the case of pre-damaged structures.

The interactive communication between SMS and the central office is completely remote controlled. Two point or multi-point connections using the internet can be realized. The measurement data are stored in a central data bank. A safe access supported by software modules can be organized in different levels, e.g. for scientific evaluation, service reasons or needs of authorities .

1. OVERVIEW

The development of a structure monitoring system under the former name TMS 2001 was realized within a long-time strategic partnership between the infokom gmbh and the Bauhaus University Weimar, Prof. Schwesinger. With his former working group he could collect many experiences in experimental supported condition assessment of existing structures . In this working field long-term observations using conventional monitoring equipments played an important part. Based on these experiences a row of demands could be introduced in the development of that monitoring system. After completion of a small number of prototypes of TMS 2001 within three years up to now further experiences could be collected under practise conditions'. Based on the conclusions from these experiences the concept for the new generation of that monitoring system, now under the name SMS 2001, was developed. In principle the general function and structure of the monitoring system from that state of development was maintained. It was characterized by the following items:

- Continuous observation of measurands as a function of time with a free selectable, low frequency and duration, e.g. daily, weekly or monthly profiles or parts of it, represents the first measurement mode.
- Event dependent observation of selectable measurands in a dynamic measurement mode at high frequency, triggered by a free selectable value of the observed measurand or by an independent Signal, represents the second measurement mode independent from the first one. Also the number of pre-trigger values and the duration of one measure cycle can be free determined.
- The system is build up in a modular manner and consists of two main parts, part 1 on the site and part 2 at the central office. Part 1 contains different kinds of electrical sensors, multi sensor modules MSM and a master-unit with the system software and a communication unit including a modem. Part 2 is realized by a communication unit tool and a PC.
- Acquisition, pre-processing and safe of data from continuous and/or event dependent measurement completely takes place within the system part 1

The most important technical changes at the new generation SMS 2001 will be:

Multi sensor modul MSM

- 10 bit / 16 bit resolution
- 10 channels for dynamic measurements
- easy calibration
- power supply in connection with master device or externally 12V
- utilised interfaces are RS232 or RS485
- protection degree: IP 65
- temperature range: -10°C to +60°

Master

- operating system WINDOWS CE
- Flash for data buffer
- Multitasking measurement
- multi user ability
- Internet communication
- Power supply 24V or 220V/110V

Communication

- ISDN (Modem)
- direct dial
- communication via internet
- remote mode
- update mode
- BUS protocol including noise protection
- PPP, TCP/IP for WAN

Intelligent power management

- permanent
- master: power save through CE typical functionality
 - sleep mode -
 - standby mode
 - stop mode
- sensors on/off
- MSM active mode / sleep mode / stop mode

User software

- Software for device control and copy of data
- program for evaluation - MS_Excel, interface via SQL Database
- software for special user reports

Database

- relational database (scaleble)
- user snapshot window, local storage in ',STORE.MDB'
- direct access to MS-Office
- system stores up data automatically at central / decentralized SQL DB

For the SMS 2001 the application field can be considerably extended. Examples of application possibilities, where traditional measuring methods are unsuitable or too expensive, can be:

- Monitoring of long-term processes, e. g. structural reactions to subsoil setting as well as their tendency and their rate of motion
- Registration of selected measurands (displacement, vibration) as a function of time, e. g. environmental conditions (temperature, humidity)
- Compiling and evaluation of characteristic parameters of new structures including static and dynamic loading values during a long period of time
- Judgement of efficiency of renovation- or strengthening works an structures by long-term monitoring of characteristic parameters
- Observation of alterations at structures or structural elements due to special events (e. g. detonations) in the course of an evidence based negotiation
- Verification of loading assumptions of exceptional structures over prolonged periods of time

In the above stated and in a lot of other cases the SMS 2001 can provide measurement data as a signal of significant structural changes long before damages were visible.

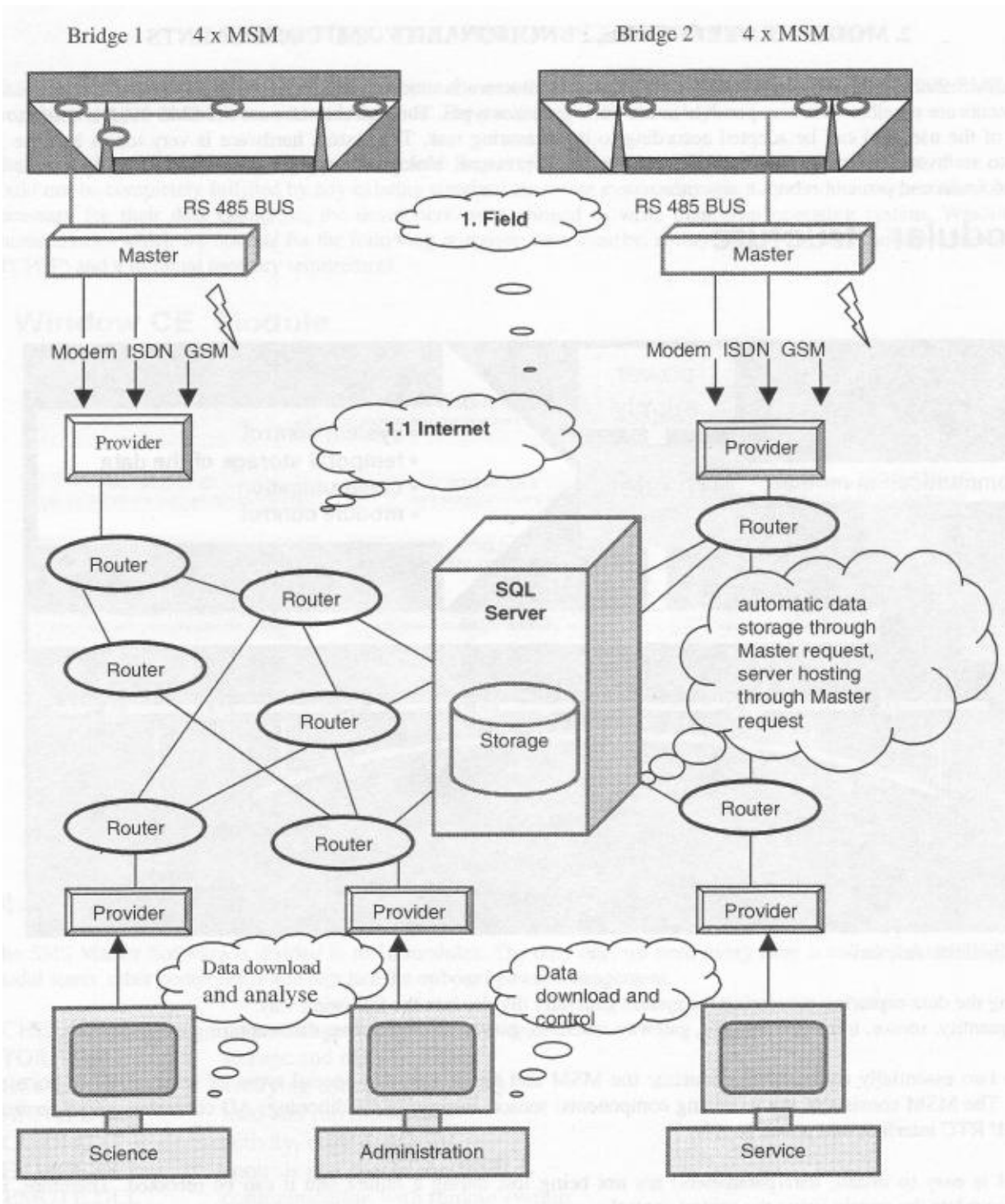


Figure 1: Overview SMS

2. MODULAR STRUCTURE, FUNCTIONALITY AND COMPONENTS

The new SMS 2001 is flexible, tough and reliable. The architecture is modular and flexible adaptable. Static and dynamic measurements are possible. It is also possible to use various sensor types. Through the software the SMS 2001 is suited to the demands of the user and can be adapted according to its measuring task. The system hardware is very tough because it is resistant to unfavourable temperature conditions, moisture, pressure, biological wear and vandalism. The system is also resistant to faults and you can reboot it any time.

modular structure

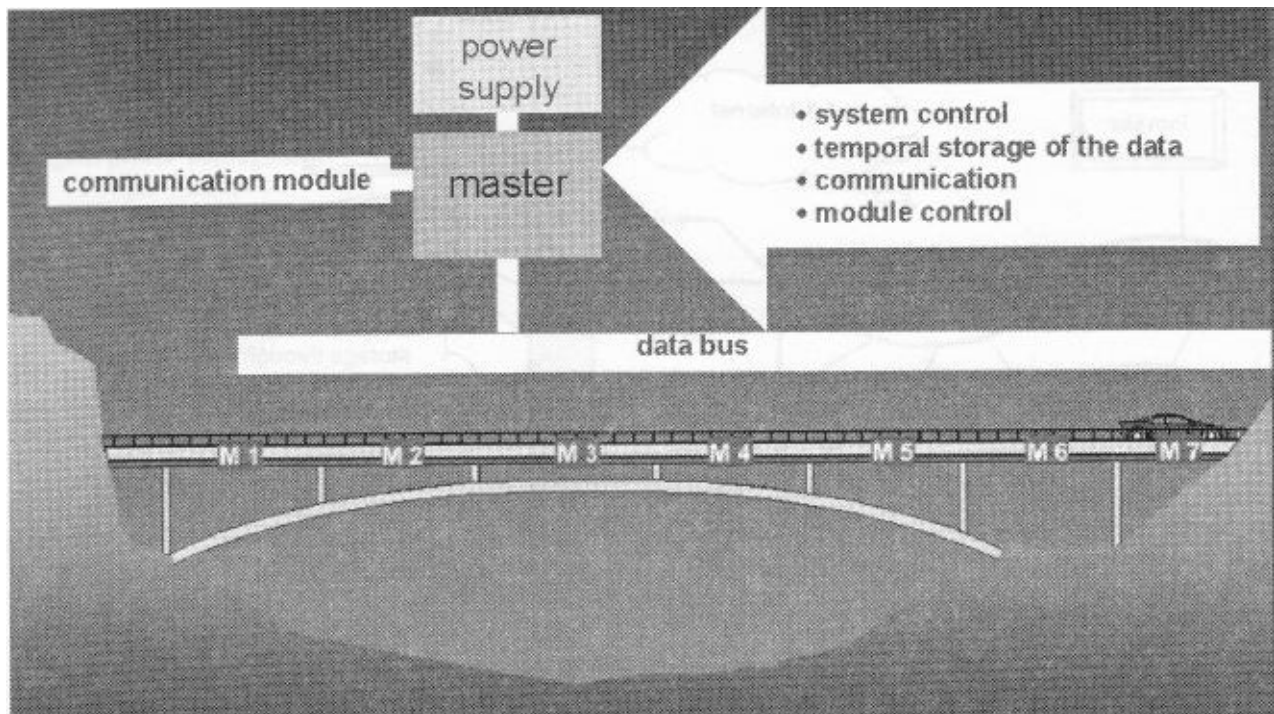


Figure 2: modular structure

Concerning the data capturing processing the system generally divides into the following way:

physical quantity, sensor, transmission field, gateway schedule, gateway transmission, data capturing and analyzing.

There are two essentially technical components: the MSM and the master. For special types of sensors sensor-boxes are available. The MSM consists of the following components: sensor; measuring conditioning; AD converter; micro-controller with RAM/ RTC interface and power supply.

The MSM is easy to install, data(parameters) are not being lost during a failure and it can be rebooted. Therefore, it is possible to update the system using the central control.

The hardware and software structure of the entire system is based on the fact that all necessary sensors will be connected to the MSM. Beside conditioning and AD conversion those sensors are responsible for the communication with the master. The master stores the data, the control of various tasks, the adjustment of threshold values, the own-supervision of the system and the communication with server.

Communication protocols are TCP/IP, PPP and some others. The communication is carried out over the direct interface RS232, a modern, ISDN and through mobile communication. The master consists of a PC Pentium that uses the operating system Windows CE.

3. SELECTING THE WINDOWS CE OPERATING SYSTEM

The new SMS product require a synthesis between the ease-of-use and the expansion capabilities of a modern office PC, and the robust, rugged control of an embedded device. The master is PC 104 based system.

The data collection devices are appropriate because they are user-friendly, robust, and secure. In the past, these requirements could not be completely fulfilled by any existing standard operating system. In order to provide customers the robust devices necessary for their data collection, the developers were obliged to write their own operating system. Windows CE has characteristics which are optimal for the following purposes: data security, ability to develop with modules, internet protocols (TCP/IP) and a minimal memory requirement.

Window CE Module

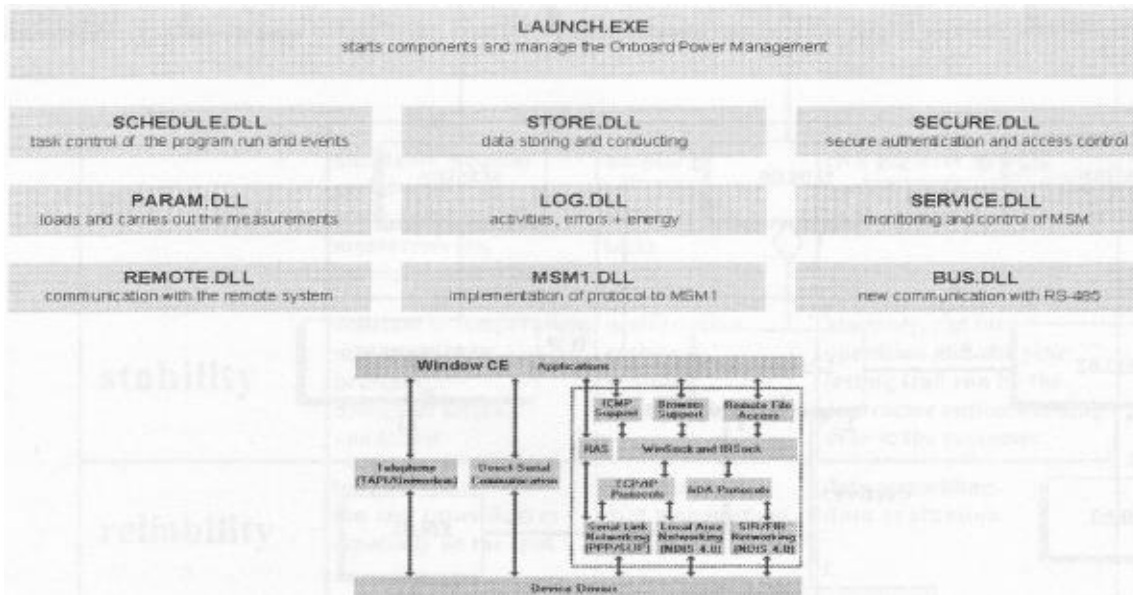


Figure 3: software structure

The SMS Master Software is divided in to 10 modules. The only one, we need every time is called 'LAUNCH.EXE'. This modul starts other components and regulate the onboard power management

SCHEDULE.DLL	process Organisation time & event
STORE.DLL	storage and manage Data
SECURE.DLL	verifying user data and rights
PARAM.DLL	load and run measuring
LOG.DLL	activity, error & energy
SERVICE.DLL	controls and checks the MSM
REMOTE.DLL	communication with remote system
MSM1.DLL	implementation of the old communication protocol from MSM1
BUS.DLL	new communication protocol for RS-485

4. DATABASE

The definitive benefit of structural monitoring systems can be achieved only with a clear representation of the necessary data flows between the technical and human resources involved in the monitoring process. Enabler for such data flows is an integrated model of the data involved in the planning-phase, in the configuration-phase, and in the execution-phase of the different monitoring system elements.

Database technology results to be determinant for the storage of large amount of structured raw measurement data and for the consequent analysis for a monitoring system. The complexity of structures often requires different types of sensors and therefore different specific analysis packages, and different configuration tools. For an integrated monitoring concept it is necessary to have interoperable systems that can easily share data and information.

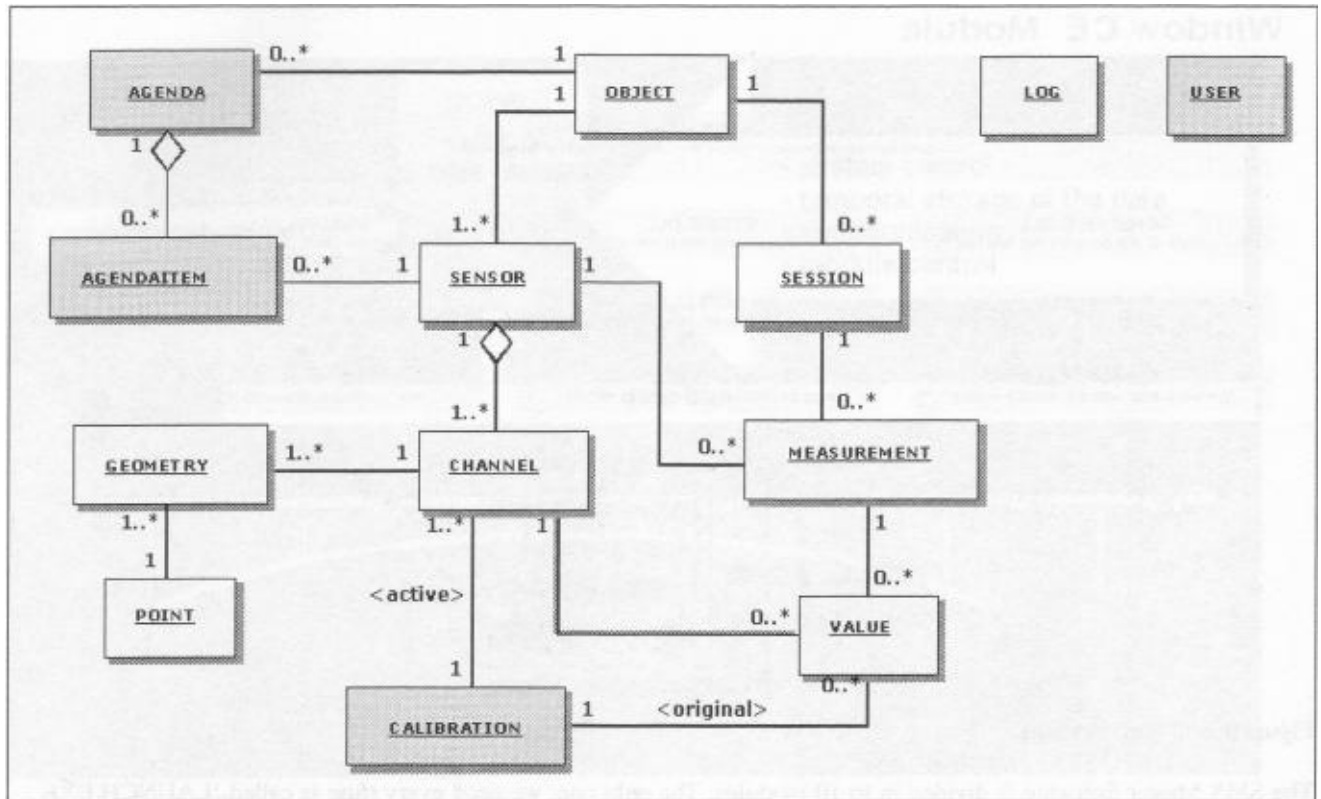


Figure 4: database structure

Given a project that involves many objects to be permanently or regularly monitored, the goal of the data model is to model for the scope of the given project all relevant entities and their relationships for assuring the long term management of the large volume of measured data, the short term and dynamic sensor-configuration and measurement-planning and the need of system-specific data. To make effective and efficient analyses of collected data from monitoring systems, it is recommend to free users from technical aspects of data converting, data transferring and data storing. Therefore Infokom is going to start a implementation of automatic remote data transfer, called i-ARDT . I-ARTD is a machine to machine communication module. Anywhere in the world wide web (also at your office) you can have a public SQL-Server or more. Any SMS2001 system is able to reach the SQL-Server and download collected data. These way of data transfer is more effective then the way to do it by user interaction. Only the SMS2001 system has exact information of the current fill of memory. Every time, the remote system needs to free internal memory resources it is able to do this it self.

At PC-side, user have a transparent connection to the same SQL-Server. Every data are collected, found in the right position and context. Most time there is a need to have multi-user access to calculate same data. Because all data are stored at central database, no overhead and other administration is needed. All available PC products can be used to transfer, sort, report and calculate data. Also it's possible to make snap shoots from subsets of data every time and store it at local database such like MDB from MS-Office.

All communication with SMS2001 is done via a Server process running at central SQL-Server. Upload parameters, download data and/or online measurements are going through this service. That gives the capability to write complete logbooks and is very user-friendly, robust, and secure.

5. CONCLUSION

Because selected Windows CE as the operating system for the SMS Master, standard software like databases, and communication tools for LAN and WAN with the data collection devices is integrated. It would realized several benefits by selecting a modular operating system for the SMS. The designers can create optimal devices for each bridge they service. Because Windows CE is an open architecture standard operating system, the customers can benefit from a multitude of third-party software and hardware drivers. Windows CE-based data collection devices will offer its customers the highest level of data security as well as energy efficiency, essential for the monitoring system. To the end shows the overview the different benefits of the new generation of the health monitoring system SMS 2001

flexibility	adaptable modular architecture, static and dynamic measurements, various sensor types	adaptable to different tasks	civil engineer specific project planning by the contractor
stability	resistant to temperature, moisture, pressure, biological attack, vandalism	malfunction resistant, remote controllable	assembly, put into operation and one year lasting trial run by the contractor option: handing over to the customer
reliability	long life time, low cost expenditures especially on the spot	redundancy, data management	data assembling, data evaluation
	hardware	software	application management

Figure 5: benefits

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