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Embedding wireless water monitoring system in Internet

Abstract. *In this paper is presented a research for environmental monitoring system with features such as alarming which is lowering delay of reaction of environmental protection emergency teams. Structure of the system based on the "Internet of Things" ideology and IEEE1451 networked smart transducer interface standard.*

Streszczenie. *W tym artykule zaprezentowane są badania nad systemem monitorowania środowiska z własnościami alarmowania co pozwala na skrócenie czasu reakcji służb ochrony środowiska. Struktura sytemu bazuje na ideologii „Internet of Things" i standardzie czujników inteligentnych zawartych w normie IEEE 1451. (**Bezprzewodowe monitorowanie czystości wody z wykorzystaniem Internetu**)*

Keywords: measurement systems, environmental protection, remote measurements, "Internet of Things", IEEE 1451 standard.
Słowa kluczowe: systemy pomiarowe, ochrona środowiska, pomiary zdalne, "Internet of Things", standard IEEE 1451.

Introduction

In contemporary economy, environmental protection is one of most important issues. Quick reaction to catastrophic results of ecological disasters, permanent protection and natural environment monitoring is on the priority list in developed countries. Fertilization increased rapidly in Poland in recent years. Additionally the wheeled transportation and developing infrastructure of oil station and petrochemical industry also increased. These changes cause unusually ecological danger both in local and the whole country scale. These conditions determined necessity for creation of distributed measurement systems with alarming function to monitor ecosystem parameters, particularly clean water sources. Main feature of this system should be flexibility and scalability in all logical layers including management, visualization, communications and measurement. In this paper we focus on two latter ones.

Architecture that is discussed here can be obtained by creating a system of monitoring based on the ideology of the "Internet of Things" [1] and IEEE1451 smart sensor standard [2]. To provide such solution is goal of presented research.

Internet of Things (IoT)

The term "Internet of Things" refers to the global infrastructure linking all the "objects" around a human being [3]. This is self-organizing networks of sensors that allows for communication between and receive data from the surrounding world. The purpose of the Internet of Things is [4]:

- interconnect all things,
- to ensure that all those things are intelligent.

To achieve the assumption of the **IoT** the required a huge number of sensors working in networks and exchanging information among themselves (based on the IPV6 it is possible to address the 2^{128} hosts. This is an opportunity to address 6.7×10^{17} hosts per one square millimeter surface of the Earth).Internet of things was inspired by the RFID technology, [5].

In IoT is created decentralized system of intelligent objects (physical and digital) having the ability to collect and process information and networking. In contrast to RFID tags, smart IoT objects using indigenes application can adaptively cooperate with other networks element as well as interacts with human.

IEEE 1451 family standard

Structure of smart sensor with net interface is presented on the Figure 1a. This sensor consists of transducers: sensors and actuators signal conditioning and data conversion block, them application center, which manages the entire sensor. In this block, the measurement data from transducer are formatted and send to the higher lever parts of measurement system, via network communication block.

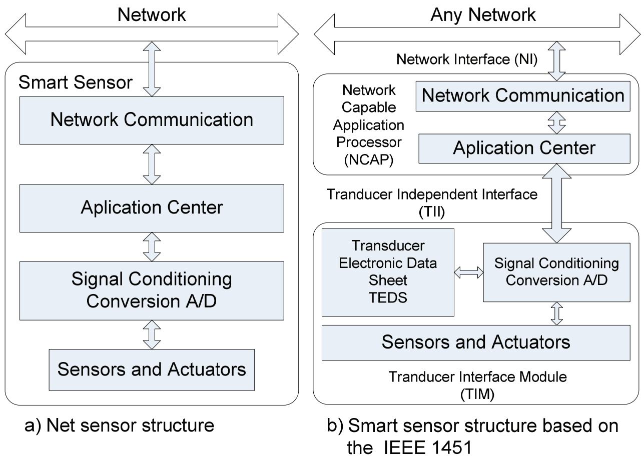

Fig. 1. Sensors structure

Family standards IEEE 1451 (standard for a smart transducer interface) describe a unified sensor work in net [6]. Structure of sensor based on above standard is presented on Figure 1b. Smart sensor structure is similar to the net sensor but is divided for two parts: measuring block - TIM and control and communication unit - NCAP.

(S)TIM – (Smart) Transducer Interface Module contains sensors and actuators, signal conditioning and A\D conversion block, and basic block for this module **TEDS – transducer electronic datasheet**. The TEDS attached to the transducer, stores as all information necessary for proper installation and use the transducer. The TEDS could by store in ROM if the contents never change or partly in RAM of TIM if some parameters can be changed [7].

Measuring block and control unit are connecting via Transducer Independent Interface. This interface can by wireless or wire, general is digital but IEEE 1451.4 allows for use the analog interface. The basic tasks of the Network Capable Application Processor (NCAP) are: control measuring process, collect data from transducers, and the connect sensor to the net.

In line with the standard, the construction of sensors consistent with the presented structure greatly increases the flexibility of the measuring system. Any sensor can by attached to the system in plug-and-play mode. Which makes that after auto-configuration (based on the TEDS data) the sensor is available in system and can by used.

Trends outlined above have been used by authors, for the determination the assumptions and for the construction of a distributed measurement system.

Similar efforts

In the 2007-2009 at Warsaw University of Technology, the distributed measurement system for hydrocarbons pollution monitoring was build [8], [9]. Each station in the system had the same set of sensors, which was defined on the designing stage. On stations we implemented adaptive algorithms which adjust measurements to current situation and adapt new rules accordingly. In practice it is handling an alarm situation

On the basis of that research we decided to further investigate issues of such system. Current design system is designed to continuously monitoring the parameters of surface water, intended for human consumption. Each system element utilize TCP/IP stack with which it can connect to Internet. Applications running on the measurement station can be upgraded during standard work of station without break in service. It's particularly important as the station is floating on a lake surface and is hardly accessible for maintenance.

System administrator will be able to create any sub-systems related to the scanning area, or quantity of measured data and provide result of measuring and statistical report authorized users.

Under Polish law [9] for full estimate the quality of drinking water, regular monitoring of 44 parameters is needed. In alarm system the short time of reaction is much more important than high measurement accuracy. Therefore is permissible to monitor the seven fundamental parameters, based on sensors of chemical parameters. The parameters and their limit values are shown in table 1.

Table 1: Basic parameters for estimate the quality of water

	Parameter	Chain	limit water indicators
1.	Temperature	^{o}C	25
2.	Reaction	pH	6.5 – 8.5
3.	Ammonia	mg/l	0.5
4.	Suspension	mg/l	25
5.	Conductivity	μS/cm	1000
6.	Chlorides	mg/l	250
7.	Hydrocarbons	mg/l	0.05

Among these parameters 1, 2, 3, 4 are important from water treatment technology point of view. Parameters 5, 6, 7, will warn users about contamination.

Hardware structure

Described system will by work whole-year. So is necessary to adapt the sensing element and measurement station to the changing conditions of works. The system should provide maximum information about water quality in: winter when the surface of monitoring water can by frozen, in spring, when due to agricultural work the probability of contamination of ammonia and chloride increases, and also in summer, when rapid growth of flora can lead to disruption of sensor work. Therefore the measurement system should be resistant to short-term work-break of individual measurement station, related with cleaning, repair, or replacement sensors. Instead the structure of a measuring station, should allow for quick and easy reconfiguration the set of sensors in the terrain.

These facts caused the structure of the measuring station is compatible with IEEE 1451 standard. The inputs signal structure (for a known set of sensor), conditioning signal block, analog\digital converter, channel multiplexer was fixed in TIM block. All information about sensors, their parameters such as: measurement range, maximum scan frequency, sensitivity, reference temperature, type of output signal and alarming level are stored in TEDS. In presented case is Virtual TEDS allocated partially in TIM and in NCAP controller flash memory. During work of measurement station, the Virtual TEDS is regular upgraded. The TIM controller has the ability to service the smart sensors with digital interface. This allows for the rapid replacement and calibration of used transducers and probes.

Fig. 2 Moxa Think Core W345 and Elpro805u-e modem.

Network Capable Application Processor based on the Moxa ThincCore W345 controller [11]. This controller has ARM9 (32bits, 192MHz) processor, 64MB RAM and 16MB flash memory. It also has four RS232C\RS485, 2xUSB, Ethernet port, and integrated GSM\GPRS modem and also LINUX operating system. Modem GSM\GPRS facilitates the station networking, what is the basic function of NCAP block. The station will be working in natural environmental, due to authors chose the GSM\GPRS as Network Interface. GSM provide directly access to the TCP/IP net, which will be used in the system.

The NCAP coordinate the measurement process on the station also. Main application installed on the controller has the following function: adaptively control sensors works, collect data from the sensors, compare measurement result with alarm threshold, format measuring and localization data and send to the server. Additional the application regular update the Virtual TEDS and is able to servicing the alarming situations. Remote administrator can log in on the station and change main application too.

Communication layers

Measurement station has two main communication links. First is Transducer Independent Interface, which connect TIM with NCAP, second is Network Interface which connect measurement station with server.

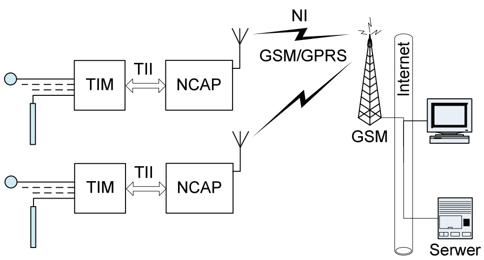

Fig. 3. First variant of communication in system

The measurement station can by deploy on the whole territory of Poland. In points where the quality of GSM signal, allows for establish stable and direct communication with server the TIM is realized as point to point digital interface. In this case one NCAP manage one TIM. Above situation is presented on the bloc diagram on the Figure 3.

Due to using the powerful controller for realization the NCAP block it is possible realized partially the Transducer Interface Module on the same computer. In this case the communication between the NCAP and TIM will be realized inside application. Independent of physical solution the communication protocol between above block based on the SCPI standard, where txt command are used.

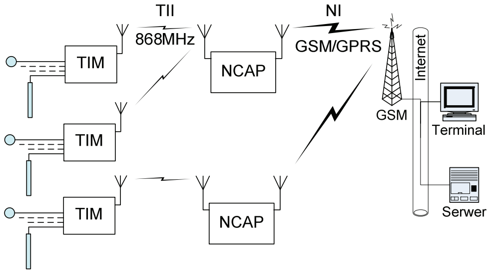

Fig. 4. Second variant of communication in system

Accordance with assurance of GSM providers the 99% surface of Poland is covered GSM signal, which allow for communication in GPRS mode. But local uneven terrain can cause interferences or interruption in transition. In situations where strength of GSM signal not allows for stable communication between measurement station and server, the TII will be realized as middle distance wireless interface. This may cause that one Network Capable Application Processor will serve some Transducers Interface Mode. Situation like this is presented on the Figure 4.

Taking into account the water environmental of work and Polish law, Authors decide to realize the middle distance interface via 868MHz ISM radio band standard. As real solution Authors chose the modem 805U-E [12], made by Elpro which is presented on the Figure 2. During test modem provides host communication up to 1 km,(the 100mW transmitter power). Modem has RS232C\RS485 interface and also Ethernet port, and can work as bridge or access point to the Ethernet net. This function is very useful and will be used to create structure shown on figure 4.

As was mentioned the Network Interface in the system is realized in TCP\IP net, provided via GSM\GPRS technology. This approach allows for quick installation of measurement station in new area, as well for reinstallation and relocation of the stations, without additional cost related to the building and telemetric infrastructure. Also allows for connect and manage a mobile measurement stations, e.g. stations floating on the monitoring water region.

TCP\IP protocol guarantees error-free data transmission, and allows for remote access to the each element of the system, independent of hardware approaches.

Measurement station will permanently collect data from the sensors and compare result with alarming level, but due to, high energy consumption by communication modems, measurement station will communicate with the server periodically. This allows for energy saving. During time communication, the station will send measuring data to the server and collect order connected with measuring process and new TEDS data. This approach gives possibilities for adapt the work of station to the current users requirements.

Conclusion

Proposed ideology on the measurement system will provide full information about monitored medium, in described case, it is quality of drinking water. The openness and flexibility of the system structure allows for any reconfiguration on measurement level of the system. In described system the measurement level is divided on two layers, what is result of the implementation of IEEE 1451 standards.

On the lowest layer we have sensors and actuators, which can by optional changed. Replacement of sensors can by performed in terrain and using in Plug-&-Play mode. The higher level - NCAP connects to the independent Internet layer, which improve reliability and not limited the territorial span of system. Administrator or users also have access to the system or measurement rapport via the Internet from anywhere in the World.

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