ENVIRONMENTAL DATA ACQUISITION BASED ON 1-WIRE INTERFACE

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Sensor networks have come a long way since the first point-to-point analog system. Tomorrow's networks will not be dominated only by one architecture, but will integrate a variety of networking schemes. Now World Wide Web browsers and object-oriented programming techniques are shaping the next generation of networks. The potential of Internet-based systems is tremendous, and the technology is available today. Looking into the future, one can see the great potential of Internet-based sensing and control. The technology for closed-loop control over the Internet is available today. The main reasons it isn't widely used today are the security and reliability, but these issues will gradually be solved as the Internet becomes more mission-critical capable.

This paper presents an approach to make an Internet-based system for environmental data acquisition. The basic structure of the sensor node, the ways of connecting the intelligent sensor nodes to Internet and the communication over Internet are presented. Integrated sensors with digital and analog output are used for accurate readings of temperature, humidity, barometric pressure, light intensity and other environmental parameters.

1. INTRODUCTION

Typical feature of complex production and communication systems is their complex hierarchal structure built on interacting to each other systems. Contemporary development of these systems is oriented towards simplification of the hierarchal structures. Often used CIM-pyramid theoretical model with five hierarchal levels is not used in practical applications. Conceptions in which the hierarchy is based on two main bus-technologies come on foreground. These are Ethernet-TCP/IP and sensor/actuator field buses such as CANopen, Profibus or Interbus.

Moreover, Ethernet-TCP/IP is used to connect the systems on information and control level. The sensor/actuator buses connect the sensors, the actuators and further peripheral components on field level. Two industrial communication systems are necessary to connect these two levels – system bus between information and control level and sensor-actuator-bus between control and field level. The choice of Ethernet-TCP/IP as system bus has many advantages, as almost unlimited compatibility with other existing systems. But the use of Ethernet-TCP/IP as a field bus for industrial applications is still not well established. In this paper an approach to build environmental data acquisition modules is regarded, which modules use Ethernet-TCP/IP together with the 1-Wire interface also as sensor field bus.

2. INTELLIGENT SENSOR NETWORK NODE

For the practical realization was chosen the microcontroller DS80C400. The DS80C400 network microcontroller peripherals include a 10/100 Ethernet MAC, three serial ports, a CAN 2.0B controller, 1-Wire Master, and 64 I/O pins. To enable access to the network, a full application-accessible TCP IPv4/6 network stack and small OS are provided in ROM. The network stack supports up to 32 simultaneous TCP connections and can transfer up to 5 Mbps through the Ethernet MAC. Access to large program or data memory areas is simplified with a 24-bit addressing scheme that supports up to 16 MB of contiguous memory. With extensive networking and I/O capabilities, the DS80C400 is equipped to serve as a controller in a multitiered network. The 10/100 Ethernet media access controller (MAC) enables the DS80C400 to access and communicate over the Internet. While maintaining a presence on the Internet, the microcontroller can actively control lower tier networks with dedicated on-chip hardware [3]. The structure of the system for environmental data acquisition is shown on Fig. 1.

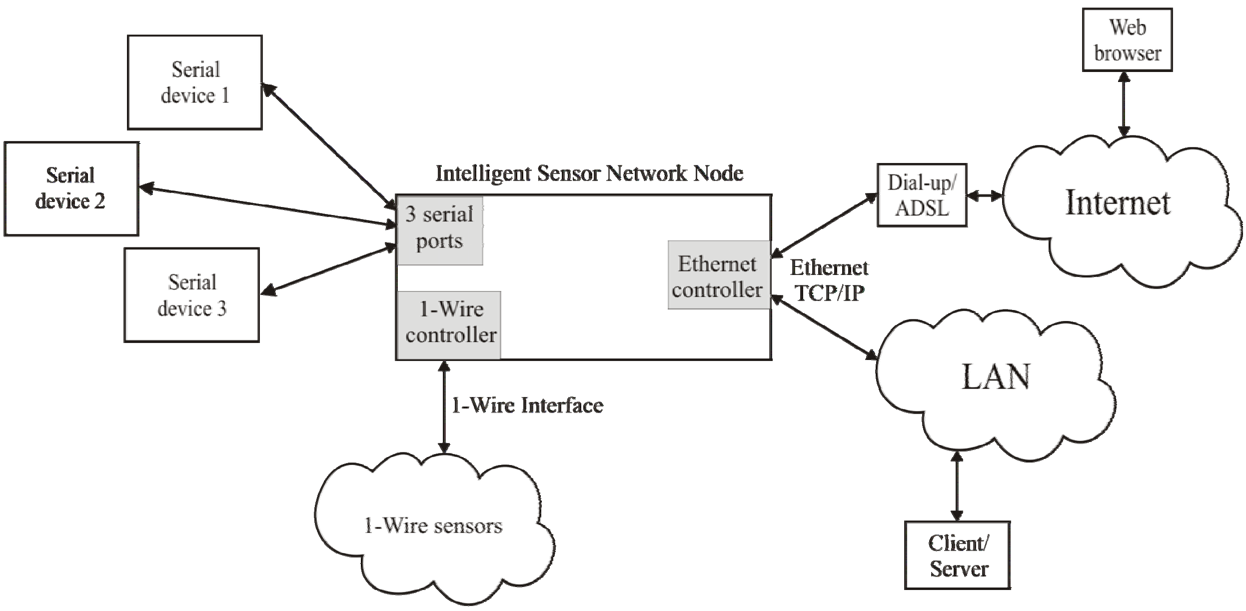

Fig. 1. Structure of the system for environmental data acquisition.

The sensor network node connects the serial devices, the sensors and the actuators with Ethernet. Depending on the realization and the requirements of the particular task the network node can transmit data directly or modify the data and interpret it.

The simplest alternative that allows the highest speed of data transfer is the direct connection of the ISNN to Ethernet based network. In cases where the direct access is not feasible, the runtime environment for the 80C400 microcontroller with dial-up networking support can be used. With the point-to-point protocol (PPP) the endpoints of the connection can communicate over the public communication networks and use the IP software infrastructure. Besides the modem and standard telephone line the connection may be realized through a mobile telecommunication. In that case after the connection is established standard Internet protocols are used. This significantly simplifies the distant management of the measuring device.

The management of the sensor network nodes is done in LabVIEW environment with the help of the integrated TCP/IP functions [6]. Simple client-server architecture is used. The application that runs on the server allows simple configuration of the system, initiation of measurement procedures, visualization and storage of the measurement data. The usage of the program environment LabVIEW helps the significant simplification of the user interface. The management of the modules can be simplified to several buttons.

For developing the software except the traditional programming language "C", the TINI environment can be used. Tiny InterNet Interface (TINI) is a platform developed by Dallas Semiconductor to provide system designers and software developers with a simple, flexible, and cost-effective means to design a wide variety of hardware devices that can connect directly to corporate and home networks. The platform is a combination of a small but powerful chip-set and a Java programmable runtime environment. The chipset provides processing, control, device-level communication and networking capabilities. The features of the underlying hardware are exposed to the software developer through a set of Java application programming interfaces. The primary goal of the platform is to provide a voice on the network to everything from small sensors and actuators to factory automation equipment and legacy hardware. The combination of broad-based I/O capability, a TCP/IP network protocol stack, and a Java programming environment empowers programmers to quickly create applications that provide not only local control of but also global access to TINI-based devices. TINI's networking capability extends the connectivity of any attached device by allowing interaction with remote systems and users through standard network applications such as Web browsers.

3. THE SENSORS FOR THE ENVIRONMENTAL PARAMETERS AND THE 1-WIRE INTERFACE

The 1-Wire net is a low-cost bus based on a PC or microcontroller communicating digitally over twisted-pair cable with 1-Wire components. The network is defined with an open-drain master/slave multidrop architecture that uses a resistor pull-up to a nominal 5 V supply at the master. A 1-Wire net-based system consists of three main elements: 1) a bus master with controlling software; 2) wiring and associated connectors; and 3) 1-Wire devices. The 1-Wire protocol uses conventional CMOS/TTL logic levels with operation specified over a supply voltage range of 2,8 V to 6 V. The 1-Wire net allows tight control because no node is allowed to speak unless requested by the master, and no communication is allowed between slaves, except through the master. Both master and slaves are configured as transceivers permitting bit sequential data to flow in either direction, but only one direction at a time. Technically speaking, data transfers are half-duplex and bit sequential over a single pair of wires, data and return, from which the slaves "steal" power by use of an internal diode and capacitor. Data is read and written least significant bit first. Data on the 1-Wire net is transferred with respect to time slots. For example, to write a logic one to a 1-Wire device, the master pulls the bus low and holds it for 15 microseconds or less. To write a logic zero, the master pulls the bus low and holds it for at least 60 microseconds to provide timing margin for worse case conditions (Fig. 2).

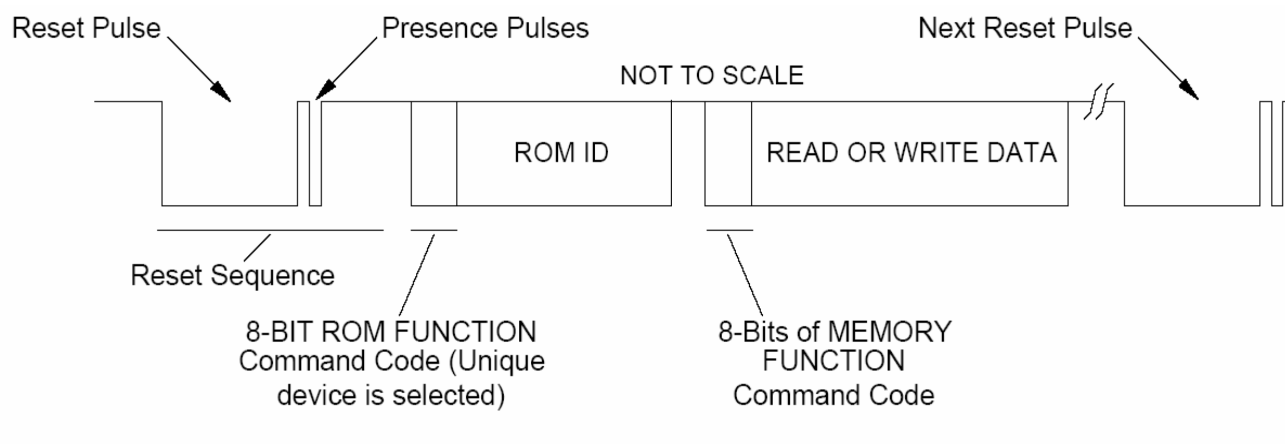

Fig. 2. A typical 1-Wire communication sequence.

A system clock is not required, as each 1-Wire part is self clocked by its own internal oscillator that is synchronized to the falling edge of the master. Power for chip operation is derived from the bus during idle communication periods when the DATA line is at 5V by including a half wave rectifier onboard each slave.

Within each 1-Wire slave is stored a lasered ROM section with its own guaranteed unique, 64-bit serial number that acts as its globally unique address [3].

In order to track the selected environmental parameters, sensors with voltage output have been selected. These sensors can easily be connected to a 1-Wire net with the help of a multifunction IC DS2438. The major components of the DS2438 are 64-bit lasered ROM, temperature sensor, 10-bit A/D, elapsed time meter and 40-byte nonvolatile user-memory.

A typical circuit how to connect humidity sensor from the family HH-3605-A to 1-Wire net is shown on Fig. 3. The DS2438 IC provides the 1-Wire communication interface, the analog-to-digital conversion and the temperature measurement. A Schottky diode SD1 is used to protect the circuit and SD2 and C are used to build a parasite-powered circuitry. This circuitry "steals" power whenever the DQ pin is high. DQ will provide sufficient power as long as the specified timing and voltage requirements are met [1].

In order to measure light intensity the sensors of the family TSL23x are used, for barometric pressure – sensors of the family MPX41xx. When the light intensity or barometric sensors are used the circuits are analogical to the one shown on Fig. 3.

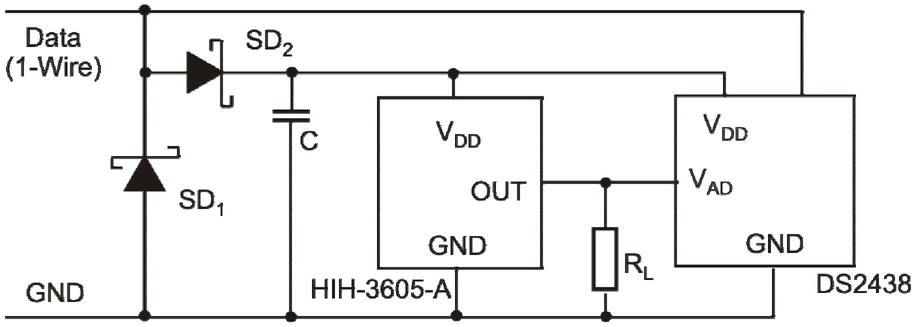

Fig. 3. A simplified circuit for measurement of humidity with sensor HH-3605-A and DS2438.

With the help of the integrated temperature sensor DS2438 the inaccuracies due to temperature dreif are easily corrected. In order to measure temperature accurately, a sensor with integrated 1-Wire interface DS18B20 is used. The structure of the developed system is shown on Fig. 4.

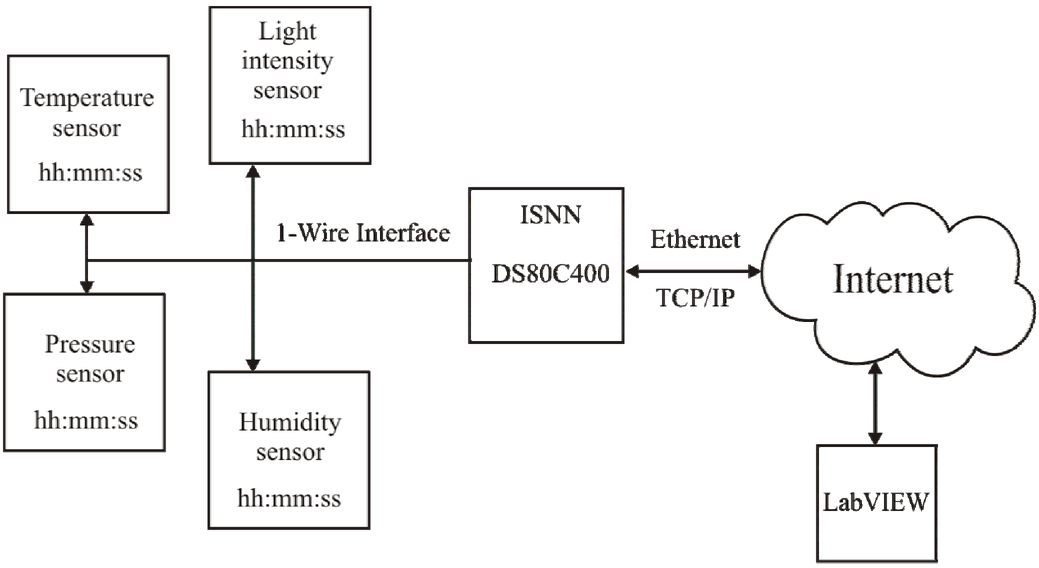

Fig. 4. Structure of the environmental data acquisition system.

With the help of a specialized IC DS2409 network a segmentation of the sensor network could be performed. By using one section as the main "trunk" and adding or removing segment "branches" with a DS2409 as needed, a true 1-Wire net is created. This also reduces the load seen by the bus master to that of the trunk and those segments connected to it by activated DS2409s. This has the added benefit of providing information about the physical location of a 1-Wire device on the bus, which facilitates troubleshooting.

4. CONCLUSIONS

1-Wire technology made possible the combination of electronic communication and instrumentation. The simple reliable identification of the sensor nodes and the ability of self-powering give significant advantages for an effective building of distributed sensor networks. Such sensor network is the presented in the paper one.

The potential of the Internet-based data acquisition and control is big. Distant monitoring of processes and laboratory data are only a small piece of the applications which require Internet access. The technology is available. One of the main reasons it is not vastly used is the problem of data security. But this problem is gradually being solved.

The presented approach for Internet-based environmental data acquisition is successfully tested in systems for monitoring and management of greenhouses.

5. REFERENCES:

[1] Awtrey, D., Transmitting Data and Power over the 1-Wire Bus," Sensors: 48-51, Feb. 1997.
[2] Awtrey, D., The 1-Wire Weather Station, Sensors: 34-40, June 1998.
[3] Dallas Semiconductor. MicroLAN Design Guide, Sep. 2003.
[4] Hill, J., R. Szewczyk, A. Woo, S. Hollar, D. Culler, and K. Pister. System architecture directions for networked sensors. In Proceedings of the 9th International Conference on Architectural Support for Programming Languages and Operating Systems ASPLOS-IX, pages 93–104, Cambridge MA, USA, November 2000.
[5] Howarth, D.: Performing Data Acquisition over the Internet. Sensors Magazine, January 1998.
[6] National Instruments, LabVIEW Manual, 2001.
[7] National Instruments, Overview of GPIB Communication Using Ethernet, 2002