INTERNET BASED SMART SENSORS

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Summary: This paper presents an idea of realizing of a new architecture of Embedded Systems. The ways of connecting to Internet are shown. The block diagram and realizing of a temperature sensor, that can be connected to Internet by using of Ethernet controller are described. It discusses advantages and disadvantages of the Internet connection. The advantages of the Ethernet connection than the modem connection are discussed too.

During the first 5 years of its existence, the Internet has attracted more users than the telephone had during its first 30 years. The net has penetrated into all fields of the public and personal life. We are not far from the time, when every office, home, enterprise will have a permanent Internet connection. Many companies have begun investing into establishing Internet connection. Facilities as Internet, cable TV and telephone will be provided by only one shared cable.

The growth of the Internet, or at least a niche in this growth, will be the Embedded Systems. This allows us to develop a new type of Embedded Systems, which is shared, and working in Internet.

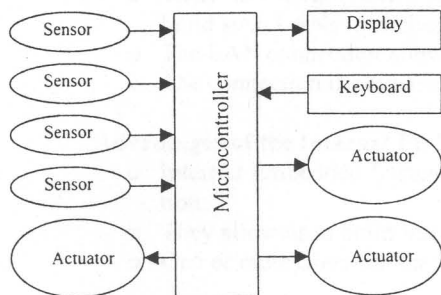The architecture of Embedded System is shown in Figure 1.

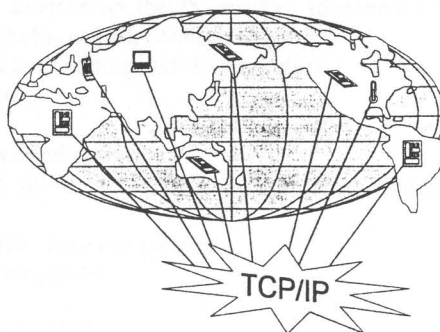*Figure 1 – Architecture of Embedded System*   *Figure 2 – New Architecture of Embedded System*

The block diagram includes same sensors and some actuators. The sensors give the input data of the algorithm, and the actuators are the output reaction of the

system. The microcontroller controls the device. Sometimes a keyboard and a display are needed. Sensors and actuators are directly connected to the microcontroller.

When an Internet connection exists, one can use the architecture shown in figure 2. The sensors and the actuators cannot be directly connected to the Embedded System. The sensors have to use some of the Internet connecting techniques (LAN, modem, etc.). Instead of Embedded system, could be used a Personal Computer, but it is not compulsory. One sensor is possible to take part in one or more then one Embedded systems. When this architecture is used, it is easy to be realized.

There are different ways to connect to Internet.
    1. *By using a modem* – Embedded system uses a modem and a telephone line to connect to Internet provider;
    2. *By using a LAN* – Embedded system is connected to LAN that is connected to Internet;
    3. *Wireless* – Embedded system uses WAP technology.

To accomplish such type of architecture, it is necessary the sensor to be connected to Internet. The Internet connection is realized by using TCP/IP protocols. PC can be realized Internet connection by browser or terminal program, which use TCP/IP protocols. The sensors send the answer (temperature) after asking from the microccontroller (PC).

To realize a temperature sensor, which can be connected to Internet is appropriative to use a temperature sensor with pulse or analog output. The sensor is read by a microcontroller, which transform input data (duty cycle, voltage) to output data (temperature) and send it after asking from the controller. The connection to Internet is done by using an Ethernet LAN. To realize this it is necessary to have an Ethernet controller (Network Interface Controller). The block diagram of the sensor is shown in figure 3. These are the fundamentals common block of the Internet based smart sensor.
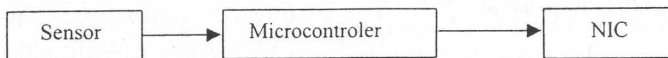
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┌──────────┐      ┌──────────────────┐      ┌──────────┐
│  Sensor  │─────▶│  Microcontroler  │─────▶│   NIC    │
└──────────┘      └──────────────────┘      └──────────┘
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Figure 3 – Block diagram of Internet based Smart Sensor

It is appropriative to use this interface to Embedded System. Instead of sending numbers, duty cycle or other data to the Embedded system it is suitable to send the measured value in °C. Therefore, after reading the sensor there is no need of post reading calculations.

Using of the interface mention above, leads to the need of same modes of operation. In case of the operating mode, the sensor send the temperature in °C, °K, °F or °R. There is a possibility, if the command "h" (help) is send, the sensor will send the available operating modes and commands.

Operating modes and commands are shown in table 1.

Table 1

Command	Execution
0	°C operating mode
1	°K operating mode
2	°F operating mode
3	°R operating mode
m	Measure the temperature and send the result
h	Show modes of operation and commands

Realization (Figure 4) uses the Smartec temperature sensor SMT 160-30, which generate to its output duty cycle signal in function of the measured temperature.
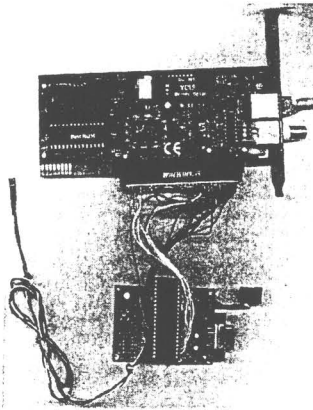

Figure 4 – Picture of the prototype

One of the most widespread NICs in Bulgaria is the Realtek LAN controller RTL8019. The RTL8019 is a highly integrated Ethernet Controller with full duplex and power down features. The full-duplex function enables simultaneously transmission and reception on the twisted-pair link to a full-duplex Ethernet switching hub. This feature increases the channel bandwidth from 10 to 20 Mbps. RTL8019 provides the auto-detect capability between the integrated 10BaseT transceiver and AUI interface. Besides, the 10BaseT transceiver can automatically correct the polarity error on its receiving pair. The RTL8019AS integrates the RTL8019 and 16K-byte SRAM in a single chip. The controller is connected to the Embedded system by using an ISA bus. It is necessary to be written a software driver, which has to emulate ISA bus. The connection is made by using 18 wires (8 – data, 5 – address, ALE, IORD, IOWR, INT и RST).

Microchip PIC16F877 has 8Mb FLASH program memory and 384 cells RAM. It is appropriative because it has enough output ports to connect to the NIC, enough FLASH and RAM.

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Internet Embedded System has to include the following additional drivers:

- □ *ISA bus driver* – It emulates ISA bus. It consists of two functions U8 inp(U8 Address) and outp(U8 Address, U8 Data). The first one reads the register with respective address and the second one – writes the data in the selected address;
- □ *Ethernet driver* – It consists of the next functions: NIC RESET, NIC initialization, errors, send a packet and receive a packet;
- □ *TCP/IP driver* – TCP/IP (Transaction Control Protocol/ Internet Protocol) is the core of the connection. It supports ARP, ICMP, IP and TCP protocols.
- □ *Sensor driver* – provides reading of the sensor by a microcontroller.

The first way Embedded System to connect to the sensor is by using port 23. This port is used of all terminal programs like Telnet and HyperTerminal. Here are used the commands described above. After starting the terminal program, it connects to the sensor. After sending an "m" command, the sensor measures the temperature and sends the result. A sample connection is shown in Figure 5.
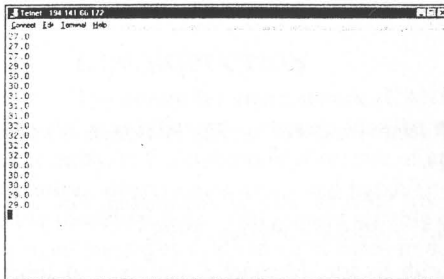
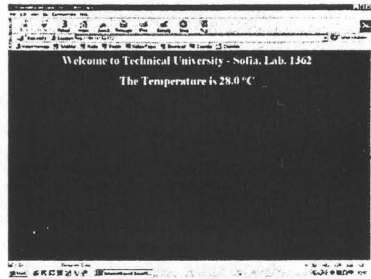

Figure 5 – A sample telnet connection   *Figure 6 – A sample browser connection*

The connection to the sensor can be done by using of Internet browser like Netscape Communicator or Internet Explorer. In this case, the browser connected to the sensor through port 80. Now the sensor is a web server and after receiving a request from the browser, it measures the temperature, prepare the code for web page, where the measured temperature will be displayed and send it to the browser. The result after reading IP address of the sensor, port 80 is shown in Figure 6. This way of connecting is the most widespread to the Internet users.

Advantages of the Ethernet Internet connection comparing to the Modem Internet connection:

- □ The connections building price are permanently dropping off. The Ethernet Controllers price is almost the same as the modem price;
- □ The baud rate is higher;

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- There is a large variety of devices on the PC market appropriate to build such LANs (switches, hubs, cables, connectors etc.);
- The LAN connection allows easy adding additional nodes;
- The connection is permanent.

Advantages of the Internet Based Smart Sensors:
- Internet Embedded Systems allow all over the world Internet connection;
- They allow us to build Internet share out systems;
- One or more users can use one sensor.

Disadvantages of the Internet Based Smart Sensors:
- This architecture is not proper when there are requirements for higher speed. Regardless of higher baud rate 10/100MBps, the real speed depends on the LAN traffic. This speed can be reached if the LAN is used only by those two devices;
- When the TCP/IP protocol is used, the information overhead exceeds useful information data.

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