EMBEDDED SYTEMS IN INTERNET

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Summary: *This paper presents an idea of connecting of the Embedded Systems in the Internet. Block diagrams of the nodes (which are needed to make an Internet connection by using Ethernet interface) are shown. It is submitted an algorithm of a subroutine which is executed when a new packet is received. In addition, it is submitted an algorithm of TCP Handler. It discusses advantages and disadvantages of the Internet connection. The advantages of the Ethernet connection comparing to 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.

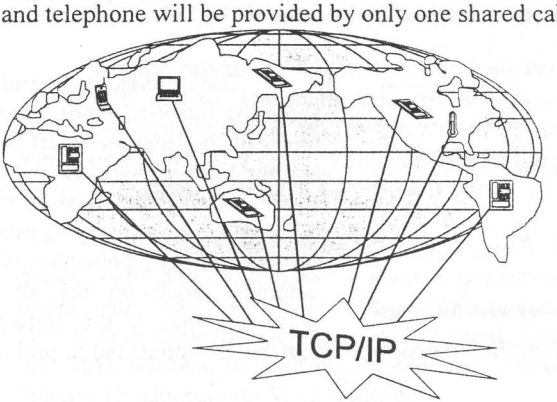

Figure 1 – Internet Embedded System Architecture

When an Internet connection exists, one can use the architecture shown in figure 1. 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. In addition, it is possible, two or more Embedded Systems to exchange information without using additional resources.

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 Embedded System (sensor, actuator and node) to be connected to Internet. Embedded System should be permanently connected to its sensors and actuators (Internet). That's why the second option (by using a LAN) is better. The most widespread LANs are Ethernet. The connection between nodes is realized using TCP/IP protocols.

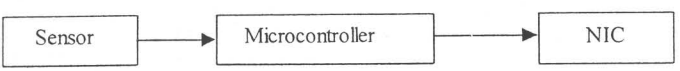

Figure 2 – Block scheme of Internet Smart Sensor

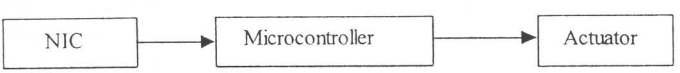

Figure 3 – Block scheme of Internet Actuator

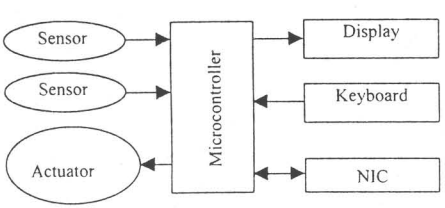

Figure 4 – Block scheme of Internet Embedded System

The figures 2, 3 and 4 show the block-schemes respectively of the Internet Smart Sensor, the Internet Actuator and the Internet Embedded System that all have the possibility to establish an Internet Connection. The common block on the all of those schemes is the Network Interface Controller (NIC). Then the Embedded System can be connected to preliminarily build LAN.

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. With the three level power-down control features, the RTL8019 is made to be an ideal choice of the network device for a GREEN PC system. The full-duplex function enables simultaneously transmission and reception on the twisted-pair link to a full-duplex Ethernet switching hub. This feature not only in-

creases the channel bandwidth from 10 to 20 Mbps but also avoids the performance-degrading problem due to the channel contention characteristics of the Ethernet CSMA/CD protocol. 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. Furthermore, 8 IRQ lines and 16 I/O base address options are provided for grand resource configuration flexibility. The RTL8019AS integrates the RTL8019 and 16K-byte SRAM in a single chip. It is designed not only to provide more friendly functions but also to save the effort of SRAM sourcing and inventory. 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).

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.

Similar drivers have been written for the Personal Computers, but they cannot be directly applied. The major reason is that the Personal Computers memory resources exceed the Embedded Systems memory resources. It is necessary to be created a new driver that suites to the Embedded Systems Memory resources. Some of the TCP/IP driver's features have to be omitted.

The first feature supported of the driver is "*ARP REPLY*". When an ARP packet with "*ARP Operation*" = *Request* is received, the driver has to send an ARP packet with "*ARP Operation*" = *Reply*. This is necessary because of the two devices have to communicate in specific LAN segment. ARP transforms Receivers IP address into MAC address. In addition, it gives the receiver the possibility to transforms the Senders IP address into MAC address.

Another feature supported of the driver is the "*echo*" function. It is used when "*ping*" command is executed. Through this function, we can test the ability of making a connection between the two devices. That is why the driver has to recognize the ICMP packet and when ICMP "*Type* = *REQUSET*", the driver has to send an ICMP packet with "*ICMP Type*" = REPLAY.

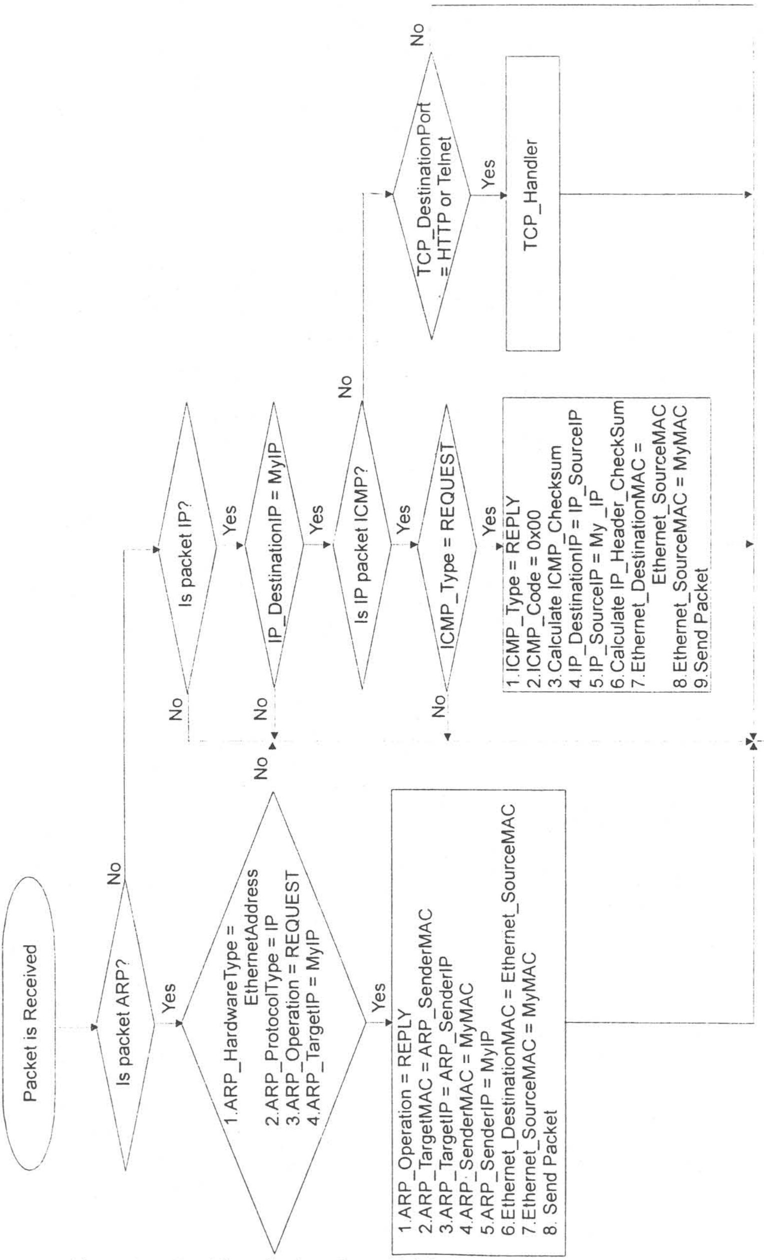

Figure 5 – Algorithm of subroutine, which is started when a new packet is received

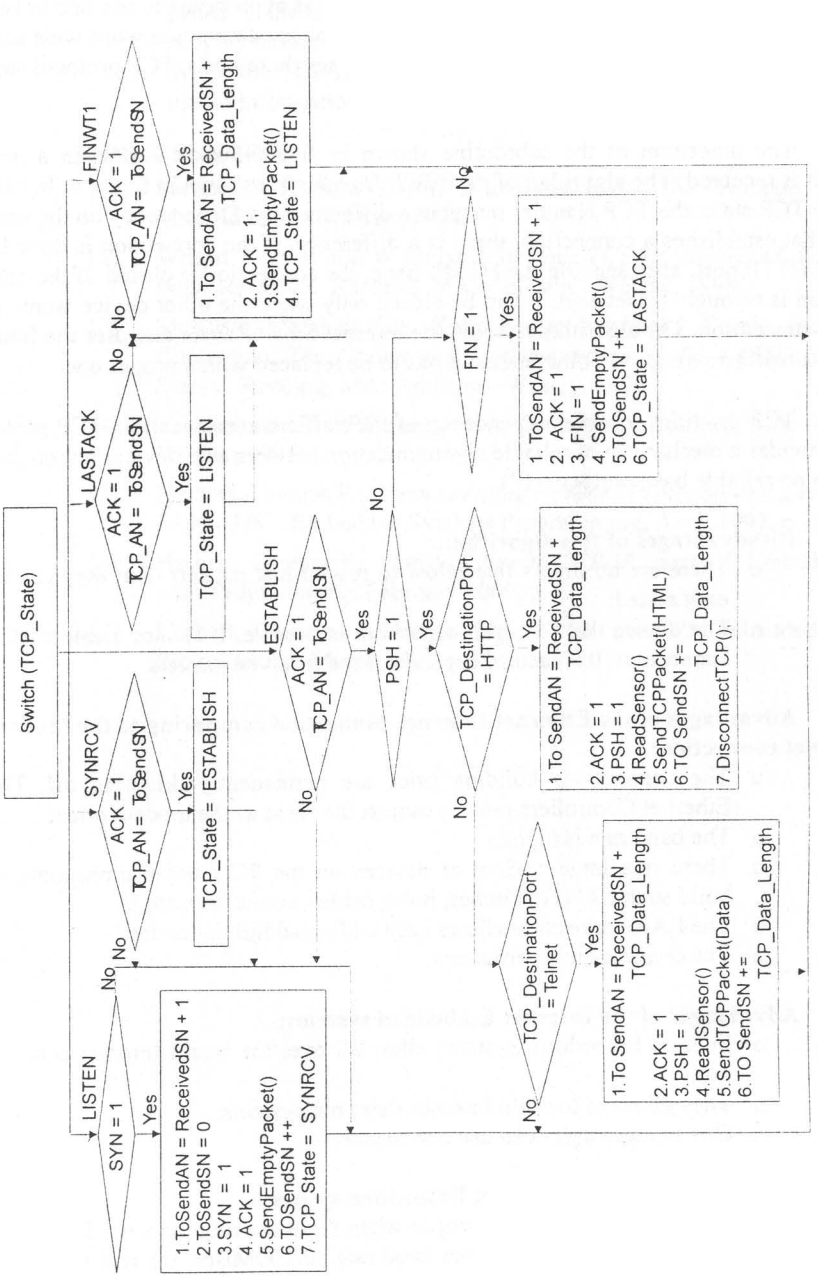

Figure 6 – Algorithm of TCP Handler

The driver has to support the TCP protocol. It is appropriate to use one or two TCP ports (Telnet and/or HTTP), because they are the most common word wide user ports. There is a lot of shareware software, which uses these ports. TCP protocol support is done by "*TCP Handler*".

The algorithm of the subroutine shown in figure 5 executes when a new packet is received. The algorithm of the *"TCP Handler"* is shown in figure 6. In case of the TCP state, the TCP Handler reacts in a different way. Dependency on the used port that establishes a connection, there is a difference. If the connection is done by using HTTP port, after sending the HTML page, the connection is closed. If the connection is through Telnet port, it can be closed only when the other device wants to close connection. The algorithm is about the Internet Smart Sensor and uses the function `ReadSensor()`. In other cases, it has to be replaced with a proper one.

TCP provides reliable, dependency of the traffic communication. TCP protocol provides a mechanism of reliable communication between two devices although it uses a no reliable base protocol (IP).

Disadvantages of this algorithm:

- There are no timers that allow to resend lost packets. But they can be easy added;
- The device that uses this algorithm is passive. It cannot create a TCP connection. Its reaction depends of the received packets.

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;
- 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 Embedded systems:

- 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 Embedded systems:

- This architecture is not proper when there are requirements for higher speed. Regardless of higher baud rate 10/100MBps, the real speed de-

pends 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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