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The control on-line over TCP/IP exemplified by communication with automotive network

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***Abstract*—One of the more important stages in the development of wireless networks was developing protocols, procedures and systems providing packet data transmission. Packet data transmission enables sending sets of measurement data and other information over long distances, and thus integrating with other available networks, for example the Internet. The aim of this article is to demonstrate the implementation of communication algorithms of the above networks as exemplified by communication with an automobile on-board network. The part of the article which deals specifically with the functionality of the discussed transmission types addresses the issues of remote control as exemplified by low-power executable devices**

I. Introduction

THE first automotive microcontroller built by the Bosch company in 1979 was a 4-bit microprocessor microcontroller implemented in BMW 732 and BMW 633 Csi cars. Its function was solely to control ignition and fuel injection systems. From the time perspective it can be said that it was the first ECU system (Engine Control Unit) in the world –computer controlling and monitoring of engine operation.

Constant development of Information Technology (IT) and microprocessor evolution enabled further development of controlling and monitoring of automotive subsystems by introducing information buses. Fast and error-free data transmission to main controllers is possible thanks to digital communication buses installed in cars which on the basis of this information make further control decisions , (e.g. correcting engine operation, ABS or EPS systems.). At present, the most popular bus used in the car industry is the Control Area Network (CAN). Its standard was made public in 1986 by Bosch and the first CAN controller (made by Intel) was made available in 1987.

The first implementation of the system took place in the mass-produced Model S of Mercedes-Benz.

Continuous efforts of designers to increase passenger safety and comfort have resulted in installation of several buses managing the work of on-board microcontrollers in modern cars, which control both operation and measurement systems. These buses create on-board information networks, such as LIN, K-Line, Flex-Ray or MOST (Fig.1)

Each of the aforementioned networks and buses controls different executable systems both while the vehicle is in motion and when it is stationary – for diagnostic purposes. (Fig.2)

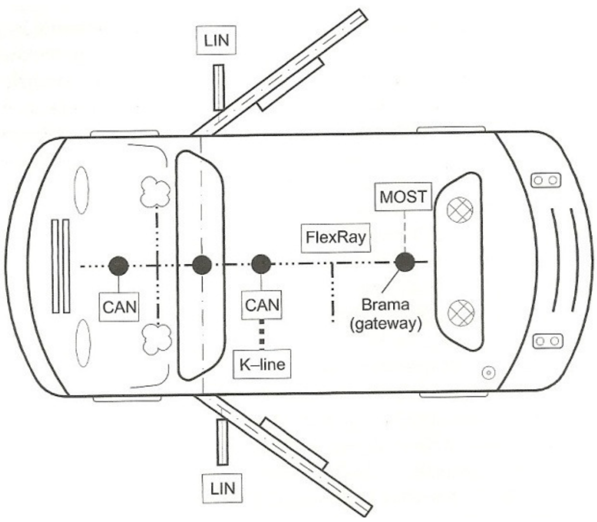


Fig. 1 On-board computer network [1]

II. Remote Control of an Object Over TCP/IP and GPRS Network

Information technology tools available at present, as well as wireless telecommunications networks, allow for easy remote monitoring and controlling of various vehicle functions [4]. Such control is made possible, i.a., by the development of the GPRS network concept, which enabled

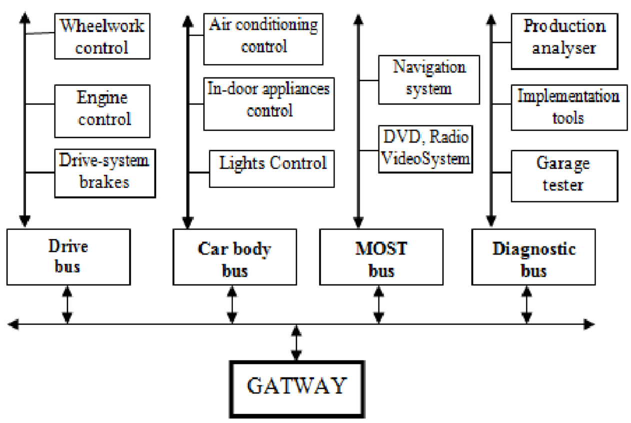
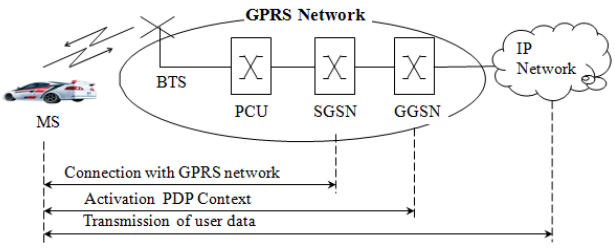


Fig. 2 Digital bus networks controlling run-time systems (according to [2])

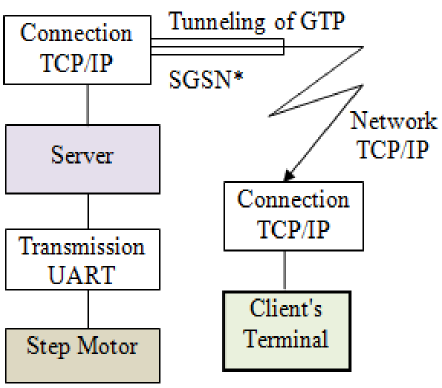
packet data transmission.[3] Figure 3 illustrates establishing connection between a MS (Mobile Station) and the Internet.



MS - Mobile Station, **BTS** - Base Transceiver Station; **PCU** - Packet Control Unit;**SGSN** - Serving GPRS Support Node; **GGSN** - GPRS Gateway Support Node;**GPRS** - General Packet Radio Service

Fig. 3 Packet data transmission over GPRS between a mobile station (MS) and the Internet [1a]

The sequence of establishing a connection involves activating and connecting an MS to the GPRS network and then defining the MS's PDP Context, including the assignment of an IP number. Then packets may be mutually exchanged, which enables the assignation of the sender's and the receiver's addresses to each connected user , , both in the IP and the GPRS network. How the GSM/GPRS network operates is described in [3]. The model of remote controlling of a selected object over TCP/IP is shown in Fig.4.



* SGSN - controller Serving GPRS Support Node, GTP - GPRS Tunnelling Protocol

Fig. 4 Model of remote control over the TCP/IP protocol

The end user (Client) controls the object via the GTP protocol (GPRS Tunneling Protocol) tunelled by TCP/IP protocol. Data exchange between the controlled object and the Central Computer (Server) uses UART.

(Tunneling means establishing a connection between two different protocols by encapsulating one protocol in another. By means of tunneling a connection between distant hosts can be established, giving the impression of direct connection.)

III. An Example of Selected Object Control

Figure 5 illustrates an example of object controlling over TCP/IP. This method of controlling was developed for purposes of laboratory teaching during lectures in Wireless Data Transmission Systems delivered by this paper's author to the Computer Science students.[5]

The object of control is a stepper motor (EDS 10) linked to a computer by means of a microcontroller 8051. The executable system is remotely controlled by over a dozen methods. Parameters of controlling are entered from the keyboard of a remote computer. (Client)

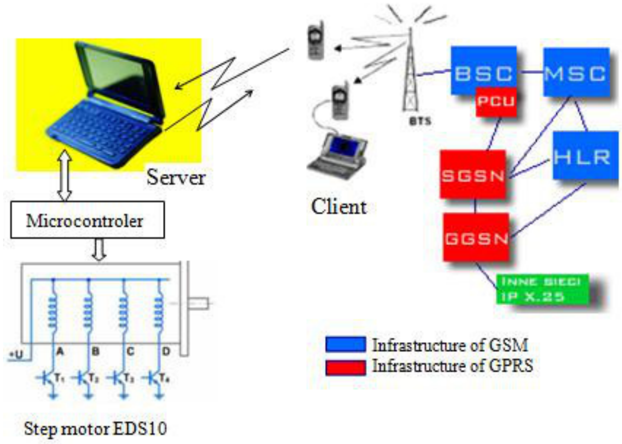


Fig. 5 Diagram of a remotely controlled step motor

Providing software for the above system involved the following stages:

- programming TCP/IP interface between a remote computer, the so-called Client Computer and the Central Control Computer - Server (initialized by the Client)
- designing and programming an interactive user interface, enabling the introduction of selected values of control parameters.
- developing programs in the microcontroller's language for controlling a given object (i.e. the step motor).

The user's (Client's) interface is shown in Fig.6.

The remote control program is run in two modes:

- Client mode and
- Server mode

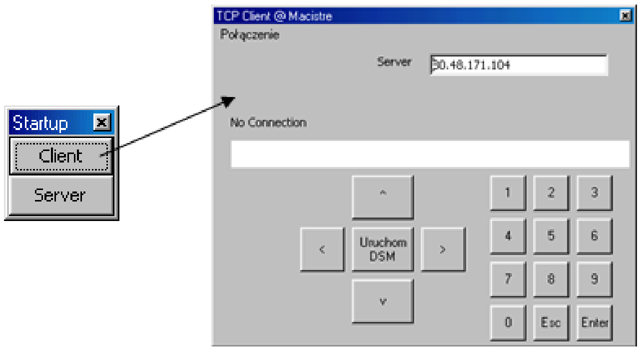


Fig. 6 User interface in the remote control system in Client mode

Client runtime mode

There are two stages in this mode:

- establishing connection with the remote server by entering its IP number in the text field of the form (the top right corner of the interface) and choosing the option "Connect" from the system menu

- handling the interactive form by means of which the user enters control parameters (keys 0-9, direction arrows, key ESC and Enter.)

The system was designed so that messages from the microcontroller 8051 could be displayed on the client's desktop. These messages show both the state of the running control program and the parameters required for control purposes. They are displayed in the white field of the interface. (They also appear on the remote LCD of the microcontroller.)

Server runtime mode.

The Server's aim is to handle communication between the Client and the microcontroller and concerns the transformation of the controller's Assembler language to messages shown on the screen of the Client's remote interface.

Handling the Server requires defining the connection between the Server and the Client as well as the Server and the microcontroller.

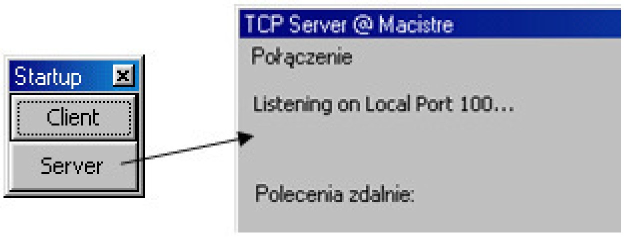


Fig. 7 User interface in the remote control system - Server mode

Client – Server Communication

The above communication was carried out on the basis of one of the available controllers working in the TCP/IP standard. Port no 100 was selected. (Cf. Fig.7)

Server - Controller DSM8051 communication

Communication between devices was set up to use the following control (counting from the Server). Transmission parameters were set to 1200 bauds (Theoretically - even for 57 600 bauds)

Microcontroller DSM8051

The DSM8051system [6] employs a Micromade 8-bit microcontroller . It is a programmable training controller equipped with both analogue and digital input/output ports, for connecting and handling peripheral devices.

, The stepper motor controlling software, which controls the step motor in different ways, was developed on the basis of available systems . (about 10 various programs) (Fig.8) . The software coded in microcontroller's assembler may be launched from the Client's remote desktop. User Interface for Client/Server mode was written in Microsoft Visual Studio 2010 Software.

Description of control program operation

There are three stages in the program:

- establishing connection between individual devices (Client, Server, Microcontroller)
- providing parameters to control the step motor from a remote control desktop
- carrying out the motor movement according to a preset set of characteristics.

Below there are examples of characteristics controlling the EDS 10 system.

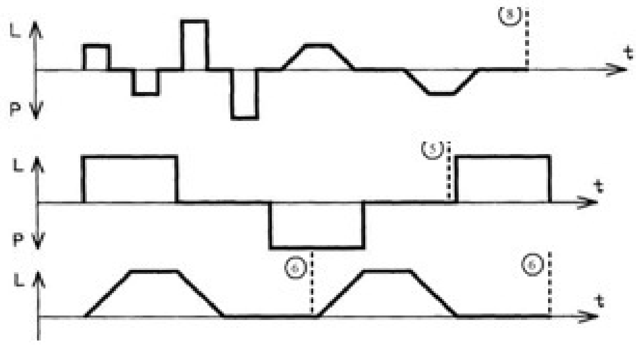


Fig. 8 Selected control characteristics of a step motor

System software has been presented as a UML diagram (use cases) below. (Fig. 9).

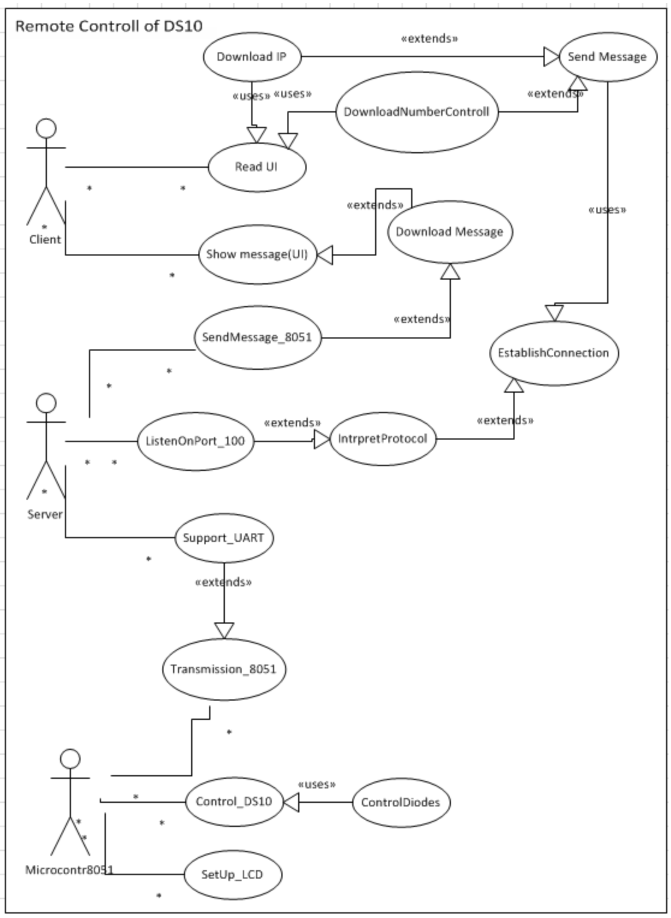


Fig. 9 Use cases for operating software

IV. CONCLUSIONS

The presented solution of remotely controlled communication with an executable system allows for:

- remote monitoring of an executable device – both continuous and on demand
- remote read-out of the system parameters - both continuous and on demand
- remote (e.g. cyclic) recording of measurement data in the microcontroller's memory, from where the data can be read out at any moment (periodically or on operator's demand).

Assuming that the server (Fig.5) symbolizes the on-board computer, there are many ways in which the described system can be used in a motor vehicle and they depend only on the designer's creative imagination and automation systems (microcontroller's) installed in the motor vehicle. Connecting the Gateway (Fig.2), handling interbus communication to the on-board Computer (Server-Fig.5) instead of the executable device/EDS 10 enables the implementation of many telematic services in vehicles. Some of them are: BMW Assist or BMW Tracking ([3], [4]) and similar. Telematic BMW services are currently available in Austria, France, Germany, Great Britain and the United Arab Emirates.

Summing up, it should be stated that the main objective of the presented solution is long distance data transmition , which can be used in all fields of technology, e.g. telemetry, positioning or remote control.

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