

MEDICAL-MEASURING-DIAGNOSTIC-SYSTEM (MMDS) BASED ON CELLULAR TELEPHONE FUNCTIONS

Krzysztof Jellonek, Malgorzata Kotulska

Department of Medical and Measuring Instruments, Wroclaw University of Technology, ul. Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland, e-mail: krzysiek@pwr.wroc.pl

Abstract - An outline of a medical system based on cellular telephone technology is presented. The system includes stimulus generating microsystem, data acquisition microsystem, cellular telephone providing an interface between a patient and the system core, and a remote communication microsystem.

Keywords - medical, diagnostics, cellular telephone, WAP

1. MEDICAL-MEASURING-DIAGNOSTIC-SYSTEM FOREDESIGN

Current state and perspectives of microsystems development allows for designing and implementation of the system for constant monitoring of the patient's physiological state. First, certain prerequisites should be established:

- Collecting medical needs and requirements for the system [9, 15, 18]
- Designing and implementation of specialized microsystems dedicated to information acquisition and processing
- Designing a simple query language for communication and optimal acquisition of the necessary information
- Designing software tools for integration between the system, databases, Internet browser and the user front-end. The software should be responsible for the dynamic exchange between system components and a system-user communication.

The system structure is outlined in Fig. 1.

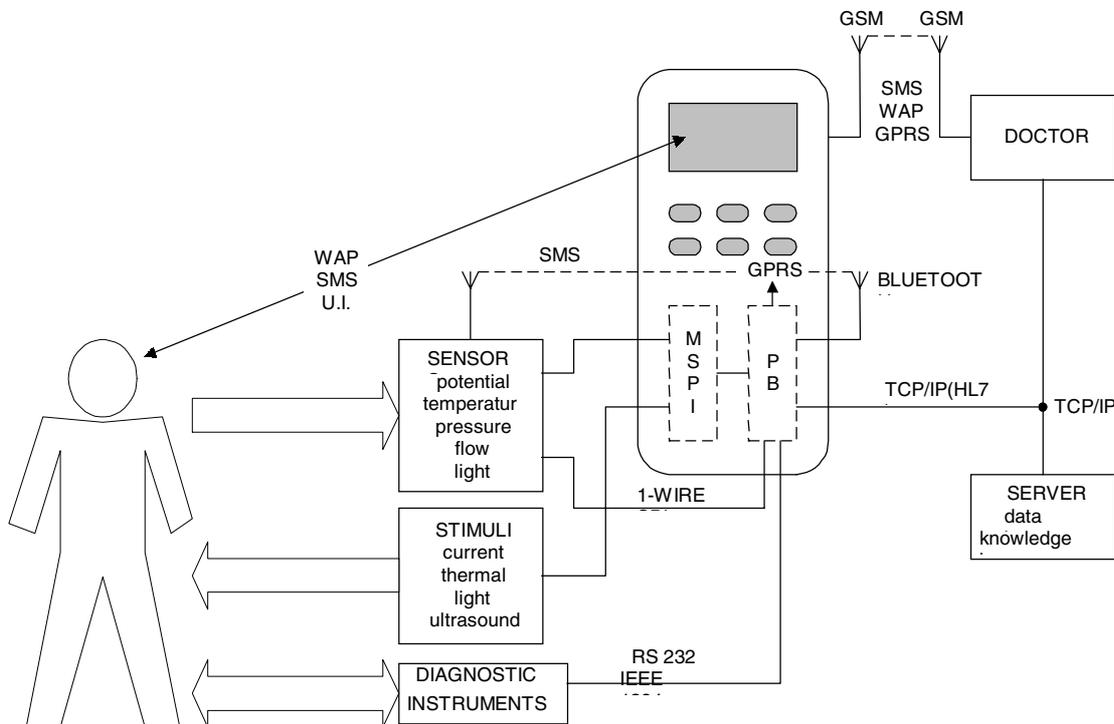


Fig. 1 - MMDS structure.

The main system parts are as follow:

1. A specialized microsystem for information acquisition and processing (MIAP – Microsystem for Information Acquisition and Processing), as well as for model signal generation,
1. Protocol Bridge (PB) conversion and data coding,
2. Cellular phones of patients and doctors,
3. Server of the medical center and terminals of specialized doctors.

The patient is supplied with a set of medical transducers, which are connected to the cellular phone through the microsystem specialized for information acquisition and for conversion to the standard telephone protocols. The set of intelligent transducers may communicate with the phone via wireless Bluetooth technology. Medical support from the medical center is available by choosing an appropriate Mobile Phone (MF) function [1, 17, 19, 20, 21]. The function allows for a transfer of patient's subjective information and measurement data via SMS technique. Access to the feedback information is available either through the WAP-based connection with the main server or SMS technique. A vital element of the system is MIAP.

2. MICROSYSTEM FOR INFORMATION ACQUISITION AND PROGRAMMING

MIAP should allow for connection of transducers dedicated to various physical quantities [14, 15, 16, 18], model signal generation, preliminary intelligent conversion of measurement data, and communication with PB microsystem. Configuration of MIAP input (Fig. 2) is a consequence of medical diagnostic tests requirements.

Input configuration of MIAP consists of three measurement channels arranged for the registration of functional electric potentials: impedance measurement channel with current generator and instrumentation amplifier, channel for photonic quantities with light source controller and detector's amplifier, two channels of input differential amplifiers with digitally controlled parameters (amplification, compensation of input voltage level). All these channels are connected, through a switch, into inputs of three A/D converters, which include 50/60 Hz filter and antialiasing filter (transducers based on TLC2400 by Linear Technology). Digital output signal in SPI standard is transferred to MIAP digital part through transoptors (galvanic isolation). There are two channels of D/A converters, supplied with output amplifiers, for model and therapeutic signal generation.

The analog part of MIAP is connected with its digital part through Serial Peripheral Interface (SPI) with galvanic isolation, which proves safety and disposal of the common artifacts. The digital part is responsible for information acquisition and processing, and for communication with external world (Fig. 3).

The digital part includes four specialized processors: DSP processor for information collection and processing, Universal Processor (UP) for general control, Java processor for communication and a client-type application, and a

processor for PB conversion that allows for connecting various diagnostic appliances communicating through interfaces of different standards (USB, IEEE 1394, Bluetooth, IRDA, RS232, RS485). This approach is available due to the potential offered by Core Based Configurable System on Chip (ARM processors) or new PCA (Plastic Cell Architecture) technique.

The term Java processor, mentioned above, should be clarified here. This type of processor provides hardware support for Java-based software. Fig. 4 presents the principles of programming by means of Java language.

Java is an object-oriented language designed for the client-server architecture, independent of the operating system type. The basic advantage of Java is its ability to generate an intermediate byte code, which is supposed to work always in exactly the same manner, no matter what processor or operating system is in use. The mechanism of Java Database Connectivity (JDBC), which allows for easy access to databases, and Java Servlets responsible for partial deposition of the software logic at the server, should be intrinsic features of Java processor. It is important that the processor should support XML language, which would facilitate effective data exchange with other programs and systems in inter-net structures [2, 6, 13]. The optimal protocol for network data exchange seems TCP/IP, with regard also to Health Level Seven (HL7) international standard for exchanging clinical and health care information [22, 23].

There are two examples of such an approach, which are being developed by Sun: Intelligent Network Vehicles (INV) and eGasStation, where Java is applied as a database for data collection and management [2]. Exemplary solutions of specialized processors for Java support can be found in literature [6]. DSP processor is responsible for fast data collection and processing. It is possible provided the processor has a strong hardware support of its algorithms and fast access to the memory. Cheap and easily approachable environment for programming and debugging is of great importance here [5]. The best solution seems adaptation of processors ADSP21161 or Sharc by Analog Devices and adjusting the LinkPort as means for communication with Java processor. Sharc processor fulfills all mentioned above requirements and it is well suited for multi-processor operation. Moreover, these processors follow JTAG (Joint Test Action Group) standard for testing and emulation, which is very desirable. PB processor should enable non-conflicting collaboration between MIAP, diagnostic tools and intelligent transducers available in the market. It is expected to convert standard interfaces into internal interface protocol. The interfaces supported by PB processor belong to three groups: outdated interfaces, which should be taken into account because a vast amount of the appliances still use them (RS232, RS485), modern but already well-proven interfaces 1-Wire, SPI, USB, IEEE 1394, TCP/IP, and promising new standards such as Bluetooth, GPRS. PB processor can be realized as a fast universal processor of large memory with software based procedures of fast protocol conversion. Instead of the universal processor, the

processor in EFPGA or FPSLIC (Field Programmable System Level IC) technology, by Atmel, can be used. In the latter case the hardware conversion takes place. Implementation of OMAP 1510 processor, by TL, provides an example for this solution. This processor, which is a combination of ARM and DSP processors, has an output in the following standards: UART, USB,

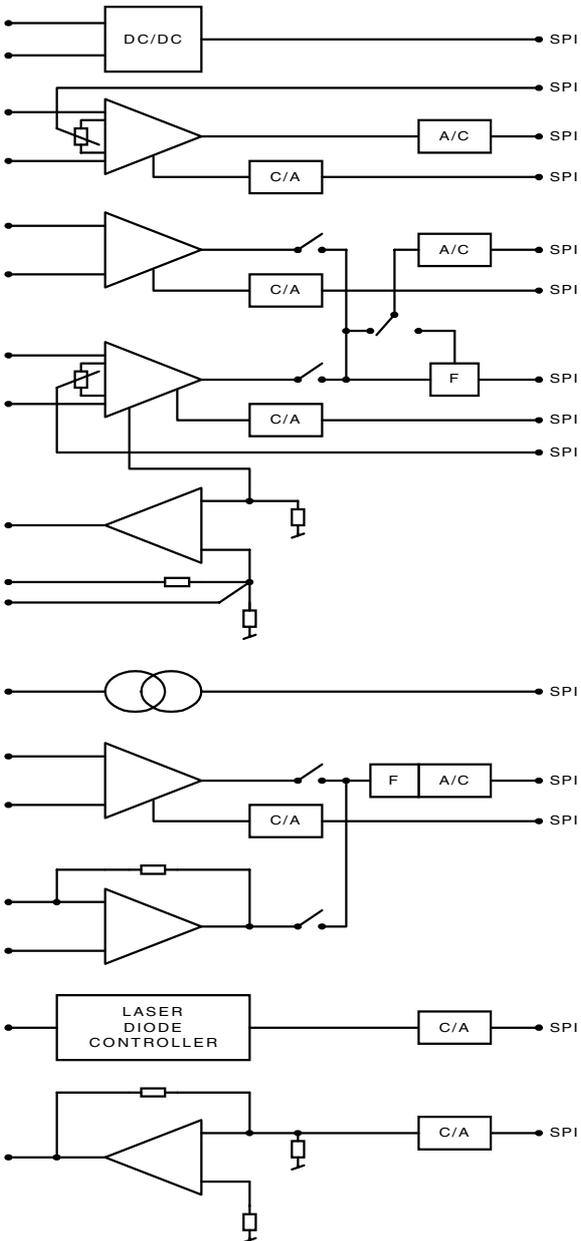


Fig. 2 - MIAP structure.

I2C, PCMAudio, SPI, modem, Bluetooth, JTAG, LCD, RTC, MicroWire. Each of these two solutions (software or hardware conversion) has strong and weak points.

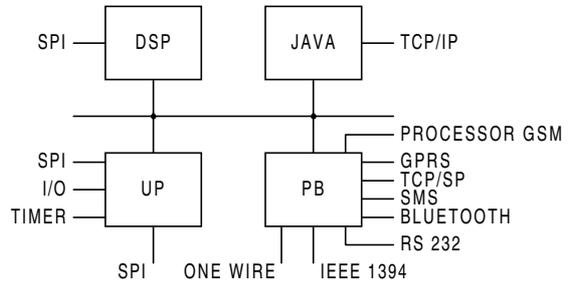


Fig.3 - Digital part of MIAP.

UP processor is a fast controller of the system, with extended function for time dependent tasks and interruptions. For this purpose RISC AT 6000 processor by Atmel seems well-suited, mostly due to its hardware capacity, cheap and effective programming environment. The only problem to be solved is inter-processor communication. A solution can provide LinkPort technique, recommended by AD or AMBA (Advanced Microcontroller Bus Architecture), by Triscend, for connecting ARM processors. All structure should use BIST mechanism (Built-in Self-Test).

All major companies producing DSP microprocessors for telecommunication are involved into development of microprocessor structures for intelligent telecommunication. Table 1 shows main solutions that are currently available.

Nevertheless, even so specialized equipment does not solve the problem of construction a patient support system based on mobile phones. The necessary element is IP (Intellectual Property) layer. The critical part of the system is its user front-end, of very limited potential (mundane and difficult data feeding, limits for data displaying) and data standardization such that they could be exchanged with other systems, too.

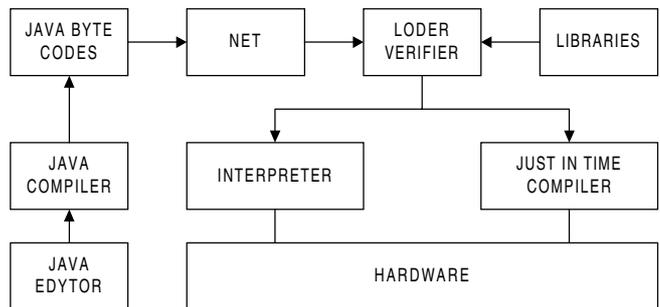


Fig. 4 - JAVA language structure.

Company	Processors	Architecture	Application
TI	ARM+DSP C55X + COPROCESOR BLUETOOTH I GPS	OMAP OPEN MULTIMEDIA APPLICATION PLATFORM	WIRELESS PORTABLE DEVICES (WPD)
MOTOROLA	ARM + DSP RISC M-CORE + DSP MSC 8101	STAR - CORE	WPD
INTEL	DSP FRIO + RISC Xscale	PCA PERSONAL INTERNET CLIENT ARCHITECTURE	WPD
AD	DSP FRIO SOFT FONE	ACP ACCESS COMUNICATION PROCESOR	WPD

Tab.1 – Microprocessors suitable for the MMDS system.

3. PROBLEMS WITH PATIENT'S FRONT-END

REFERENCES

Specification HL7 provides a standard here and the system software should be adjusted to it. Nevertheless, a user front-end can be designed in a more flexible way. There are three techniques of data feeding into a cellular phone: subsequent letters method, first letters method, and automatic word adjustment based on the given set of words with the help of scrolling menu and restricted number of arrow buttons. The third technique is most convenient for the user but most difficult for realization. It requires a very precise division of the knowledge into classes and designing a rigorous set of words for the knowledge transfer. On the other way it proves the information uniqueness. A useful tool for such query language is UML (Unified Modelling Language) technique [11, 12, 24, 25]. It allows for precise division into classes, packages, objects and dependence formalization. Current research heads for assembling a minimal set of unique expressions.

The next step should be division into classes, packages, objects and establishing their inter-relations by means of diagrams, sequence diagrams and collaboration diagrams. Preliminary work shows difficulty in devising a rigorous set of expressions, compatible with the language used by physicians, as well as relatively low precision in medical literature when compared to technical requirements. However, an example of HL7 indicates that normalization in this field also will be developed. Such situation could have been observed in the field of automatic systems, based on PLC elements, where users generated the need for defining task and instruction language. As a consequence IEC 61131 standard has been established and a programming process of automatic systems based on PLC circuits became a unique and manufacturer independent process, available through cellular phone or PALMA.

We are convinced that the system for remote patient control is going to be widely used because it fulfills the social needs to apply modern advanced technology into the healthcare. The future will show whether the solutions proposed here will prove the best.

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