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Model and hardware-software implementation of information processing system for psychophysical and psychophysiological researches

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The conceptual model of the information processing system for psychophysical and psychophysiological researches has been developed. The hardware-software implementation of this system will allow us to diagnose a person's mental state on site or remotely, to identify person's professional suitability, to measure psychophysiological and cognitive characteristics, to store and process research information using the cloud service. The structure of the information processing system model is represented by UML diagrams. The detailed plan of the information processing system realization is presented.

Keywords: information processing system, UML diagram, psychological research, microcontroller, remote control, cloud service, mobile application.

Разработана концептуальная модель информационно-измерительной системы для психофизических и психофизиологических исследований. Аппаратно-программная реализация этой системы позволит локально и удаленно проводить диагностику психического состояния человека, выявлять ее профессиональной пригодности, измерять психофизиологические и когнитивные характеристики, хранить и обрабатывать информацию об исследовании, используя преимущества облачного сервиса. Структура модели информационно-измерительной системы изображена с помощью диаграмм UML. Представлен подробный план реализации информационно-измерительной системы.

Ключевые слова: информационно-измерительная система, UML диаграмма, психологические исследования, микроконтроллер, дистанционное управление, облачный сервис, мобильное приложение.

Розглянуто важливість застосування спеціалізованих програмно-апаратних комплексів з батареями психодіагностичних тестів для психофізіологічного та психофізичного моніторингу. Описано проблему нестачі сучасних інформаційних технологій для побудови систем якісної психодіагностики, особливо тих, що дозволяють проводити дистанційне обстеження. Доведена актуальність створення інформаційно-виміральної системи, що має сучасні способи отримання, передачі, обробки та збереження даних. Розроблено концептуальну модель інформаційно-виміральної системи для психофізичних і психофізіологічних досліджень. Апаратно-програмна реалізація цієї системи дозволить локально і віддалено проводити діагностику психічного стану людини, виявити її професійну придатність, вимірювати психофізіологічні та когнітивні характеристики, зберігати та обробляти інформацію про дослідження, використовуючи переваги хмарного сервісу та мобільного додатку. Структура моделі інформаційно-виміральної системи зображена за допомогою діаграм UML. Структурна модель представлена чотирма блоками: блоком управління (робоче місце експерта), блоком тестування (робоче місце досліджуваного), блоком отримання і передачі даних та блоком обробки та збереження даних. UML діаграми відображають як склад кожного блоку, так і способи взаємодії між компонентами системи. Представлений детальний план реалізації інформаційно-виміральної системи. Наведений короткий опис: способу налаштування та з'єднання Wi-Fi модулю ESP8266 із мікроконтролером STM32F4, принципи роботи хмарного сервісу ThingSpeak. Описані функції мобільного додатку інформаційно-виміральної системи.

Ключові слова: інформаційно-виміральна система, UML діаграма, психологічні дослідження, мікроконтролер, дистанційне керування, хмарний сервіс, мобільний додаток.

Problem statement

Obtaining objective and reliable information on the professional suitability of the operator of complex systems and processes as well as the actual functional and psychological state of the employees and their ability to perform responsible or monotonous work is of high priority in the workplace safety and health management. Being ready to rapidly take action on basis of that information is a prerequisite for the effective management of the task assigned to the individual or executive team. The identification of the individual characteristics of an employee's job and the ability to assess the probability of an impending event is the basis for the optimal distribution of staff in any team. The sources of such information are specialized software-hardware complexes for psychophysiological monitoring by means of sets of psychological tests [1 - 3].

The development of models, logical flowcharts, algorithms and computer programs for psychophysiological research requires a detailed study of the psychological, physiological, and moral aspects of the problem, as well as professional experience with information technologies, electronic equipment and programming languages. Despite the growing need for such research and the relevance of computer-assisted psychophysiological diagnostics, the present information processing systems are

extremely insufficient, and their functionality is significantly limited. This is particularly true for systems that allow remote monitoring. For example, remote monitoring of the psycho-emotional state of truck drivers, diagnosing the functional state of athletes and military personnel determine their readiness to perform complex and responsible work.

Therefore, the development of information processing systems for psychophysical and psychophysiological studies that meet modern requirements is an urgent task [4, 5]. The urgency of creating and using information systems in psychophysiological and psychological research is determined by the fact that nowadays a person's information load has considerably increased. As a result, stressful situations, the need for ambiguous decisions, and the need to find solutions in an uncertain environment are increasingly occurring. The active use of specialized software-hardware systems for psychophysical training could contribute to the adaptation of human behavior in the context of information noise and global digital transformation of society. Obviously, the citizens' mental health depends on the effectiveness of implementation and usage of such systems.

The Internet, modern information technologies and electronic environment offer new opportunities for building more advanced psychodiagnostic systems.

The proposed development of a new generation of specialized information processing system is aimed at fast and effective psychological support for decision-making, diagnostics and control (including remote control) of psychophysiological state and cognitive abilities of a person.

Conceptual model of information processing system for psychophysical and psychophysiological researches

The presented information processing system has the following features: it provides end-to-end information support for psychological research at all stages of the information flow based on integrated data presented in a unified form, information storage, visualization and data protection. The significant advantages of the system are the usage of cloud services in the process of data collection and processing, the ability to easily change and expand both the devices for the tests and the tests themselves, to work with various network technologies, as well as to engage, by the mobile application, professional psychologists and experts specializing in the subject areas.

In addition, the form and method of presenting information during the research process can be adaptively reshaped in the system. Thus, the functionality of the system can be described by the following levels: 1 - collection, registration and structuring of information, creation of information space; 2 - storage and search of additional information, set up of information exchange; 3 - statistical analysis of data, decision support and synthesis of test effects.

Let us consider the structure of the conceptual model of the information processing system, which is represented as a UML diagram of components.

Fig. 1 shows the information processing system consisting of the following units: the control unit (essentially, workplace expert), the testing unit (workplace investigated), the unit for receiving and transmitting data, and the unit for processing and storage data.

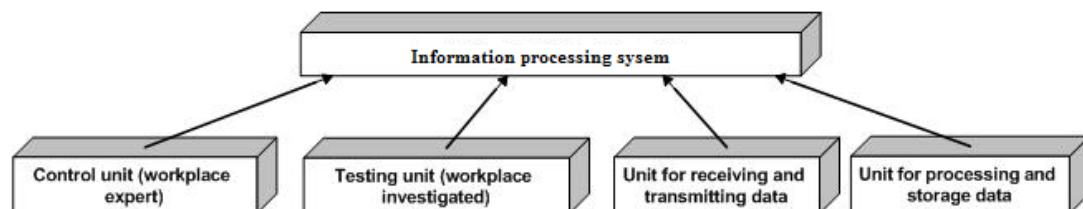
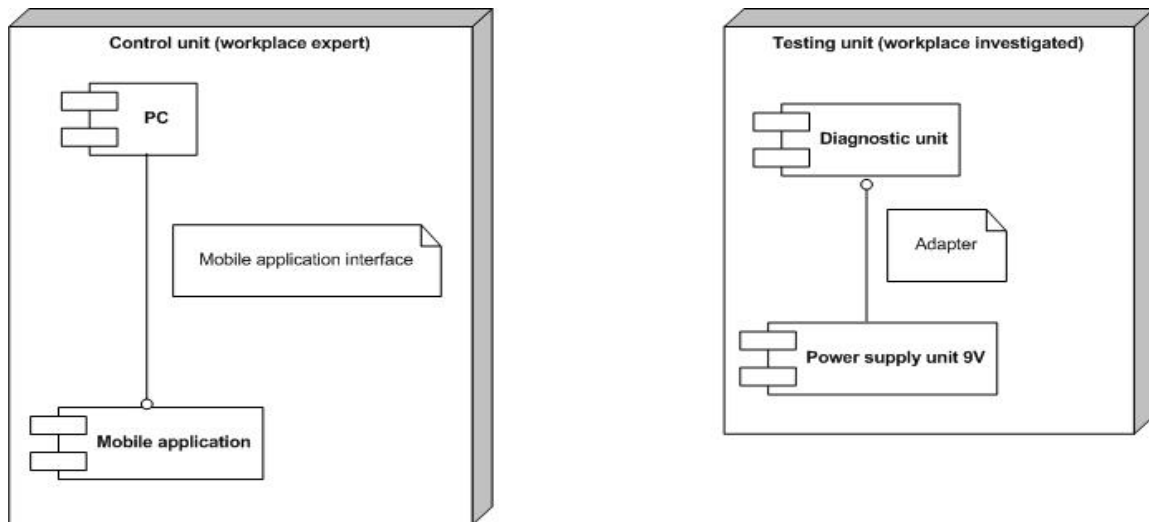


Fig. 1. Information processing system for psychophysiological research

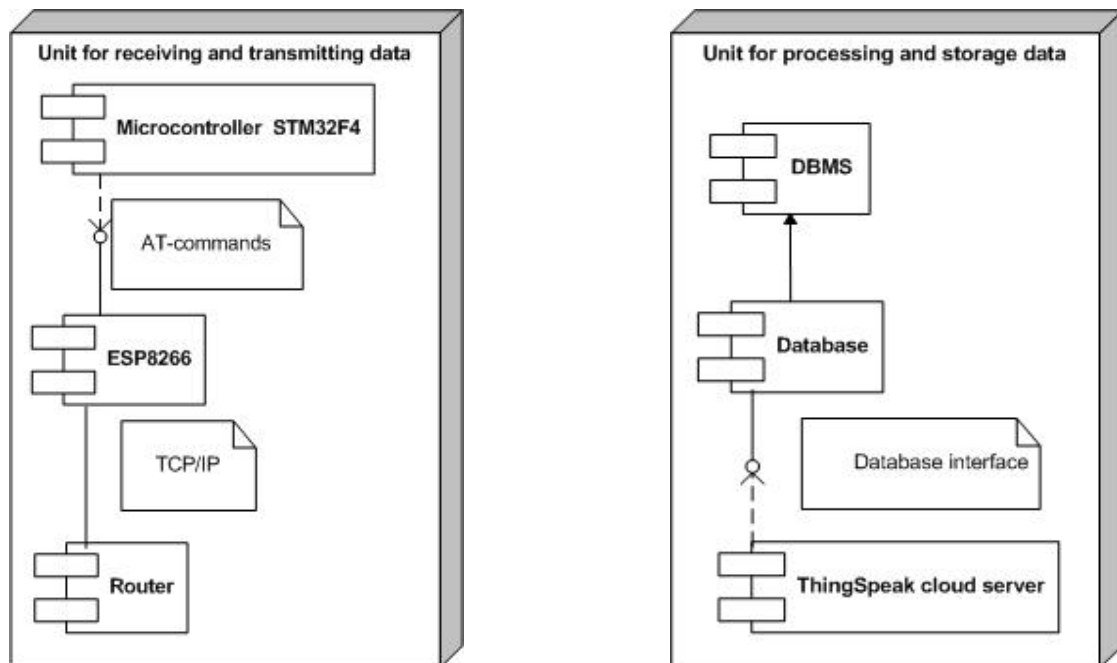
Fig. 2a is a diagram of the components of the control unit (workplace expert) consisting of a PC communicating through the mobile application interface with the mobile application, and the testing unit (workplace investigated) containing the diagnostic unit which feeds through the adapter from the 9 V power supply unit (Fig. 2b).

Fig. 3a presents a diagram of unit for receiving and transmitting data, comprising an STM32F4 microcontroller and an ESP8266 Wi-Fi module, that interact with each other through AT-commands, and a router that is connected through TCP / IP communication protocols. In the absence of the Internet, mobile communication or recording on a built-in fixed memory can be used with subsequent data transmission to the cloud-based subsystem of reception, processing and storage.

The unit for processing and storage data, presented in Fig. 3b, consists of a database management system (DBMS), the database itself, and a ThingSpeak cloud server.



a) b)
Fig. 2 UML diagrams of the control unit (a) and the testing unit (b)



a) b)
Fig. 3. UML Diagrams of the Unit for Receiving and Transmitting Data (a) and the Unit for Processing and Storage Data (b)

Fig. 4 shows the general structure of the conceptual model of the information processing system for psychophysiological research. The developed model describes the processing and analyzing data remotely in real time. The general structure presents not only all the components, but the functional

connections between the components as well: the mobile application and the ThingSpeak cloud server interact through the ThingSpeak interface, and the mobile application and the DBMS interact through the DBMS interface respectively. Data transmission between the router and the ThingSpeak cloud server is possible within HTTP requests. The connection of the diagnostic unit to the STM32F4 microcontroller and its efficient functioning are possible due to the IDE libraries included in the basic STM32F4.

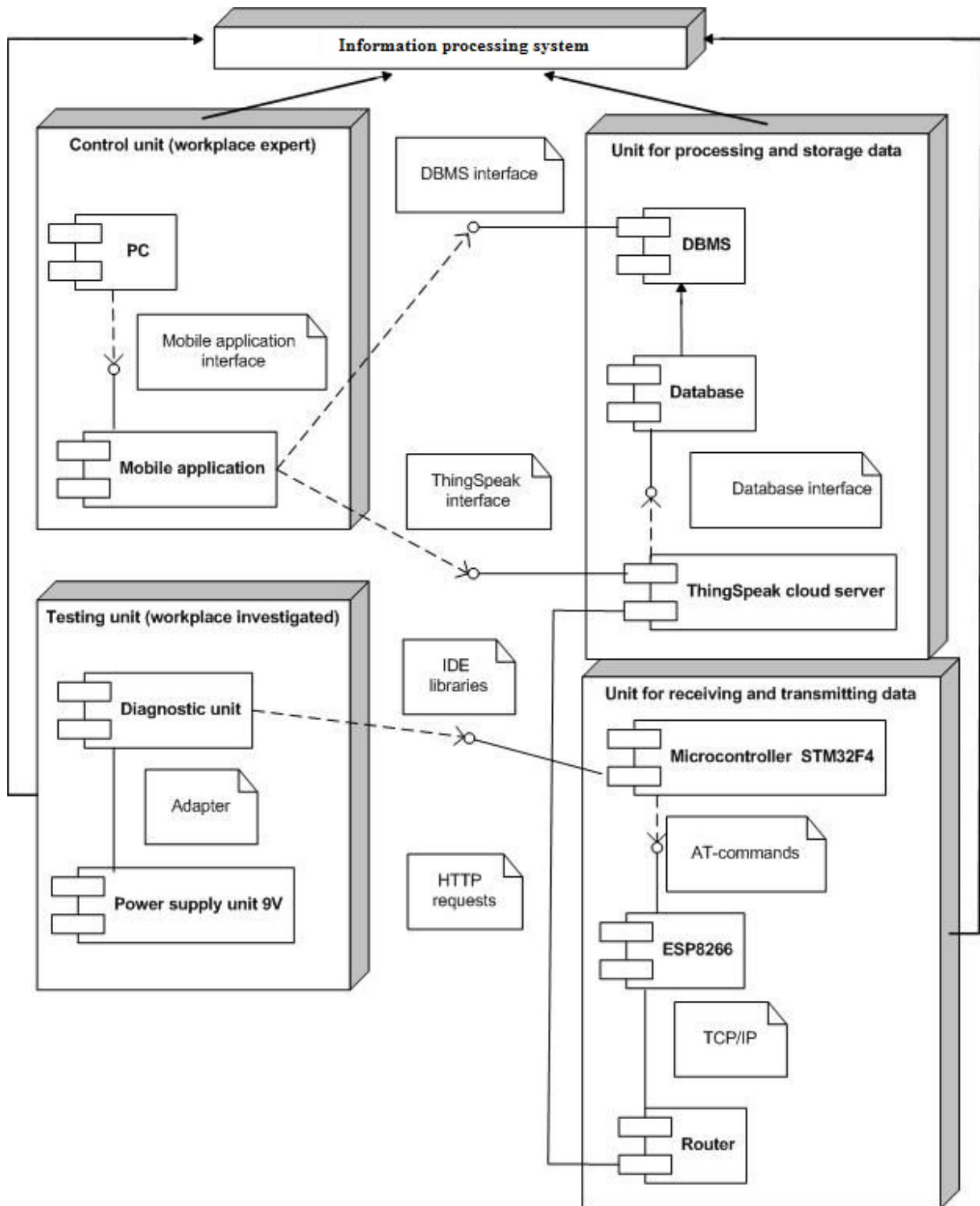


Fig 4. UML diagram "Conceptual model and hardware-software implementation of information processing system for psychophysiological researches"

System model implementation

The steps planned for the system model implementation are:

1. Installation and testing of the diagnostic unit
2. Installation, configuration, connection and testing of ESP-8266
3. Configuration of the ThingSpeak Status Channel
4. Install ThingSpeak code on STM32F4
5. Database development
6. Development of Android application
7. Installation and configuration of external devices
8. Configuration of the ThingSpeak Actuators channels
9. Configuration of the STM32F4 with external devices
10. Testing Android application with sensor status check
11. General testing of the hardware-software complex.

To connect sensors it is necessary to use certain libraries native to STM32 IDE. These libraries make it possible to initiate sensors, obtain sensor readings and display them on the monitor screen.

The use of ESP8266-12 requires the usage of AT-commands (the module includes an AT-commands processor). To connect the module and adjust the rate of data transfer, it is necessary to connect STM32F4 to the PC, use empty code and AT commands in the open IDE. The final connection to the already configured ESP8266-12 includes the following connections:

- ESP-12 RXD --> STM32F4 PIN PD6
- ESP-12 TXD --> STM32F4 PIN PD4
- ESP-12 Ch-Pd (En) --> Vcc (3.3V)
- ESP-12 Reset --> STM32F4 Pin PB5
- ESP-12 Vcc (Red) --> 3.3V
- ESP-12 Gnd (Black) --> STM32F4 PIN PC15

The next step after installing the sensors and connecting the ESP-8266 is to configure the process of transmitting information from the sensors to the cloud service. ThingSpeak's cloud service allows collecting information from the sensors, as well as processing and analyzing it. After registration on Thingspeak, channels responsible for collecting sensor data (keyboards) and controlling actuators (visual stimulus unit) through the mobile application are created. HTTP requests are required to transmit data to the cloud. For example, to record data in the Status Channel fields (at a frequency of 1 every 15 seconds), it is necessary to submit an HTTP GET request.

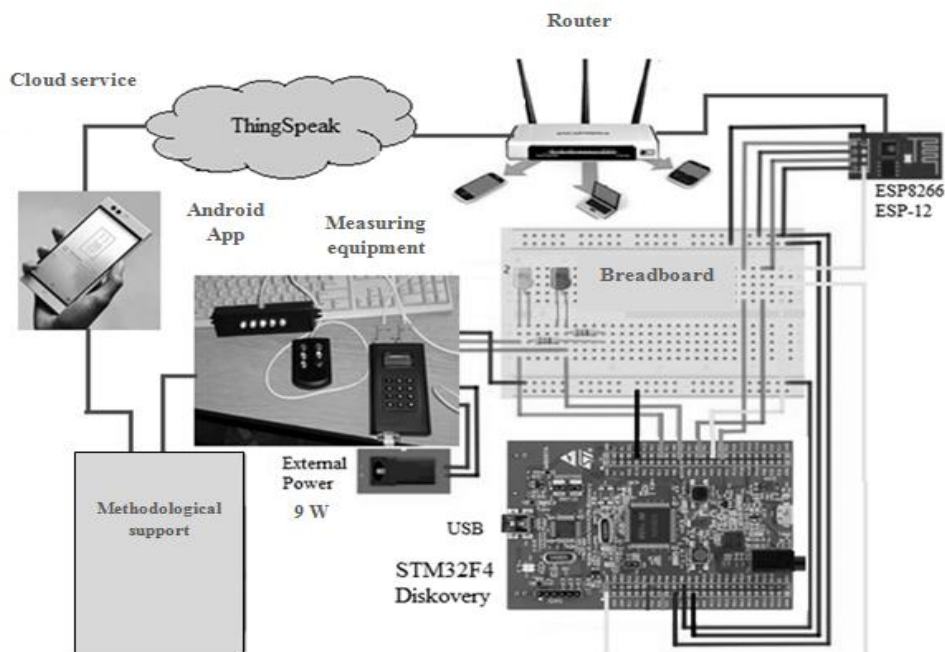


Fig. 5 Current layout of the subsystem for receiving and transmitting data for remote monitoring.

The mobile application of the hardware-software complex allows not only remote controlling of the executive devices (turn on, turn off, select the mode of the methodology) and viewing the information received from the sensors through the cloud server Thingspeak, but also drawing the initial and final expert conclusions on the diagnostics of the investigated personnel and storing them in the database. A significant advantage of the ThingSpeak cloud is the availability of a powerful suite of applications for solving scientific and technical computing problems (MatLab) which can perform all necessary data operations [6,7].

The structural and functional organization of the current layout of the subsystem of receiving and transmitting data for remote monitoring of psycho-emotional state is shown in Fig. 5. The subsystem layout is made on the basis of the STM32F4 Discovery microcontroller board. The board is connected to one of the information-executive modules of the psychodiagnostic system (described in [8]), the Wi-Fi module ESP8266-12 and the power adapter.

Conclusions

The conceptual model of the information processing system for studying of psychophysical and psychophysiological patterns of sensory processes of a person is presented in the article. The model is a framework of functional blocks, the inputs and outputs of which are connected through the appropriate interfaces. It is presented as UML diagrams of general structure and detailed diagrams of system components. Such presentation made it possible to qualitatively and clearly visualize the structure and describe the system operation principles. Building a conceptual model greatly simplifies the next stages of designing an information processing system. The basic stages of implementation have been developed and described on the basis of the model of real information processing system with the possibility of both local and remote research of psychophysical and psychophysiological functions.

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