

## GSM-BASED MOBILE HEALTH SYSTEM

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**Summary:** GSM-based mobile health system is a beyond state-of-the-art portable wireless telehealth appliance for on-line telemonitoring of patients' vital cardiovascular parameters (pulse, blood pressure, ECG) by physicians located at remote sites. The system consists of a Portable Cardiovascular Device (PCD), a state-of-the-art GSM with WAP web access, interface and physician's computer (PC) with specialized software. The system addresses GP, hospitals, insurance institutions, old people houses and large groups of European citizens - cardiovascular patients, elderly, pregnant women, etc. Benefits from system's application are cost saving and improved quality of health care service, development of advanced interactive environment for doctors and nurses and intelligent environment for patients.

The GSM-Based Mobile Health System (MHS) is a portable, wireless, personal health device suitable for telemonitoring of patients' cardiovascular parameters (pulse, blood pressure and electrocardiogram) at any time, from anywhere from physicians located at remote sites.

The idea for MHS development is initiated by the Bulgarian Academy of Sciences, created in collaboration with physicians, technical and computer experts and realized by multilateral partnership with medical and information technology industry.

MHS utilized standards in information technology and medicine as well as beyond state of the art computer and telecommunication technology. Its design and development are based on the application of on hand cardiovascular, computer and telecommunication devices, managed by especially developed software.

The GSM-based mobile health system consists of a Portable Cardiovascular Device (PCD), a state-of-the-art GSM with WAP web access, interface and a physician's computer (PC) with specialized software (fig. 1). This is the minimum configuration required for on-line telecare.

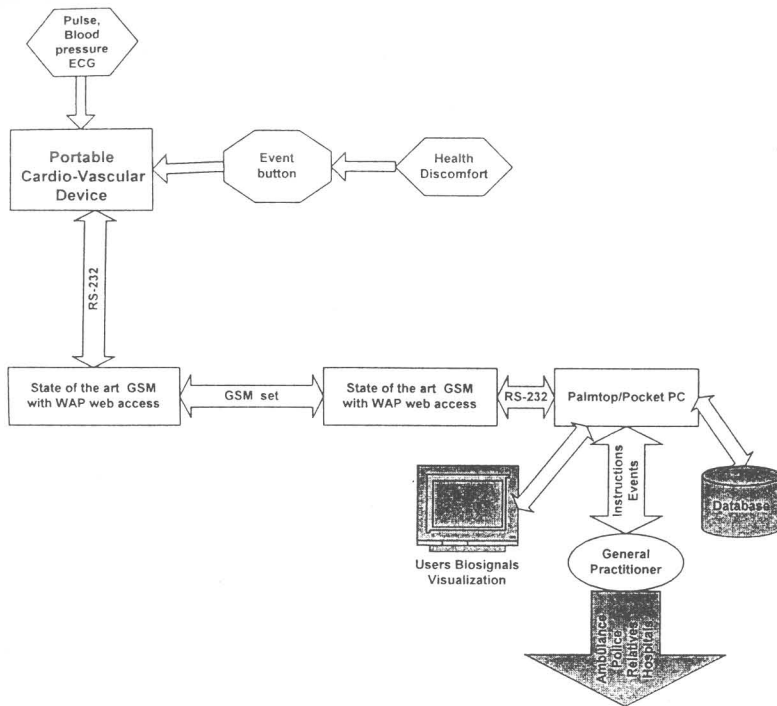


Fig. 1 Block diagram of GSM-based mobile health system

The PCD measures and records continuously patient's physiological parameters. It consists of a portable pulse and blood pressure meter and portable 4-channels electrocardiogram (ECG). PCD has a 32-MB flash memory on smart card and an event button. All data are recorded and saved on the smart card, which contains patients' personal data. This gives possibility both to transmit the recorded data on-line and to exchange the smart card and thoroughly to examine and analyze the parameters later on. Pressing the event button initializes data transmission on patient's request, i.e. in case of health discomforts and activates an alarm signal in physician's PC thus giving priority to this record over all other data sets. This option increases the possibility for more precise assessment of the function of cardiovascular system.

The available at the moment ECG software performs continuous real-time ECG analyzes - measures ST intervals, tracks rhythm and morphological changes, highlights abnormal ECG epochs, every minute computes the width of QRS intervals and the variability of RR intervals, perform continuous statistics of ventricular and

extraventricular extrasystoles. The ECG is build under the IEC 601 electrical safety Standard. The size of the ECG appliance together with the interface to the GSM is 120 x 70 x 38 mm.

Siemens S 35I GSM is connected to the PCD in order to transmit patient's cardiovascular parameters toward the GSM net and physicians' PC. The PCD manages the GSM via standard RS-232 interface in a way to avoid noise on the cardiovascular measurements by the GSM UHF signals. Highly specialized software enables physicians to monitor patients' biosignals, while reading their medical history from the database, to visualize database on various clinical symptoms and syndromes, to estimate the validity of the received data, to generate automatic conclusion on patient health status and edit it; to send instructions to patients and when necessary easily to communicate with hospitals, ambulance, police or patients' relatives. At present the consortium has not yet decided what would be the best choice for physician's PC – Siemens IC 35 unifier, HP Jornada 540 color pocket PC or Siemens-Fujitsu Lifebook B-series.

The main innovations of the proposed GSM-based mobile health systems are:

(1) The type of services. For the first time a system especially dedicated to large groups of European citizens (elderly, cardiovascular patient, pregnant women, etc.) including the whole circuit beginning from patient and ending with physicians is proposed. The system is suitable for extended healthcare service providing reconnection between users and doctors. This statement is based on the survey done by ITU /International Telecommunication Union/ and Inmarsat in 59 countries [1].

(2) MHS is designed for personal use. It is portable and mobile, realizes wireless communication between patient's body and physicians PC and interacts with patients and physicians in a user-friendly way. Thus the system enables anywhere/any-time access to health care service. Or the system is not only beyond the state-of-the-art, it is also ubiquitous. The application of newly developed wireless technology in MHS design gives the possibility to secure the freedom of patients' movements and will not interrupt users in fulfillment of their everyday activities. Similar systems do not exist and are not applied in Europe.

(3) MHS register and send cardiovascular parameters on-line but at the same time is able to store them for rigorous examination later on. 32-Mb smart card memory and rechargeable Lithium-ion batteries achieve this.

Having in mind the innovations of the GSM-based mobile health system we declare that the proposed MHS is really beyond the state-of-the-art telecare device. Table 1 compares MHS and existing products that are at first glance more or less similar to our system. The products included in the table are well known product of Shahal/Israel [2-3], an experimental Japanese home health system [4-5], A&D HealthWatch Blood Pressure Monitor [6], Welch Allyn's Home-Based Hypertension Monitor [7], AMD-8200 Vital Signs Monitor [8-9] and Aviva Single Line System [10].

None of the other appliances included in the table is really mobile. The fact that the recorded data are transmitted via ordinary telephone lines restricts patients to stay close to the telephone.

Table 1. Comparison of on hand home-based telemedicine appliances

Product	Parameters			Use		Mobile	Portability	Phone	Internet	Long-term monitoring	Event records	Wireless
	Pulse	Bl. pressure	ECG	Indoor	Outdoor							
Shahal	+	+	+	+	-	-	+	optl	-	+	+	-
Japan	-	-	+	+	-	-	-	optl	-	-	-	-
A&D Health Watch	+	+	-	+	-	-	+	optl	-	-	-	-
Welch Allyn	+	+	-	+	+	-	+	optl	-	+	-	-
AMD-8200	+	+	-	+	-	-	-	optl	-	+	-	-
Aviva	+	+	-	+	-	-	-	optl	-	+	-	-
<b>GSM-Based MHS</b>	+	+	+	+	+	+	+	<b>GSM</b>	+	+	+	+

The partners firmly believe that GSM-based mobile health system will help to solve two important problems that European society faces in the coming century (1) the increasing percentage of cardiovascular diseases and (2) the increasing proportion of elderly in the population.

1) Cardiovascular disease is the leading cause of death in Europe. It claims more than a million lives each year. It accounts for more than a third of all deaths among males between the ages of 35 and 55.

The examination of pulse, blood pressure and electrocardiogram are the first and the most important tools providing clues to the heart problem. A physician can detect many heart conditions before symptoms become apparent by measuring pulse, blood pressure and ECG. The ability to monitor on-line the just mentioned parameters is the most advanced method to obtain first symptoms of the coming myocardial infarct or other cardiovascular complications.

Extremely large groups of patients need periodical control of cardiac parameters. The follow up care, including blood pressure, pulse and ECG monitoring, is important to reduce the risk of developing of cardiovascular episodes.

2) Another very large group of European citizens to whom the MHS is addressed is the group of elderly. The number of persons aged 60 years or older is estimated to be nearly 146 millions in 1999 in Europe and is projected to grow to almost 214 millions by 2050. With advancing age health status generally declines. The added years in many instances are hampered by cardiovascular disability, dependency and infirmity. Congestive heart failure, one form of cardiovascular disease, is the single most frequent cause of hospitalization for people aged 65 years or older. In addition, more and more of the elderly are living alone in their homes and

need to be cared for at home, which results in a burden for both the family and the society. A possible solution of this rather complicated problem is to develop and expand the percepts of home health care and especially home health care based on modern telecommunication technology for information exchange between elderly people living alone and the medical staff providing home health care. The GSM-based mobile health system is one possible solution of the problem.

The treatment of cardiovascular disease and the care for the elderly are very important problems but there are at least two more groups who will benefit from the wide application of the MHS. These are (a) pregnant women whose cardiovascular parameters are followed strictly for the sake of both the mother and the child and (b) all who must perform the treadmill ECG test. This test is used to determine the causes of chest pains, the capacity of the heart or the appropriate exercise levels in those initiating an exercise (fitness) program, no matter if they are cardiovascular disease patients or healthy people.

At the end it is necessary to underline that the wide application of MHS will lead to the following benefits:

- For physicians - quicker diagnosis, improved treatment, reduced delay in giving medicines and performing scheduled actions, improved consultation and follow-up, more time available to devote to patients, reduction of waiting lists, travels and lost of time, reduction of stress and time pressure, etc.

- For patients - improved quality of health care service due to faster diagnosis and treatment, avoidance of inconvenience of travelling, distant consultations by real time examination, reduction of length of stay in hospitals, psychological comfort.

- For the society – reduction of health care budgets (cost saving) and improved quality of health care service.

In sum:

The ability and motivation of any person to live depend in large part on the supports and challenges presented by both the social and physical components of the environment. Technology is a part of the physical environment. The consortium firmly believes that the proposed GSM-based mobile health system with all the above mentioned innovations will influence both social and physical aspects of the European citizens' environment. Its wide application will contribute for the development of intelligent environment for health promotion and illness prevention as well as for the growth of advanced interactive environment for patients and medical specialists.

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