# An Autonomic Mobile Computing System for Cardiac Parameter Monitoring

E Ramírez-Islas, PV Morales-Montañes, A García-Avelar, E Moyao-Chamorro, U Ravelo-Antonio, C Morales-Torres, Y Terán-Salgado, DA González-Perales

Laboratorio de Bioingeniería, Instituto Tecnológico de Cuautla, Morelos, México

## Abstract

*An increasing number of users are surrounded by multiple computing devices such as PDAs and cell phones. There is some evidence that the use of mobile devices in health care settings might improve decision-making and reduce the numbers of medical errors. However, mobile devices are not commonly used in telemedicine and health care, and there is a lack of suitable functions and software applications. The aim of the present study is to develop an autonomic mobile computing system that can manage itself with an Attentive User Interface for important cardiac parameter monitoring. We have developed a mobile computing system, SaneHeart, using modern wireless mobile technology. The system was programed with J2ME and J2SE. The present work includes a study case for cardiac pressure monitoring. SaneHeart was proven in hypertensive patients, 4 men and 5 women. In conclusion, attentive mobile devices may improve and facilitate the experience of patients in the monitoring of cardiac parameters.*

## 1. Introduction

The complexity of computing systems appears to be reaching the limits of human capability. The need to integrate heterogeneous environments and connectivity into the Internet have introduced new levels of complexity. As systems become more interconnected and diverse, designers are less able to anticipate and design interactions among components, leaving such issues to be dealt with at runtime. In the future, the systems will become too massive and complex for even the most experts system integrators to install, configure, optimize, maintain and merge. Autonomic computing might be an option to deal this scenario. In Autonomic Computing, the systems can manage themselves given high level objectives from system administrators [1, 2].

An increasing numbers of users are surrounded by multiple computing devices such as PDAs and cell phones. As our devices connect to a global wireless network, we become members of a global society, one where we are always connected. The users have the requirement to be available at any time or place in order to adapt to changes in information environment. The computing devices do not satisfied this situation, this is because their graphical user interface (GUI) have not fundamentally changed in last years. Each device acts in isolation, as if it were the only device of the users. Devices bombard users with the request for attention, regardless the cost of their interruptions. Computing interfaces that are sensitive to the attention of users, are called Attentive User Interfaces (AUIs) [3].

Hypertension can be effectively prevented and controlled only if it is constantly monitored, along with the support of the health education and professional medical care [4].

In the present work, an autonomic mobile monitoring computing system with alert mechanism in hypertension monitoring is proposed and implemented.

## 2. Methods

The block diagram of the proposed system in the present work is shown in Figure 1. The autonomic mobile computing system is compound mainly of three parts: 1) a cuff that includes a sensor and the circuitry necessary to measure the blood pressure (BP) and the wireless transmission of the information by means of bluetooth, 2) a mobile device that controls the operation of the cuff and receives the generated information of blood pressure and 3) a server connected to the Internet that stores the data of the measurements of blood pressure of each user of the system.

The cuff is used to measure the blood pressure by the oscillometric method. For the communication between the cuff and mobile device is used bluetooh technology (Rabbit$^{TM}$ module EB506). The control of the cuff is by means of an application developed for the mobile device.

Figure 1. The block diagram of the autonomic computing system proposed. The system is compound of three parts: a cuff, a mobile device that controls the operation of the cuff and a server.

The data of the blood pressure collected by the cuff are sent to the mobile device for their storage.

J2ME is used to write a custom software application (SaneHeart client) for the mobile device, the user interface of our design is shown in Figure 2. The program menu includes two functions: (1) Medir (Measure): the command that the application (SaneHeart client) sends to the cuff so that the measurement of the blood pressure begins. Before beginning the measurement, the cuff is placed by the user of the form in which it was indicated; (2) Guardar (Save): this menu option allows to store the information of the blood pressure sent by the cuff and user data.

The back end of the system is a server. The server stores the records of the measurements of cardiac pressure of all the users. An application (SaneHeart server) was developed with J2SE that runs in the server and that communicates with the mobile device by means of bluetooth technology. Using the approach of autonomic computation, the server and the mobile device can interchange information without the intervention of the user. The GUIs of the applications, client and server, follows an approach of Attentive User Interfaces that adapt their characteristics according to preferences and needs of users.

## 3. Results

The autonomic computing system was proven by nine hypertensive patients, 4 men and 5 women by a period of a month. Two mobile phones were used in the tests, a Nokia$^{TM}$ 5320 and a Sony Ericsson$^{TM}$ W300. The developed application (Sane Heart Client) was installed and executed without problems on both phones. The application GUI was adapted to user preferences, such as font size and interface colors.

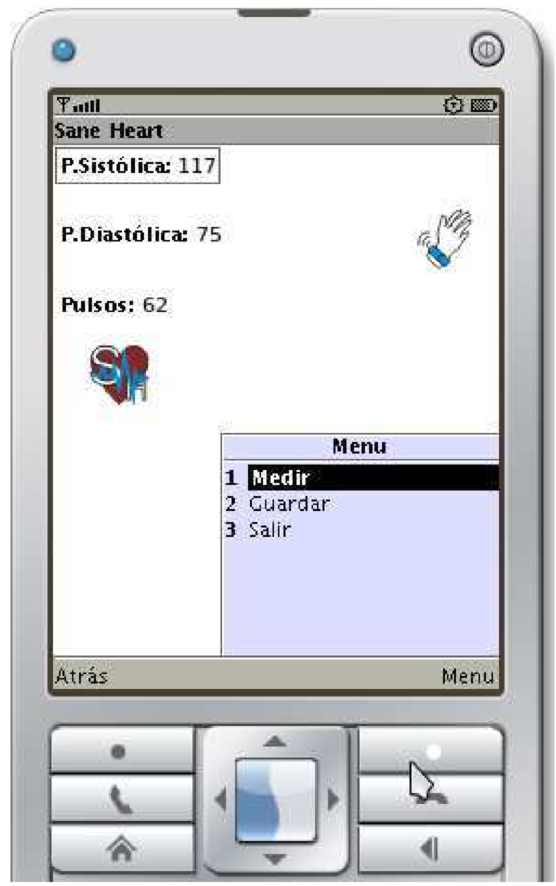


Figure 2. Appearance in the device emulator of graphical user interface (GUI) of the application program (SaneHeart client) for the mobile device.

The blood pressure values obtained with the system cuff were compared with the readings obtained with a commercial equipment (Citizen$^{TM}$ Digital Blood Pressure Monitor CH-432B). The comparative is shown in Figure 3 for a session with the 9 patients for systolic and diastolic pressure. The readings obtained with both equipment are similar, except for patient #7 where exists a difference of +5 mmHg for systolic pressure. In later sessions the system was readjusted trying to reduce the differences between the custom cuff and the digital blood pressure monitor.

The developed system was tried on using the approach of Autonomic Computing (AC) and Attentive User Interfaces (AUIs) and under an operation manual mode. A survey was applied to users with the aim of evaluating the system under these two operation modes. The results of these tests are shown in table 1.

According to the results, the aspects of handling and interface are better evaluated under the approach of AC and AUI. On the other hand, the users do not appreciate an

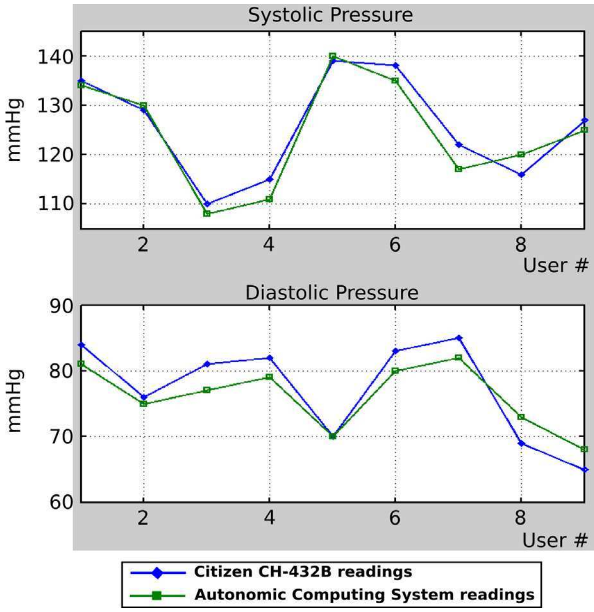


Figure 3. Comparison between the systolic and diastolic pressure readings of proposed Autonomic Computing System and a commercial digital blood pressure monitor (Citizen$^{TM}$ CH-432B).

important difference in the functions of the system. With respect of the autonomy of the system, this aspect is the worse evaluated because the user must take part in the positioning of the cuff to carry out the measurement of the blood pressure. The survey showed that the perception of users is favorable to the developed system under the approach of Autonomic Computing (AC) and Attentive User Interfaces (AUIs).

Table 1. System evaluation under two operation modes.

| Evaluated Aspect | Manual Mode | AC and AUI Mode |
|---|---|---|
| handling | 2 | 8 |
| functions | 5 | 8 |
| interface | 3 | 9 |
| autonomy | 4 | 7 |

## 4. Discussion and conclusions

In healthcare, physicians need to monitor one or more parameters of the patients who are hospitalized or at home. Some of the diseases such as hypertension or diabetes require a constant monitoring. In these cases, the equipment availability that facilitates the local and remote monitoring of the parameters of the patients over a long period of time is needed. Telecare systems which utilize information and communication technology can provide proper medical care for remote patients [5, 6]. Many devices for patient remote monitoring have been developed [7–9]. The system that we propose focuses not only to monitoring, it also looks for an autonomous operation with an advanced user interface. The proposed system is selfconfigured according to the preferences and characteristics of the patients and utilizes modern wireless mobile technology.

Many developed devices uses services like SMS (short messaging system) or 3G technology (WCDMA system) for the transmission of the information [4, 10, 11]. In the present work, the proposed autonomic computing system uses bluetooh technology. The system can transmit to a distance of approximately 20 meters, that is a short distance. So that, the cuff and the mobile device can communicate when they are to a restricted distance. This is a disadvantage of the system, but on the other hand, it is a more economic proposal for the data communication of blood pressure.

The trend to use more computing devices may provide an opportunity for increased their potential and to provide the desired benefits and would be a critical part of health care information system and telemedicine.

In conclusion, attentive mobile devices may improve and facilitate the experience of patients in the monitoring of important cardiac parameters.

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Address for correspondence:

Esteban Benito Ramírez Islas
Laboratorio de Bioingeniería, Instituto Tecnológico de Cuautla
Libramiento Cuautla-Oaxaca S/N Col. Juan Morales CP 62745
Cuautla, Morelos, México
E-mail: jebmor@gmail.com