BLENDING SOFTWARE AND COMPUTER ENGINEERING IN STUDENT PROJECTS

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SUMMARY

In this paper we describe three student projects elaborated for the IEEE Computer Society International Design Competition (CSIDC). All three projects involved students of software engineering and computer engineering who demonstrated excellence in design of a system consisted both from computer hardware and software. Moreover, the students had to invent the system specification with some additional constraints on used hardware and software and the theme of the competition. The main requirement was general benefit to society. In CSIDC 2000 students designed under the health care information appliance theme the Asthma Monitor & Allergy Data Information Appliance called AMADIA. The result of next year competition was the EUNICA system (Extensible Universal Control of Appliances). In the CSIDC 2002 our students elaborated mobile sleeping laboratory project. Both CSIDC 2001 and 2002 were oriented towards wireless communications using Bluetooth.

Keywords: *Computer Society International Design Competition, teamwork, excellence in education.*

1. INDRODUCTION

Slovak University of Technology is involved in the annual IEEE Computer Society International Design Competition (CSIDC) from its inaugural year in 2000. The goal of the CSIDC competition is to advance excellence in education by having undergraduate students design and implement solutions for real-world problems [3], [2]. The competition emphasizes teamwork in the design, implementation, and testing of a computer-based system. Starting from 50 competing teams in 2000, now in the year 2003 nearly 170 teams is involved in project work. Only the teams authoring the top ten projects – as judged by a panel consisting of international experts from industry and academia according the reports submitted – are annually invited to compete in the World Finals.

Teams of undergraduate students from the Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava were in CSIDC 2000, 2001 and 2002 among the top ten and presented the result of the project at the World Finals in Washington, DC. They were evaluated among the five highest ranking teams taking the 4th place in CSIDC 2000 and CSIDC 2001 and the 3rd place in CSIDC 2002. All these teams worked under supervision of Mária Bieliková and Tibor Krajčovič from the Department of Computer Science and Engineering.

In this paper three successful projects are described: Asthma Monitor & Allergy Data Information Appliance called AMADIA (CSIDC 2000), EUNICA: Extensible Universal Control of Appliances (CSIDC 2001) and mobile sleeping laboratory project (CSIDC2002). Description is based on the final reports submitted to the CSIDC [5], [4], [1].

2. AMADIA: ASTHMA MONITOR & ALLERGY DATA INFORMATION APPLIANCE

Juraj Hercek, Peter Kleinert, Radoslav Kováč and Dušan Lacko developed Asthma Monitor & Allergy Data Information Appliance [5]. The AMADIA is designed to fulfil three basic functions: collecting data about a user's health condition, collecting data about an environment and review and manage collected data. The main task of the AMADIA is to monitor a user's health condition. The user regularly enters the peak expiratory flow rate, heart rate, blood pressure and body temperature readings (obtained through simple home measurements) into the system. The recorded data, together with supplemental information about asthma triggers and symptoms, allow the patient and the patient's physician to make accurate treatment decisions. Monitored data are manually entered into the information appliance because there is no standardized interface for acquiring such information directly from the measuring devices. Data entering is simplified by extending the user interface with a touch screen.

Since allergens and changes in either temperature or humidity are common triggers of asthma, a user is regularly informed about current pollen and weather conditions. Recorded environment data are obtained from the Internet. Data are always available to the user and can be used to identify triggers that cause his/her condition to worsen. The source of pollen counts is the AAAAI (American Academy of Allergy, Asthma &

Immunology) Web site. Current weather is obtained from the Yahoo Weather web site. This web site provides weather forecasts for a large number of cities around the world, although parsing of data from these HTML web pages is relatively difficult.
Recorded health condition data, along with pollen and weather data, are displayed on a graph (see Figure 1), hence transformed to valuable information for a user. Peak flow values are drawn into four zones that are calculated according to the user's personal best peak flow value:

– green zone (more than 80% of personal best) signals good control,
– yellow (high yellow) zone (65% - 80% of personal best) signals caution,
– orange (low yellow) zone (50% - 65% of personal best) signals warning and
– red zone (below 50% of personal best) signals a medical alert.

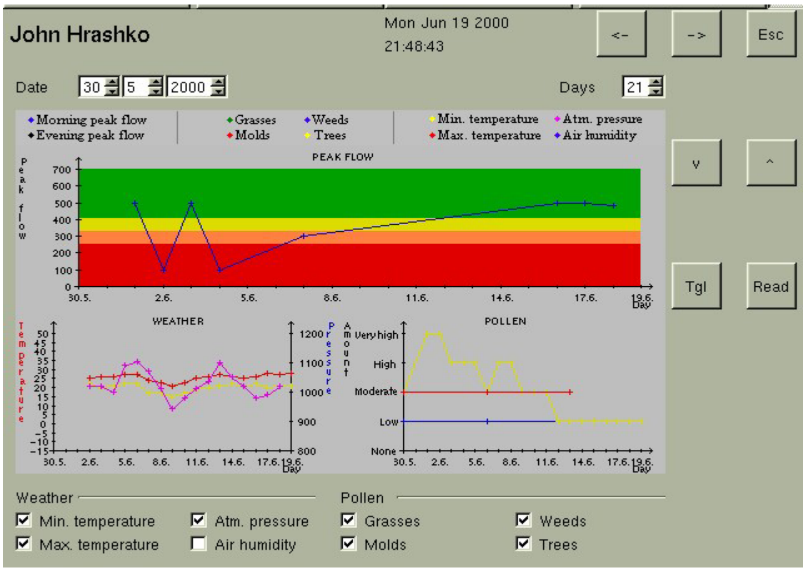

Fig 1 Graphic representation of collected data

The AMADIA shows a warning if the peak flow values fall into the lower zone, so the user (according to his/her symptoms) can take a particular action from the action plan prepared by his/her physician.
History and current information about the user can help not only the user to self-manage asthma, but it can also help the physician to evaluate the course of the disease. Monitored data can be sent in regular intervals to the physician by e-mail. According to the received peak flow readings, the user's physician can effectively organize a user-specific asthma management plan, which is also a part of our system.

The AMADIA stores also practical information about the user's health care providers (like phone numbers, office hours and e-mail addresses) in the XML. Information about physicians, health centers, pharmacies or emergency departments is maintained and updated directly from the Internet.

Every information appliance depends heavily on the entered, stored, accessed, and manipulated data. For this reason the students used data-centered architecture, which enables the development of a highly modular software system. The system works with data from two basic sources: (i) health condition data entered by the user, (ii) environment related data gathered automatically from the Internet.

Recorded data are represented by a passive repository using a relational database. Database schema of data from the first group is relatively stable. After series of interviews with physicians the students identified type of health condition data, which should be recorded and monitored in order to improve self-management of asthma.

Structure of all data from the second group cannot be defined in advance. In order to use resources effectively, already available data on the Internet are used either accepting its structure (e.g., current pollen and weather conditions) or using designed appropriate XML structure for not widely available data (e.g., health care providers). The students proposed WWW-parser method that uses a set of independent parser modules for differently structured web documents represented in both HTML and XML. Since XML was not yet widely used at the time of project solving (1999-2000), the parsers also allow the specification of XML data into comments of an HTML page. WWW-parser method starts with reading a selected configuration file and executes the appropriate parsers to obtain data from all active information sources. Gathered data could then be used by all the AMADIA users, and saved into the relational database (see Figure 2).

The configuration file is a text file that specifies which program (parser) should be used for parsing web pages containing particularly formatted data. The configuration file allows simple system reconfiguration for use with different or updated parsers if the structure of the used HTML pages radically changes (this could easily happen because pollen and weather information were not available in the XML format).
The AMADIA is implemented in OpenLinux operating system, KDevelop Integrated Development Environment both supplied in the CSIDC Project Kit, and free PostgreSQL database system.

One of the main goals of the AMADIA prototype was its user friendliness. The AMADIA

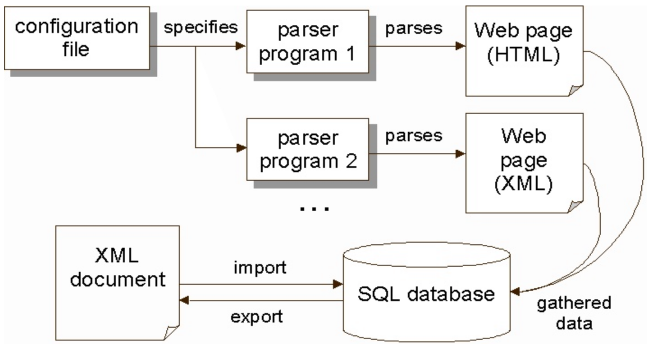

Fig. 2 WWW-parser method

does not use any pull down menus nor toolbars. Each function is represented by one screen. The user can access the screens through buttons on the main screen. Another way to ease the user interface is to remove the keyboard and to use some sort of touch screen. To address this issue, the students decided to build a prototype of a simple touch screen. The touch screen consists of eight infrared (IR) beams arranged around the LCD display in five rows and three columns. Software displays buttons on the display and the user has only to point his/her finger to activate them. After crossing an IR ray, touch screen sends the identification number of the crossed ray to the host computer through the RS-232 port. If the user crosses two beams at the same time, the host computer will know that user's finger is at a certain position.

3. EUNICA: EXTENSIBLE UNIVERSAL CONTROL OF APPLIANCES

CSIDC 2001 competition's challenge was to apply Bluetooth wireless communications technology to today's world. Rastislav Habala, Jaroslav Kuruc, Vladimír Marko, Dalibor Rak and Anton Weissensteiner worked towards a vision of a household where appliances serve a user according his/her current needs [4]. The students designed and developed a prototype of the system called EUNICA, which is intended to deliver various home-related services to the users. It is sensitive and responsive to the presence of people (the occupants or visitors of a household). The user in the household is surrounded by a multitude of interconnected appliances. The network of appliances is invisible. Appliances serve the user according to his/her customs and preferences. The whole system exhibits some kind of intelligence, e.g., it is able to recognize each individual in the household and adapt behavior according his/her customs and preferences, it is able to recognize specific events (such as time or move of a user) and act upon arisen situations.

Important feature of the EUNICA is providing mobility: mobile access to appliances on the one side and possible mobile connection of appliances on the other side. The wireless technology, namely the Bluetooth, which presents the primary way of communication, is granting the EUNICA features to supersede conventional infrared remote control. However, the EUNICA is not limited to a single set of communication methods or fixed set of appliances. It uses the open concept of loadable drivers to be prepared for future appliances and technologies. The system covers features allowing access to appliances also from outside of a user's household via phone lines or Internet. The EUNICA provides also strong appliance management functions that are kept hidden for the standard use. It provides trustworthy way of appliance installation.

The heart of the EUNICA is the control unit. Any appliance can be connected to the control unit using various types of connections (see Figure 3). Monitoring and controlling appliances is visualized on simple mobile Java based user interface devices connected to the control unit using the Bluetooth wireless communications technology. All kinds of inexpensive, physically compact devices, such as PDAs are allowed. These devices are called "eurecos" (EUNICA remote controls). They display and allow browsing information received from the control unit (represented in the EUNICA Markup Language that is based on XML) and send user's requests back to the control unit.

To fit the system to a house of any size the access to mobile components of the system in a big house is proposed through a network of access points (realized by Bluetooth modules connected to the control unit). The appliances themselves are not part of the EUNICA; however they should include support for the EUNICA.

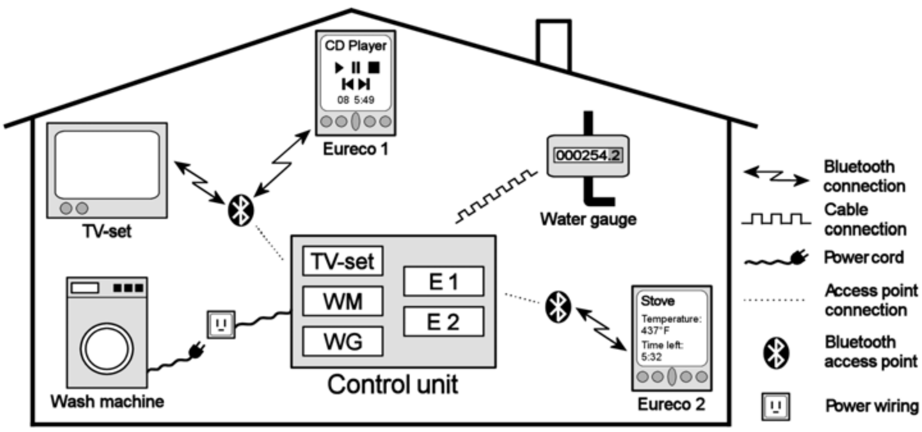

Fig. 3 The overview of Eunica

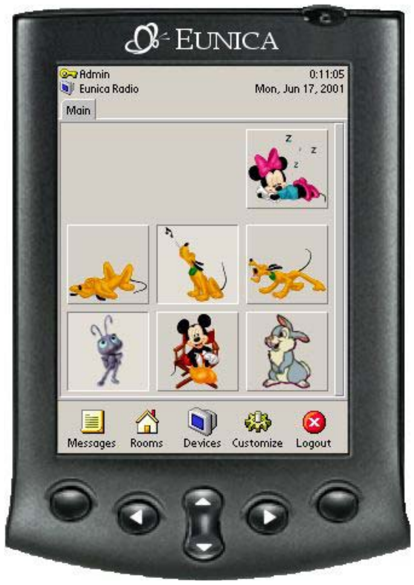

Fig 4 Eureco design of radio control for children

From the user perspective, the EUNICA is a system, which enables to monitor and control appliances in a household by *eurecos* (see Figure 4). Several eurecos can exist in the household. Any user can use any eureco, as each eureco is always adapted to the current user. To make the eureco able to easily and comfortably identify its current user, the eureco prototype is equipped with a fingerprint scanner.

To simplify the monitoring and control of appliances for various individuals and groups (e.g., children, adults, elderly), means to adapt and customize controls is included. The adaptability regards number of control elements, its layout and appearance. In addition, the EUNICA monitors user's actions and adapts to his/her preferences (e.g., the EUNICA can regard the level of light brightness the user uses the most often and later automatically set observed level).

The EUNICA provides sophisticated access rights control. Parents can restrict watching particular TV channel for one child, or forbid switching on the wash machine for all children.

The EUNICA brings new view to control over appliances. Besides common way of appliances control (remote control of TV-sets, Hi-Fi), the system is able to monitor state of appliances (temperature on thermometer, remaining washing time, surveillance camera in the children's room or electronic doorman); control appliances using menus (automatic program selections based on the amount and kind of clothes inserted using the wash-machine menu); program various embedded appliances (heating system, alarm), and help in automatic data acquisition (e.g., from various kinds energy meters). Measured data is sent through the network to the energy providers without a possibility of user intervention, so the user cannot abuse it.

The eurecos can be used also to access Internet resources such as email, weather forecast or electronic newspaper. The system can support wearable computing devices for tracking physiological parameters, locating the users, etc.

In the eye of manufacturers, the EUNICA represents straightforward extension for appliances they produce. In order to support the EUNICA they should extend existing appliances with the Bluetooth or another connection technology (the EUNICA provides versatility of appliance connection – by serial or parallel link, by net, AC power lines, or wireless Bluetooth). Manufacturers should develop a driver that will be dynamically added to the control unit. It will enrich the appliance with required logic, which will perform the commands of the control unit and send the state of the appliance to the control unit.

Drivers and appliances are not passive components (which respond to a user requests only). Wristlet on child's hand can monitor his/her temperature and, if it increases, the EUNICA automatically notifies the parents. Drivers and appliances have to satisfy certain requirements for installing and running. These requirements ensure cooperation between drivers in the control unit, but also security. Finally, manufacturers have to design control pages in the EUNICA Markup Language for their appliances.

The control unit is implemented using Sun Java2 JDK 1.3 Standard Edition, because of reducing the platform dependencies and taking advantages of extensibility including security architecture and dynamic loading of new classes into the running code. These features stood in the good stead when outfitting the system with runtime module addition.

The eureco is implemented in Sun Java2 JDK 1.3 Micro Edition (J2ME) designated for portable personal appliances such as PDA. Target platform is devices with low memory (512KB), battery operated and with limited communication capabilities, so it perfectly fits the needs for remote control.

The Eunica is designed with considering security issues on several levels: security in communication between the control unit and appliances, security in communication among modules inside the control unit and avoiding unconscious and conscious misuse of the EUNICA and appliances.

4. MOBILE SLEEP LABORATORY: BODY MONITORING SYSTEM WITH EEG SENSORS

Peter Blšták, Matúš Horváth, Peter Lacko and Marián Lekavý elaborated a concept of human body monitoring based on providing a unified way of controlling several body sensors by a single device [1]. The Body Monitoring System (BMS) is

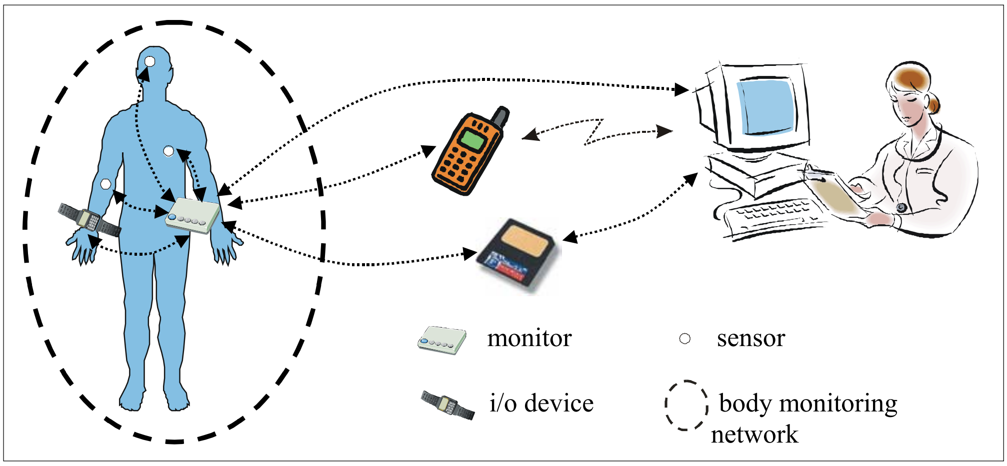

Fig 5 Overview of the Body Monitoring System

designed as a mobile device that is able to collect measured data and to act according to instructions set by a supervisor. The system constitutes a *body monitoring network* (see Figure 5). In order to recognize monitored person's state, the *monitor unit* connects to various *body sensors* and *i/o devices* using either wired or wireless communication technologies. Data from all sensors is collected, stored and analyzed in real-time and according to the analysis some actions may be performed. For example, a thermometer detecting high temperature can use an i/o device (e.g., a wristwatch display) to advise the patient to consult a doctor.

A supervisor uses his/her computer as an interface to the body monitoring network. Developed software allows him/her to configure the monitor unit for the monitored person, connect sensors and i/o devices, define and upload instructions for monitoring and download collected data (e.g., directly from the monitor unit, over a mobile phone or using an external storage device). In order to cooperate with existing diagnostic software, collected data may be stored in some standard format, e.g., the IEEE 1073 or CEN/TC251 standards that are used to store medical data by many existing medical applications.

The BMS is designed as a centralized body network for every user (a monitored person). The body monitoring network assigned to the user is autonomous. The BMS, as a centralized system, is resistant to failure of one of its sensors. However, failure of the monitor unit introduces a problem. When no specialized monitor unit is available, a desktop computer can be used as a temporary substitute.

The monitor unit software consists of three modules: *communication module* is responsible for connecting sensors to control them, and to gather and pre-process measured data; *storage module* serves for storage of collected data, and *policy interpretation module* is responsible for controlling behavior of the monitor unit according to instructions defined by a supervisor.

The monitor unit does not make a distinction between sensors and i/o devices. Both of them are able to transfer data to and from the monitor unit. What distinguishes sensors and i/o devices are just supervisor's instructions (e.g., "measure blood pressure every two hours, if something goes wrong display the message", but also "measure blood pressure every two hours, if something goes wrong measure pulse, too"). Two types of drivers are introduced. A *communication driver's* role is to hide the way data is transmitted. There is one driver for every type of communication interface, e.g., a Bluetooth driver or an IEEE 802.11b driver. The communication driver does not care about the data. It is the role of *device drivers.* Each type of sensor has its own device driver. When a device driver receives a message from one of its sensors it decodes the message and informs the *policy engine* about the state of the sensor. To send/receive a message to/from a sensor the device driver uses corresponding communication driver.

Behavior of the monitor unit is controlled by interpretation instructions defined by a supervisor (called *policies*). A policy describes monitor unit's response to events reported by sensors. Policies are written in the Policy Markup Language (based on XML). It enables to write general policies using "virtual" objects that are substituted by physical devices at run-time. An object may also refer to an entire class of devices, i.e., to all devices implementing one particular interface.

The monitor unit prototype is implemented in Microsoft embedded Visual C++ 3.0 on Compaq iPaq Pocket PC HR3870. The user interface exploits the well known "tab control" present in many graphical user interfaces. Each driver is free to create any number of sheets in it and can use it to display any supported controls like edit boxes, buttons or graphs.

To validate the system design the students used it in specific field of medicine – *sleep research*. To cope with a problem of sleep disorders, sleep laboratories in hospitals are used to monitor patients

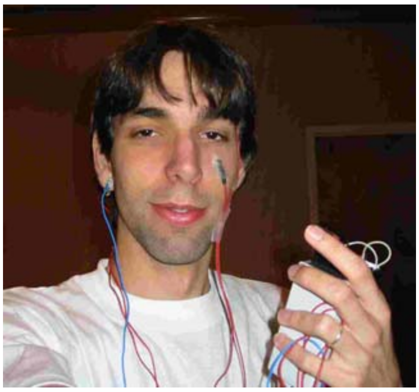

Fig 6 The EOG sensor in action.

overnight. However, patients influenced by the hospital environment usually show different sleep patterns than patients at home. As a solution to this problem a mobile sleep laboratory which can be used at home was developed. The prototype employs an electroencephalograph (EEG, monitors brain waves), an electrooculograph (EOG, monitors eye movement) and a thermometer. Analysis of EEG and EOG data allows identification all sleep stages.

Sensors implementation goes out from a common sensor platform designed in the course of this project. The common platform contains a detecting element, some amplifiers and filters, an AD converter, a microprocessor and a Bluetooth module. 8-bit ATMEL 89C2051 microcontroller was used as a core of the sensors. While being small and having low power consumption, it is fast enough. To convert measured signals to digital form, 8-bit ADC0831 AD converter was used. With its resolution and sample rate (50 kHz) it is sufficient for the project purpose. The developed EEG sensor could be used for continuous EEG examination as well. Such an examination is necessary for patients suffering from epilepsy.

The most distinctive features of described project are:

- it provides *wireless communication between various sensors* attached to the human body;
- it provides a *unified way of controlling several sensors by a single monitor device*;
- it is possible to *adapt monitoring to patient's state*, i.e., measurements and alerting messages are controlled and provided according to the current context;
- it allows to *define complex schemas for sensor control* represented in a specialized language called PML (Policy Markup Language) which is powerful enough for describing mutual dependencies and co-operation among several sensors, and even for defining complex schemas for taking medicaments;
- it provides a secure way for transmission and storage measured data;
- it can be used for *monitoring nearly any interesting body parameters* since the design supports different sensors using practically any communication technology.

Although the students concentrated on monitoring human body for medical purposes, design of the body monitoring system can be used in many different fields of human activities as well (e.g., pulse rate monitoring in sports, preventing the Sudden infant Death syndrome, monitoring people working in dangerous environment).

5. CONCULSIONS

The theme of the CSIDC 2003 is *Added Value*. Student teams were asked to take a PC, laptop, or hand-help computer and turn it into something new by adding an external interface and the appropriate software. Developed application may use more than one computer and computers may be linked by any suitable medium.

One of the main strengths of the CSIDC is the freedom it gives to students to be creative. There is no restriction on what the students can do subject to the spending limit and the (wide-ranging) requirements of the project specification. This is difficult task for students as they are usually provided with detailed requirements on their assignments during their regular studies. The most valuable fact is their working on real problems, with real customers and working in a team.

CSIDC is now an integral part of curriculum in Informatics at the Slovak University of Technology. We believe that the competition will continue and will have even stronger impact on education over the world.

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BIOGRAPHY

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