Health Gateway - A mobile eHealth solution bringing point-of-care flexibility a step further

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***Abstract* - Timely review of patient data with close to real-time feedback is a critical success factor in today's disease management. This paper introduces eHit Health Gateway, an effective and secure tool to wirelessly transfer data from different measurement devices to the health care service provider by using a mobile platform. The system consists of a mobile platform, which collects the information from the measuring devices, and a server platform, which receives the collected data and forwards them to the existing Information System. The mobile platform can be used on most different devices such as mobile phones, smart phones and Personal Digital Assistants (PDA). An overview of the system functionality is followed by some important notes about security and privacy and by three reference cases illustrating the functionality of the system in different disease management environments.**

I. INTRODUCTION

eHIT Health Gateway represents an effective and secure tool to wirelessly transfer data from different measurement devices to the health care service provider via a mobile platform. It provides patient and nursing solutions ensuring that measurement results are available, accurate and both cost and time effective.

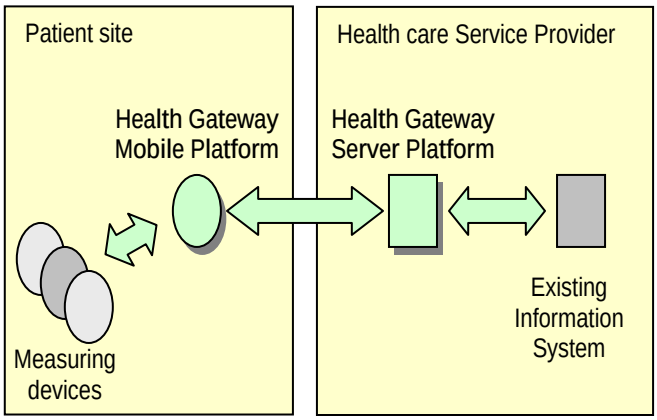


Figure 1. Health Gateway concept

The system consists of a mobile platform, which collects the information from the measuring devices, and a server platform, which receives the collected data and forwards them to the existing Information System.

The mobile platform can be used on different devices such as mobile phones, smart phones and Personal Digital Assistants (PDA).

II. WORKFLOW

A. Collecting data

A single mobile device can collect, store and transfer information from different measuring devices. This also makes possible the integration of devices from different manufacturers. For instance a blood pressure measuring device, a scale and a glucometer can be used to collect and register key information in diabetes care. The mobile device guides the patient and seamlessly collects information from the measuring devices. The patient can also follow his/her progress in the therapy directly from the display of the mobile device.

B. Transferring data to the care unit

The information is then automatically transferred to the health care provider by using a secure GPRS/GSM/3G connection. The received information can be stored in the Health Gateway server or directly forwarded to an existing information system. In this way measurement results are always accurate and they are available to the health care professionals in real-time and in the correct form.

C. Receiving feedback

Authorised personnel of the health care provider can browse the received data and send an almost immediate feedback to the patient by using the Health Gateway client application.

This bidirectional connection guarantees a faster patient treatment process as the patient can receive a feedback almost immediately.

The system is also capable of generating automatic alarms according to predefined algorithms. These alarms can be addressed to the health care professionals as well as to the patient.

III. CONFIGURATIONS AND MEASURING DEVICES

Health Gateway is a fully modular system, which can be delivered in different configurations ranging from direct interface between the mobile platform and the existing information system, up to a complete system including

centralised server and remote/local clients for data reviewing and editing. Health Gateway already interfaces to a broad range of measuring devices allowing for remote analysis of blood glucose, blood pressure, coagulation, body weight, heart rate, EMG, ECG, oxygen saturation, peak expiratory flow, and other parameters.

A. *Device integration problematic*

A common problem in integrating measurement devices to the mobile device is the connection between the devices. Today there are a lot of measuring devices communicating with cable or infrared connections. However most of the mobile devices can hardly handle cable connections and the infrared option is also disappearing from today's mobile devices as Bluetooth is becoming more and more a "standard" option for mobile device wireless connectivity.

To overcome these connectivity problems eHit has designed a special hardware adaptor module called eLink. eLink is a standalone, battery-operated and small-sized module that transparently converts measurement device cable and infrared communication into wireless Bluetooth communication. Thanks to eLink, a wide range of existing measurement devices, which would be otherwise impossible to interface, can be taken in use.

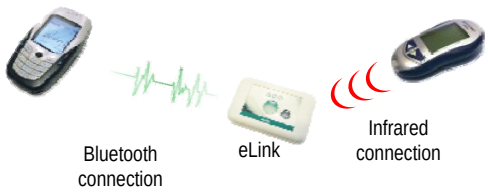


Figure 2. Use of eLink to enable an infrared connection

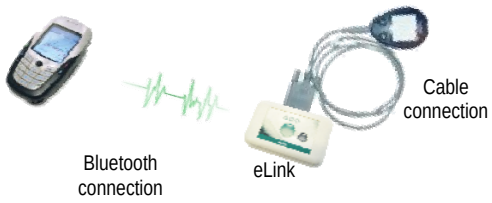


Figure 3. Use of eLink to enable a cable connection

A unique feature of the eLink adaptor is the "smart connect" function, which is the capability of initiating a connection to the measuring device. By using the "smart connect" function, the data extraction procedure from the measurement device can be initiated with the push of one button.

IV. Dealing with Security and Privacy Issues

When dealing with security and privacy issue, the first matter is to determine how secure the system should be. A low security level may lead to unwanted disclosure of sensitive data but on the other hand, high security level could make the system too complicated to use or would considerably raise the expenses of building the system. [1]

Local legislation and security policies of the organizations involved should define the security level required. Additionally, a threat analysis should also be done to assess the security level to guarantee the integrity and the availability of data as well as the privacy of patients' data.

It is important to note that technical issues are only one aspect of security. Threat analysis should also include threats caused by force major events, organisational shortcomings, human errors and deliberate acts. [1]

Systems like Health Gateway act as a bridge between the portable measuring device and the main information system, therefore the security analysis should be extended to cover the whole chain.

In this article we concentrate on the two links the Health Gateway Mobile Platform is concerned with. These are the connection to the measurement device and to the health care provider.

A. *Connection to the measuring device*

The first link of the chain is the connection between the measuring device and the mobile device. In most cases, data transfer here is performed by using a Bluetooth connection. Bluetooth is a short-range, low-cost, and small form-factor technology allowing for user-friendly connectivity among portable and handheld personal devices. [3]

Several studies have been done on Bluetooth security issues and the possible attacks an intruder could carry out [4][5]. The first matter is that on both devices security features shall be enabled. The devices should comply with Bluetooth security mode 3, so that they initiate security procedures before the channel is established. This mode is used in critical applications where security is mandatory.

The most critical phase of a Bluetooth connection is the so called pairing phase, where the devices exchanges information in order to establish a link key, which will then be used for encryption.

Since the initial exchange of keys is done using non-encrypted channels, this is the weakest part of the pairing procedure. It is recommended that the user should be in a "private area", before using the pairing procedure. According to Bluetooth SIG, an area is defined as "private" when it can be considered a place where you are confident that unknown devices are not in the neighbourhood. [6]

Another issue is the choice of the PIN code. During paring procedures, Bluetooth devices require a PIN code to be exchanged. This code should be long enough and configurable. Bluetooth specifications allow for up to 16-byte long PIN code. While 0000 or 1234 are very poor PIN codes, a string like "Pw3$Ud9Lab0A1s" would do a much better job by making the hacking attempts harder.

Also the procedures used to initiate the connection dramatically affect the security features of the system. Some measurement devices are designed to initiate the connection.

In the worst cases, the device searches for any Bluetooth enabled device that provides for instance a standard Serial Port Profile and tries to establish the connection until someone accepts it. As a consequence, the results might be sent to the wrong place and some unauthorized connections are tried. A slightly better solution would be a measurement

device searching for Bluetooth enabled devices that provides a specific service (e.g. standard Serial Port Profile) with some specific predefined name. In this case the results are more likely sent to the correct place.

Definitely a better solution is having the mobile device to initiate the connection. In this case the connections can be handled in a controlled way, allowing for a more secure data exchange.

B. Connection to the Health Care provider

The mobile device usually sends the information downloaded from the measuring device to the health care provider by using GPRS/GSM/3G data transfer. This implies the use of an Internet Access Point and relying on services offered by an Internet Service Provider. Internet is a public network and therefore often considered insecure without proper security actions. However modern technologies offer several ways to make the connection more secure.

For instance establishing a secured communication channel between the sender and the receiver ensures data integrity and data protection. In HTTPS data transfers, the session data is encrypted using a version of the Secure Socket Layer (SSL) or Transport Layer Security (TLS) protocols, ensuring reasonable data protection. Virtual Private Network (VPN) allows for creation of a private communication network within a public network. Secure Shell (SSH) allows for secure logging into and executing commands on a networked computer.

A step further is reached by using Public Key Infrastructure (PKI). This technology is based on public and private keys and it enables users to be authenticated to each other, and to encrypt and decrypt exchanged messages.

Besides technologies, data security and data privacy is also affected by procedures. For instance privacy can be ensured by transferring anonymous data. Transferred data doesn't need to contain direct references to the patient ID. Instead the id of the measuring device can be transferred and the link between the patient and the data can be at the health care provider site. In case a malicious eavesdropper would intercept the transferred data, this could not be easily linked to the patient.

V. REFERENCE IMPLEMENTATIONS

A. Diabetes management

Diabetes mellitus is a lifelong, chronic condition that is characterised by the body's inability to control glucose levels in the blood [7].

Diabetes affects about 22.5 million adults in the European Region and is increasing rapidly in most countries. Moreover, it has changed from affecting mainly older people to also afflicting people in the first half of their lives [8].

Recent projections, based on the assumption of a stable obesity rate, foresee that at least about 26 million citizens in Europe (about 6 per cent of the population) will be affected by diabetes in the EU by 2030 [8].

Monitoring of blood glucose is an integral part of treating diabetes as it supplies essential information to the health care personnel to adjust the therapy [7].

Self-monitoring of blood glucose gives the patient the possibility of immediately seeing the effects of certain activities, foods and drinks on glucose level [7].

Near-patient blood glucose measuring devices are becoming more and more common. The Health Gateway mobile solution is able to collect blood glucose measurements directly from the measuring devices and seamlessly transfer the collected data to the health care personnel for further analysis.

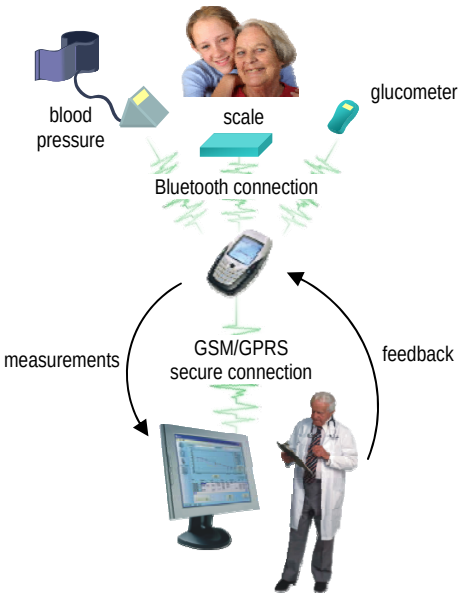
Several measuring devices are capable of storing measured values in their internal memory. This information can be easily transferred to the patient mobile device via Bluetooth, Infrared or cable connection according to the type of measuring device.

The patients then have the possibility to browse the results from a list or to have them displayed in a clear graphical follow-up form directly on the display of their mobile device. This gives the patient an immediate overview of his/her blood glucose behaviour. Results are also immediately forwarded by GPRS/GSM/3G to the clinic where they are available for analysis to the health care professionals.

In addition to collecting information from the glucometer, the same Health Gateway mobile device can wirelessly collect measurements also from an electronic scale and a blood pressure monitor.

This additional weight and blood pressure monitoring helps in giving the health care personnel a more complete picture of the condition of the patient.

Figure 4. Use of Health Gateway in Diabetes management



All of this information is linked together and sent to the health care professionals, which after analysis or consultation can send a feedback to the patient.

Therefore, in addition to instantly viewing their progresses on the mobile device display, patients can also receive information from the caring personal regarding for instance changes to the treatment, diet or exercise program.

B. *Blood coagulation monitoring*

Oral anticoagulation therapy (OAT) is necessary for people carrying an artificial heart valve, or affected by atrial fibrillation or thrombotic diseases. The correct dosage of anticoagulant is crucial for the patient health. People may react differently to the therapy and other drugs but also food and drinks may alter the effect of the anticoagulant. Regular monitoring of coagulation is therefore essential [9].

Traditionally, monitoring of coagulation (INR values) requires a blood sample being drawn from a vein and analysed by health care professionals. This is a time consuming operation and it usually requires the patient to travel to a health care centre or doctor's office.

Today the advantages of self-monitoring have also reached coagulation monitoring. This gives the patient many advantages: it is straightforward, it makes routine testing easier, it gives independence back and it also means patients can be directly involved in their own health care, in collaboration with health care professionals [9].

An additional service can be offered by using the Health Gateway platform. As the mobile device receives the measurement data from the coagulation meter, the program may calculate the suggested new value of the anticoagulant medication automatically.

Furthermore, the measured values and the calculated medication values are transferred to the health care professionals, which can then send a feedback to the patient's mobile device.

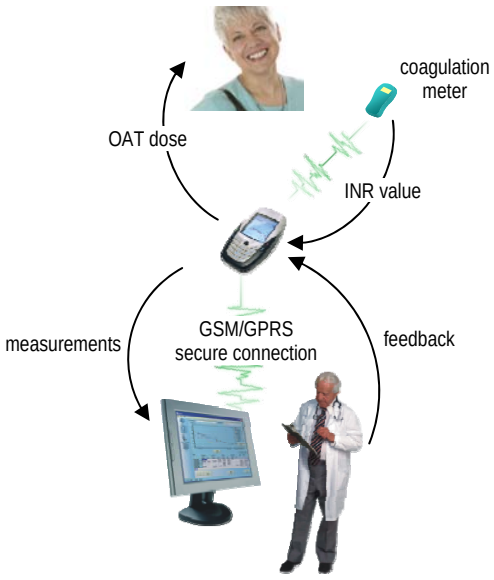


Figure 5. Use of Health Gateway in Blood Coagulation Monitoring

C. *Incontinence treatment*

Stress urinary incontinence is mainly a reflection of decreased pelvic floor muscle control. Urinary incontinence has a number of causes and conventional treatment may sometimes be ineffective. In severe cases surgical intervention may be needed [10].

Preventive training of the pelvic floor muscles before pregnancy and/or after childbirth improves the situation significantly, especially if the training can be done at home and progress is monitored by a health care professional. The condition and the activity of the pelvic floor muscles can be detected and measured using electromyography (EMG) [10].

The unique FemiScan™ concept by Mega Electronics Ltd facilitates both subjective and objective follow up of the patient's progress towards continence while in the clinic and at home. The system consists of a vaginal electrode, and a battery operated training device equipped with headphones. The device guides the patient in the daily performance of the pelvic floor muscle exercises. The instructions for the treatment can be created individually for every patient and programmed in her own home treatment device. The patient will hear a voice-controlled training program by head phones in her own mother language. She will get clearly worded feedback of every contraction / relaxation session immediately.

Health Gateway makes the incontinence treatment even easier. The FemiScan™ Multi Trainer automatically keeps a daily record of the treatment, which can be transferred to the clinic by using Health Gateway mobile solution. The information is wirelessly transferred from the FemiScan™ Multi Trainer to the patient mobile device and forwarded by GPRS/GSM/3G to the clinic where the data are analysed in graphic form using the FemiScan™ software.

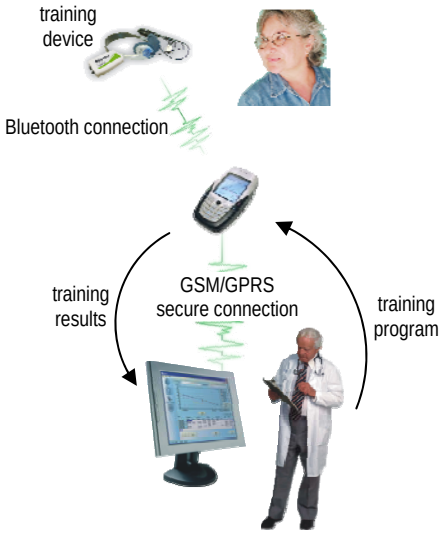


Figure 6. Use of Health Gateway in Incontinence Treatment

According to the results, the caring personnel may decide to make some changes to the training program. The bidirectional capability of Health Gateway makes also possible a remote update of the instructions for the treatment. The new training program is transferred from the clinic to the user mobile device by GPRS/GSM/3G and wirelessly uploaded to the training device. In the same way, the patient can also receive fast feedback from the physician/nurse directly to the display of her mobile device.

FemiScan™ concept gives the patient the possibility of performing her training session at home in a private environment. Health Gateway brings this concept further, allowing the patient to exchange information with the caring

personnel and even to update the training program, without the need of travelling to the clinic.

VI. Conclusions

Point of care testing is growing rapidly in terms of technology advancements and healthcare economics. The combination of self-monitoring devices with mobile technology presents several advantages in comparison with traditional methods: measurement results are accurate, available in real-time and in correct form; faster patient treatment process – patient can receive feedback almost immediately; motivating treatment progress information directly available to the patient; evidence based process traceability information: remote measurement and monitoring regardless of patient location; easy to use for both patient and nursing staff. Health Gateway platform offers a complete mobile solution, which brings point-of-care flexibility a step further.

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