Securely control Infusion Pumps via Internet for efficient Remote Therapy of Pain

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Abstract— **Pain therapy is an important part of the current health care system and will become even more significant in future, because of the demographic changes. Though there are shortfalls in medical care of patients with pain. There are not enough specialized clinics and most of the patients do not get adequate therapy. In this paper the authors present a system that can solve these problems in pain therapy and enables specialized clinics to increase their efficiency in order to increase the capacity for pain care. The system combines telemonitoring of patients with the ability to remote control the patient's infusion pump from afar. The physician is able to adapt the therapy of a patient without the need to visit him personally. Because of the fact, that the infusion pump applies analgesics that are able to cause vital harm, special interest is taken in the security and safety of the teletherapy system.**

Keywords— **remote therapy of pain, telemonitoring, trusted computing, embedded security, radio frequency identification**

I. Introduction

Therapy of patients with severe pain is often done with infusion pumps, which apply analgesic drugs continuously over an intravenous (IV) line in order to permanently suppress the recognition of pain [1]. These patients use their infusion pumps and can live in their familiar surroundings and don't have to stay in the hospital. The doctor sets the dosage of pain medication dependent on the level of pain and dependent on the vital status of the patient. A nursing service is responsible for refilling the medicine reservoir to make sure that there is always enough medicine left.

Fig. 1 Infusion pump (Pegasus GmbH, Kiel, Germany) used for therapy of patients with pain.

A. Patient Controlled Analgesia

Usually, the infusion pump has a mechanism that enables the patient to request an additional dose (bolus) of delivered medication in case of arising pain. This therapy is called patient controlled analgesia (PCA) and has the advantage that smaller doses are necessary for pain relief [1].

Normally there is a button attached to the infusion pump. By pressing the button the additional dose is delivered. After the button is pressed the patient has to wait for a certain time before the next additional dose is possible. This mechanism avoids the patient from giving himself an overdose.

A drawback in the treatment of patients with PCA pumps at home is the fill level of the medicine reservoir. Because of the additional dose the patient can request, it is not known how much medicine is left in the reservoir. Therefore the nursing service has to frequently visit the patient at home and check the fill level of the reservoir.

Because the average distance between the nursing service and the patient's home is usually big, every visit means an enormous effort in time and money.

B. Tolerance

Another big problem that comes along with pain-treatment is the effect of tolerance. If a patient is taking strong analgesics for a longer time, the body gets used to the medication and the effect of pain relief decreases. The first stadium of tolerance can be compensated by the patient, because he can request an additional bolus. But when the effect of tolerance increases, the doctor has to adapt the therapy and determine new values for continuous and additional dose.

Normally the patient has to visit the pain center in order to allow the doctor to analyze his vital status. Therefore vital parameters like EKG and blood pressure are measured and evaluated and the new values for continuous and additional dose are calculated. The new configuration is directly programmed by the nurse or the doctor, using the simple user interface of the pump.

Because of these extensive efforts and the bottleneck in pain service facilities, many patients do not get an adequate treatment when their pain level increases.

II. Teletherapy system

The next picture shows the teletherapy system developed by the authors to overcome the above mentioned problems that exist in modern pain therapy.

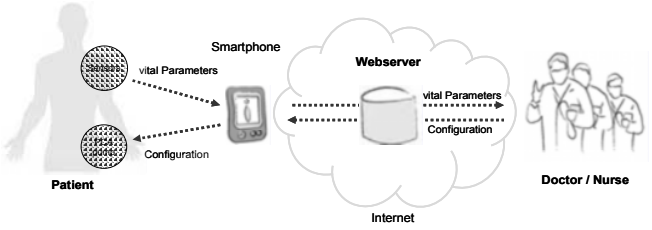

Fig. 2 Teletherapy System

The system combines telemonitoring with the possibility to remote control the PCA pump from the desktop of the doctor.

A. Sensor/Actuator network and Communication

The sensors that are connected to the patient's body measure vital parameters. The sensor/actuator network is formed as a bluetooth piconet between the smartphone, the pump and the sensors. Using the mobile internet connection of the smartphone, the sensors are able to transfer the measured vital parameters to a web server which has access to the central database [2], [3]. Additionally to the vital parameters, the event recorder of the PCA pump is transferred to the web server and stored in the database.

Both, the vital parameters and the pump events enable the doctor to decide if the therapy for the patient has to be changed or not.

A new approach in comparison to the plain telemonitoring system explained above is the therapeutic component, the remote control of the PCA infusion pump. After the doctor has evaluated the data received from the devices at the patient's site, it is possible to program the new configuration into the pump remotely. The doctor just has to fill in the new values for continuous rate and bolus into a web front end and can send the configuration to the pump.

B. Security Subsystem

A challenge of the presented system is to enhance the security of the sensor/actuator network, which is directly connected to the internet by the smartphone. In case of an unsecured communication over internet there are many possible ways to compromise a part of the system or the whole communication. The worst case of unsecured communication in the teletherapy system is an unauthorized access to the patient's PCA pump. The attacker could then reconfigure the pump in the same way as the doctor which could cause life-threatening complications.

To avoid this problem, the authors developed a security system based on a Trusted Platform Module (TPM) which was designed to increase trust in personal computer networks [4], [5]. With these security mechanisms it is practically impossible to compromise any part of the teletherapy system.

All sensors and the PCA pump are equipped with a TPM that is directly soldered on the PCB of the embedded devices. The TPM allows the device to encrypt the whole communication and only give access to authorized persons or subsystems by using strong cryptographic methods. Additionally, it is possible to detect any kind of manipulation at the sensors or the pump what for example may be caused by a virus or an attacker. Therefore the TPM stores the platform configuration and the doctor can check it in a secure manner before every conversation.

C. Safety Subsystem

Another problem that exists in telemedical systems is the danger of confusion. When the doctor assigns the devices (sensors, pump, and smartphone) to the patient and makes a mistake in this step, for example mixed up the pump with another one, there is no direct possibility to recognize this confusion.

To avoid it the initial assignment of devices to the patient must be automated. Also the assignment has to be checked automatically during the lifecycle of the system. This is done by using the Radio Frequency Identification (RFID) [6]. A RFID transponder is implanted in the patient's body and all devices are tagged with RFID labels. The initial assignment is done by reading the tags and automatically creates links between them in the database. This links between the patient and its devices is checked every time the device sends or receives data, by the RFID reader in every device.

III. Conclusions

The presented system helps to overcome the problems in modern pain therapy. The problem of the unknown fill level of the reservoir is solved by the monitoring of the pump events and by the transmission of this data to the nursing service or the doctor. In this way the status of the pump is always well known and an exact plan of necessary visits can be done. Furthermore, the doctor has the chance to see the

patient's vital parameters and can analyze the efficiency of the therapy. There is no need for the patient to visit the doctor if an adaptation of the dose and bolus is necessary. The doctor can set up the pump with the web frontend from afar and has any information that is needed about the vital status of the patient. So the teletherapy system is able to increase the capacity of pain care facilities and helps to give an adequate treatment to every patient.

With the presented mechanisms for safety and security it is possible to protect the system against malicious attacks as well as against other faults due to confusion of devices or patients. So, compared to the current situation in pain treatment, with our solution there is no risk involved by the teletherapy system and especially by the remote control of PCA pumps.

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