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Real-time remote monitoring cardiac patients at distance

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1. Introduction

Patients with heart arrhythmia usually need to be monitored and controlled in hospital for one to several days. These patients are treated to reach on normalizing their heart arrhythmia or achieve an average heart frequency. Sometimes it is necessary to monitor some heart patients in longer period of time to provide more certain documentation for the treatment's correctness, but the patients often are released from the hospital to give the priority to other heart patients on the waiting list, whom need to be hospitalised immediately. Furthermore, some of heart medicaments are effective only when the patients have minimum activity, namely, when they are hospitalised, but these medicaments are not so effective at home, where the patients have normal or higher activity level.

There are two main issues of interest to deal with. Firstly, the heart patients should be monitored in more natural environment, in their real daily lives, while they are using their heart medicine for a better test and evaluation of the treatment efficiency. Secondly, the hospitalisation should be reduced in order to lower the expenses of the health care system and reduce the patient's waiting time.

The most need, and the most obvious place to impact healthcare costs, is providing homecare services1; 2. The rational behind of the present study is that by integrating a real-time telemedicine system in home healthcare policy an improvement in disease management can be achieved; considerable amount of money can be saved and resources can be used effectively.

The present study takes an interest in investigating the possibilities for development and implementation of a real-time wireless telemedicine system using modern communication technologies, in order to monitor heart patients in real-time, while he/she is doing his/her daily activities at home or outdoors in neighbourhood.

2. Materials and methods

The system consists of three well-defined parts, namely a patient's unit, which is composed of an ECG telemetry device and a GSM mobile phone, a Teleguard Modem Server (TGMS), and a Teleguard Monitoring Station (TMS). The system uses GSM as public mobile communication network.

The system is designed and specified by the first author, and developed in collaboration with Danica Biomedical A/S, SONOFON A/S, Ericsson A/S and Department of Health Science & Technology, Aalborg University Aalborg University in Denmark.

The system is designed after a careful consideration. In this progress, the technical, data security, practical and economical aspects were taken into consideration to achieve a suitable system design and set-up. In order to select the most appropriate technology for the system realization, properties of the existing modern technologies such as Bluetooth, GSM, DECT, Wireless LAN, Infra Red, and General Packet Radio Service (GPRS) have been investigated3;4;5;6.

In order to reduce the complexity of the mentioned system and investigate the applicability of that, in the first step a prototype GSM based telemedicine system was designed and developed, which is presented in this article.

3. System function

As it is shown in figure 1, five disposable electrodes carry the ECG signals, from the patient chest to an ECG telemetry transmitter (T3300 from Danica Biomedical). The T3300 is connected to a T610 Sony Ericsson mobile phone through RS232 serial cable with 9600-baud rate. As soon as the ECG telemetry device detects the heart bits, it invokes the T610 mobile phone to establish a GSM connection through public mobile communication network to a Modem Server (TGMS) at the hospital automatically.

When the connection is established, the T610 mobile phone acts as a mobile modem to the T3300 and it transmits the data over the GSM network. The TGMS receives the data, multiplex it onto 115.200-baud rate line, and converts it to emulate the patient monitor at the monitoring room. The data then is sent to the Teleguard device via serial cable. Teleguard interoperates and converts the received data to graphical ECG on a monitoring screen.

The T3300 ECG transmitter uses BPSK modulation, CRC Error Correction method and applies interlaced transmission as enhanced burst error correction. The mobile telephone uses a modified battery package for an extended lifetime up to 24 hours. It takes 24 hours to fully charge the mentioned battery package. The T3300 ECG transmitter works with 2 x 1.5 V alkaline AA batteries for 48 hours.

The data is sampled by 100 Hz/s frequency and sent as data packages. Packets of 34 bytes data are sent every 80 ms. the packets contain 2 channels ECG, 1 bit for pacemaker and 4 samples SpO2. Checksum and sequence number has been used for packet's error and lost packets check. The data transmission rate is approximately 450 bytes/s.

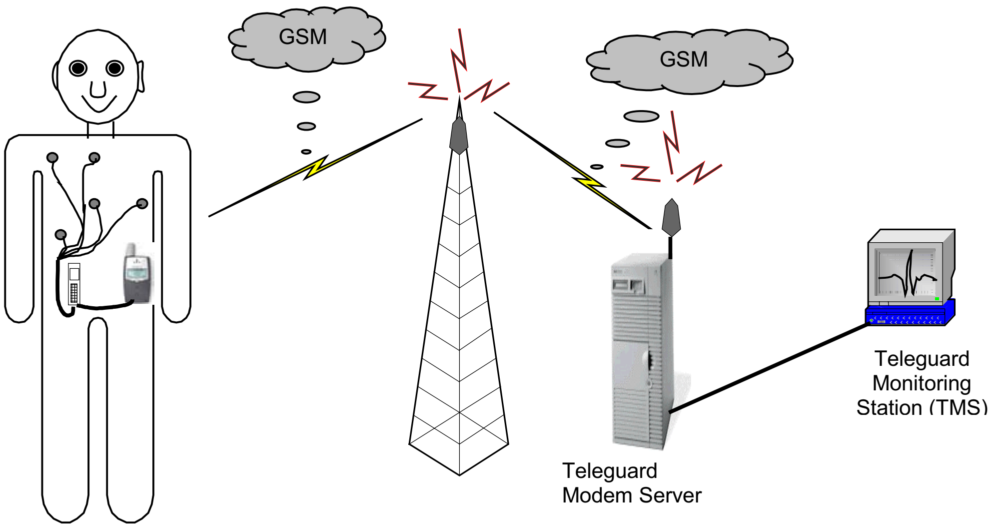

Figure 1 shows a principal sketch of the telemedicine system

4. Results

As the system is still under test, there are no final results, and in the present article only preliminary results are mentioned.

In the present study data security, patient security, system reliability, system performance, clinical integration and data quality were planed to be investigated and verified. Up to now, just the reliability and performance has been tested and verified, however the performance is not fully tested. The other mentioned aspects are still under investigation and test.

Concerning the reliability and performance, a series of tests have shown the following preliminary results.
Three times 24 hours of data transmission have transferred 3090887 packets in average. Of that 13 packets were lost and 7 packets had errors in average. It means that 0.0002 % packets were erroneous, and 0.0004% packets were lost. From 72 hours connection time, the system was 57 hours up and functioning, which is 79% Up-time. The data transmission was carried out in the laboratory with a fixed ECG simulator.

5. Conclusion

System up-time is not promising and could be better as close as 90%, but it is a reasonable result for the prototype and the start point of the development. 0.0002% erroneous packets and 0.0004% packet lost express a promising performance, but the system should be tested in situations when a subject is moving and when the subject is in a moving vehicle.

6. Future works

Further works are in progress to complete the technical and clinical integration tests. Furthermore works in progress to develop and integrate a real-time multichannel mobile telemedicine system capable of simultaneously transmitting medical data such as ECG, Non Invasive Blood Pressure (NIBP) and SpO2 applying Bluetooth and GPRS technologies, to make the system fully wireless and flexible.

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