# PDA-BASED SYSTEM FOR CARDIOLOGY HOME CARE AND PREGNANCY MONITORING*

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Most of home care monitors use full disclosure ECG transmission requiring a continuous high throughput wireless channel, while few others use a built-in interpretation software. Our approach introduces a programmable patient-side device based on a PDA computer for the reason of easy software development and interfacing. The process manager and communication procedure are executed in Microsoft Pocket PC operating system, while all interpretation routines are dynamically loaded, replaced and adjusted remotely. Thanks to the software flexibility, the programmable recorder adapts to the patient features and to the diagnostic goals also while monitoring in progress. Moreover, the modifiable transmission protocol enables exchange of the data on a wide range of processing level and is very useful in optimizing the wireless channel use, providing the expert with a pre-selected information when required.

## 1. Introduction

The home care is currently considered as one of the most emerging medical technology that increases the patient's wellness and the degree of diagnostic accuracy. Another very important aspect is the real-time connection between patients and their virtual doctors, making the rescue action as immediate as required.

Unfortunately, the remote cardiac monitoring commercialized today [1][2] is quite expensive due to the continuous wireless connection required for the transmission of ECG signal. The alternative proposed recently [3][4] benefits the computational power of today's wearable battery operated computers and assumes remote signal interpretation. This approach, however, uses the same interpretation criteria for all patients regardless the diagnostic goals assumed by the doctor.

Our approach goes a step further and uses a programmable patient-side device. Its kernel is a PDA computer for the reason of easy software development and interfacing with standard peripherals: wireless transceiver, signal acquisition module and extensible memory buffer.

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## 2. Methods

The adaptability of the remote monitor is not limited to the adjustment of processing parameters but includes also an on-line modification of communication protocol and processing routines. The software architecture consists of process management and communication control kernel and of a set of basic interpretation routines linked upon request. Each routine is implemented as a dynamic function library and can be adjusted remotely with a vector of interpretation parameters or replaced by an alternative routine from the basic set or by the code provided by the supervising center. This option enables a deep modification of monitor's function (fig 1), in result the particular device may be used for various monitoring tasks including:

- Sleep monitoring in patients with apnea or sleeplessness.
- Muscle fatigue assessment during training or physical exercise.
- Uterine contraction detection based on abdominal potentials in patients at risk of premature delivery.

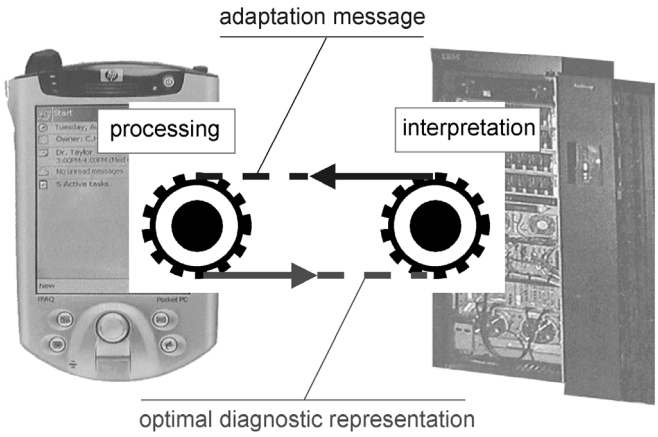


Figure 1. Adaptation of functionality and diagnostic representation negotiated between the interpretation center and remote intelligent vital signs monitor

One of the consequence of interpretation programmability is the multitude of output signal formats ranging from raw electrocardiogram to the sparse data (e.g. heart rate). The modifiable transmission protocol is very useful for optimization of wireless channel use aiming at keeping the monitoring costs at the commonly acceptable level. The general rule assumes the transmission of basic interpretation results for all the monitoring time and more detailed reports

for short time intervals. Occurrence or suspicion of any event result in a more detailed report including up to a corresponding strip of raw signal. This approach was proposed as a result of cardiologist's behavior analysis, but it can be remotely programmed upon request.

The adaptability of the remote monitor goes far beyond the functional or economic aspects. In our belief, it has a considerable impact to the diagnostics quality due to the following advantages:

- The monitoring and auto-alerting parameters are adjustable to the patient-specific signal, during the initial recording phase and anytime thereafter the device may be remotely taught what is correct and what is wrong.
- The reporting can follow any unexpected event and the interpretation is flexible enough to cover a variety of diagnostic goals changed or updated remotely.
- The audiovisual communication with the patient or his supervisors provides an interactive channel for instructions necessary in case of technical troubles (e.g. electrode replacement), medical risk (e.g. physical overload), medication intake or remote modification of monitor's function.

## 3. Result

The prototype of monitoring device has been designed around the HP PDA with use of a standard 8-channels acquisition card and the Siemens S55 GSM mobile telephone with the GPRS modem. The computer uses a Pocket Windows operating system that is compatible with Microsoft Windows platform for desktop PCs. The interpretation software was re-designed accordingly to the assumed architecture. Sample data flow diagram is displayed in figure 2.

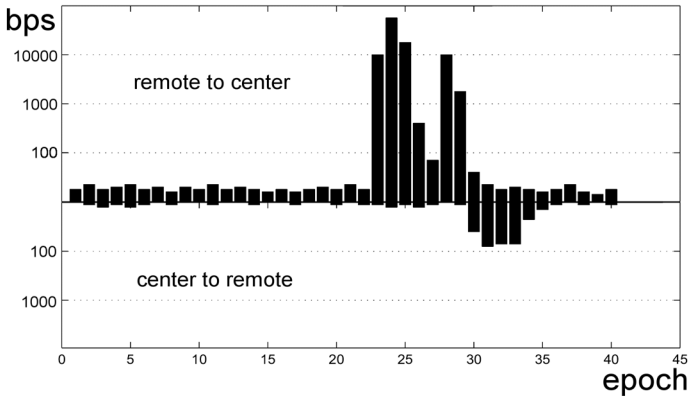


Figure 2. Data flow diagram for the case of unexpected ECG: Epochs 1-22 - only diagnostic data is sent, epochs 23-29 – raw signal is sent to the center as an example of difficult case, epochs 30-34 – diagnostic library in remote device is updated, epochs 35-40 - only diagnostic data is sent.

## 4. Discussion

The tests performed with use of CSE database files revealed all expected behavior of negotiating devices: diagnostic data transmission, raw signal transmission, remote procedure adjustment, remote procedure update. The data flow was asymmetric, the average data stream from the remote device to the center was 41 bps, while the opposite average data stream from the center to the remote device was only 12 bps.

Although the reported research demonstrated the expected advantages and the feasibility of a remotely programmable cardiomonitor, a lot of work is to be done towards the first network of such devices:

- The general purpose acquisition card should be replaced by an ECG-dedicated circuitry and the external GPRS modem should be replaced by built-in module.
- The dependencies of interpretation results and implied changes in interpretation process and reporting format should be investigated on the medical background.
- The multi-threaded software for the cardiology center should be developed in order to perform independent supervising of several remote monitors and for the management of patient's data archive.

## References

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