A TELEMONITORING ARCHITECTURE TO SUPPORT CHRONIC DISEASE MANAGEMENT AND ACUTE EPISODE MONITORING

M. Clarke, R W Jones

Department of Information Systems and Computing, Brunel University, Uxbridge, Middlesex, UK

malcolm.clarke@brunel.ac.uk

Abstract: We describe a telemonitoring architecture designed to support the dual role of chronic disease management and acute episode monitoring. In the former, measurements of parameters such as weight and blood pressure are taken periodically and are used to determine a change in the condition of a patient and thus prompt intervention in therapy. However, such patients can deteriorate rapidly and enter a phase where constant monitoring of vital signs is required. In these conditions, our system monitors ECG, SpO_2 and temperature continuously and transmits data on preset events or at preset times. To date such monitoring has required two systems; we have developed a single system to fulfil both roles. Transmission and control protocol are designed along principles of the 11073 standard. We show how such monitoring can manage patients with acute conditions such as unstable angina and heart failure.

Introduction

The 11073 (IEEE 1073) family of standards [1] defines the characteristics of medical devices in terms of the communication protocols, data formats and interactions between the device and the data store. This set of standards was primarily developed for devices working within the hospital environment and currently does not directly support the functionality or architecture anticipated for use in remote monitoring.

At the same time, new applications and systems are being developed, and it is necessary for experiences from these prototypes to be reported so that we may distil best practice to help guide the development of the new standards for this family of devices. We also require evaluation of more diverse monitoring types in order to better characterise the systems that need to be produced.

Our own research on monitoring in a residential home setting [2] has shown that systems designed to support the combined roles of chronic disease management and monitoring the patient during an acute episode may be extremely powerful in affecting the outcome for individual patients. Such systems are characterised by the sensors and the modality of monitoring. Chronic disease management is based on periodic (once per day) measurement of parameters such as weight, blood glucose and blood pressure, which are monitored for predefined change indicative of a change in condition and prompt for intervention in therapy. We have observed that such patients may deteriorate rapidly, and there follows an acute episode, during which, different parameters should be monitored, such as ECG, temperature, and SpO_2, on a frequent (every few minutes) or even continuous basis. The system must be reconfigurable remotely for the different roles. We currently use two separate systems for this monitoring.

Interactive Continuous Monitoring

We have designed the Telecare telemonitoring system to support this method of working. It is designed as a configurable remote monitoring device that monitors vital signs on a continuous or intermittent basis and only sends an alarm and representative physiological data when an algorithm monitoring the data triggers an event. The device may also send periodic recordings of selected data to manage the patient in the acute phase. The remote device is permanently connected to the server through TCP/IP using suitable link technology, such as GPRS to allow it to be reconfigured by the physician to match the needs and circumstances of the patient. This might include adjusting alarm parameters to be patient specific or reconfiguring the device to transmit ECG, temperature and SpO_2 data on a near continuous basis when a patient needs to be closely monitored, such as during an episode of angina, myocardial infarction or CHF.

For chronic disease management, the system accepts input from sensors for weight, and blood pressure on a periodic basis. Readings may be sent at any time, but it can be configured to give reminder prompts at preset times.

Design Approach

The system is designed along the principles of 11073, and uses a hierarchical structure of devices and sub-devices. In the Telecare structure, figure 1, the top level device captures the data; the sub-devices process the data, for example the ECG device has sub-devices to monitor ST segment level and heart rate. This approach allows a common abstract nomenclature for alarms and monitoring protocol to be developed and this is applied to each device and sub-device so that they are managed and controlled in a uniform way. Furthermore, by developing a rich control set for alarms and monitoring, devices for chronic disease management (BP, weight, glucose) can be included in the same structure.

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A feature rich set of controls has been developed for alarms, and includes parameters such as hysteresis level, hold off time, and frequency of occurrence in order to reduce the incidence of false alarms.

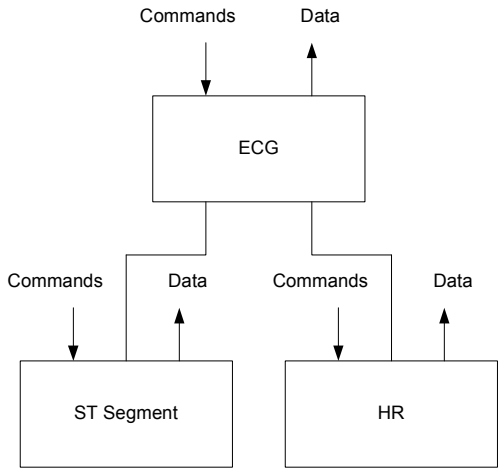

Figure 1: Hierarchical Design Structure

Data Measurement

The power of such a system is demonstrated in figures 2 to 4. The ECG and SpO_2 of a lady complaining of feeling unwell were recorded from a remote residential home and the data viewed by the physician at a separate health centre. The initial ECG recording, figure 2, shows significant ST depression in lead III with T wave inversion.

Figure 2: Initial recording of Lead III

Aspirin and angina medication were prescribed and administered by local staff. Figure 3 shows the ECG 45 minutes later. ST depression is reduced, and the ECG normalising.

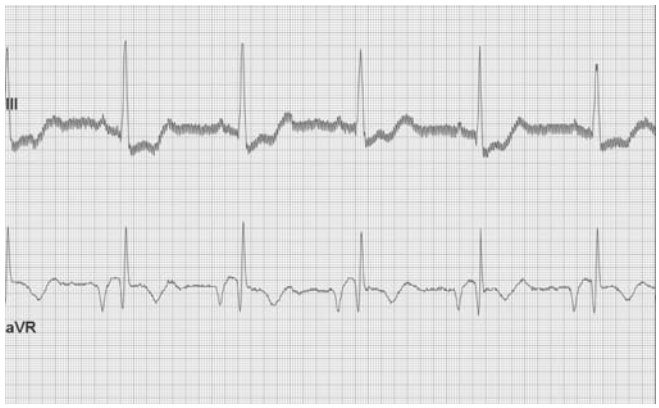

Figure 3: Final recording of Lead III

The condition was complicated by the patient having CHF. The SpO_2 was recorded at the same time (top trace figure 4) and can be seen to continue to fall. The lady became very breathless and was admitted to hospital to receive oxygen therapy.

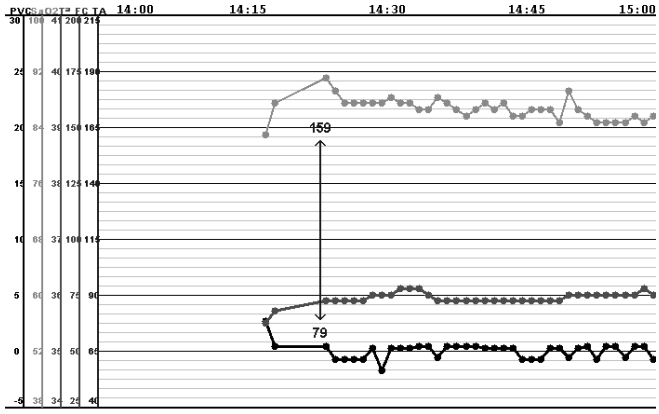

Figure 4: Recording of SpO_2 (top trace)

Discussion

Experience from separate programmes of chronic disease management and acute monitoring has demonstrated that the condition of patients may deteriorate rapidly. Chronic disease management can be successful in providing information to allow therapy to be modified and so change the course of deterioration. However this is not always the case and patients may continue to deteriorate and enter an acute phase. Remote monitoring may then be used to determine how best to manage the patient. In our example, monitoring determined that hospitalisation was the most appropriate.

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We have determined that dual role monitoring offers exciting possibilities for improvements in the management of patients. By designing a system from the outset to fulfil this purpose, a unified architecture and control protocol results. It is also clear that the system must be remotely configurable, in order to adapt to the changing needs in monitoring according to the condition of the patient. GPRS, with its always connected behaviour, is ideal. By developing a lean, light protocol, communication cost may also be kept low; in the UK, even less than POTS.

A flexible approach was adopted for the design of architecture and protocol, and this allowed support for types of monitoring other than chronic disease management and acute monitoring. This would include ambulatory monitoring, where vital signs are monitored continuously and algorithms are used to detect an event and send an alarm plus representative data.

Conclusion

The Telecare system was conceived as a flexible system to support remote monitoring of parameters. Sensors are intelligent, so that signals may be monitored within the sensor itself, an essential element if data transmission is to be minimised. The sensors need to be controllable, and sub-devices were a new feature that allowed easy control of recording and monitoring of derived signals, such as HR from ECG. The hierarchical model allows each base sensor and sub-sensor to be controlled in a consistent way, simplifying the database and protocol design. It was realised that the architecture was easily adaptable to support all forms of telemonitoring, and we are using it as a reference architecture for research towards standards for telemedicine.

Acknowledgment

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References

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