Home Care Telematics for Peritoneal Dialysis: Field Analysis and Design Considerations

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HOME CARE TELEMATICS FOR PERITONEAL DIALYSIS: FIELD ANALYSIS AND DESIGN CONSIDERATIONS

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ABSTRACT

Homecare telematics can be regarded as one of the fastest growing healthcare delivery sectors in the developed world and it is further reinforced as healthcare delivery paradigm is shifting from doctor and hospital-centered towards a new model where the citizen becomes responsible for the personalized management of healthcare, delivered at the point of living whenever possible. Among else, homecare telematics include services for end stage renal disease patients on haemodialysis or on peritoneal dialysis. This paper reviews current trends in home care telematics for patients on peritoneal dialysis and comments on certain design considerations that prohibit the widespread deployment of such services. Furthermore, the paper presents the PERKA approach for developing homecare services for peritoneal dialysis, a component-based design founded on internet communication protocols and generic standard interfaces that allow integration among third party components.

KEYWORDS: home care telematics, peritoneal dialysis, web services

INTRODUCTION

Most developed countries are facing important overall problems regarding healthcare services[1], such as: (a) increased demand of healthcare due to an increased number of elderly and changed life styles leading to an increase in chronic diseases, such as end-stage renal disease, diabetes, asthma, etc.; (b) demand for increased accessibility of care outside hospitals, moving health services into the patient’s own homes; (c) need for increased efficiency, individualisation and equity of quality-oriented healthcare with limited financial resources; (d) difficulties of recruiting and retaining personnel in the healthcare services in general and in home and elderly care in particular; and (e) increased demand for providing and sustaining quality of life for the chronic patient and the erderly. Such challenges turn homecare telematics in one of the fastest growing healthcare delivery sectors in the developed world. Indeed, it is expected to grow even more dramatically as healthcare provision and reimbursement policies and changing while an increasing number of cost effectiveness trials are conducted[2]. Homecare telematics are also reinforced as healthcare delivery paradigm is shifting from doctor and hospital-centered towards a new model where the citizen becomes responsible for the personalized management of healthcare, delivered at the point of living whenever possible.

This paper describes a novel architectural approach for developing homecare telematic services for monitoring, managing and communicating with end stage renal disease patients on peritoneal dialysis. The proposed approach builds on open internet standards for communication between well defined and self-described functional units, thus supporting solutions based on integration of components from various vendors.

HOMECARE TELEMATIC SERVICES

Homecare telematics (or telehomecare) involves the use of information, communications, measurement and monitoring technologies to evaluate health status and deliver healthcare and support personalized healthcare management. The more modern term *home teleHealth* includes in general any use of telecommunications by a home care provider to link patients or customers to one or more out-of-home sources of care information, education, or service by means of telephones, computers, interactive television, or some combination of each. Finally, the concept of home based eHealth is sometimes used to include both telehomecare and smart homes)[3]. Generally, homecare telematic services can be used to support preventive healthcare through information dissemination and education for self-management, enhance health maintenance in special high risk groups with pre-existing chronic medical problems, assist rehabilitation after disease and major therapeutic interventions, and support health in both acute and chronic health problems. Such services fall broadly into the following categories[2,4,5]: (a) addressing patient and citizen anxiety; (b) providing patient information and consultation for quality of life; (c) supporting telemetry of vital signs and related patient data; and (d) combining some or all of the above to set the basis towards integrated personalized care. However, a recent literature review[1] suggests that most of the work on homecare telematics is towards two dominant services: audio-video teleconsultation and vital sign telemetry, while other added-value services such as decision support for medical staff and advanced information access and communication are rather sparse.

The most common medical case and disciplines supported by homecare telematics include: cardiovascular disease (rehabilitation after surgery, prevention and guessing of episodes, chronic patient monitoring), diabetes (teleconsultation to enhance adherence to medical regimen), chronic pain consultation (update on patient progress, medication change, and counseling), psychiatry (dignity psychotherapy, monitor medication adherence), pulmonary disease (chronic patient monitoring, teleconsultation to monitor and enhance adherence to therapy), neonatal monitoring (virtual patient visits in the neonatal care unit and virtual house calls after discharge and vital sign telemetry for low birth weight infants, cardiorespiratory syndromes), oncology (home care and support via teleconsultation and virtual home visits), supporting the elderly (mobility telemonitoring). Last, but not least, home telehealth includes also services to support renal disease: teleconsultations and virtual home visits, education, and vital sign telemetry for hemodialysis[6-8] and peritoneal dialysis patients[9-13].

TELEMATICS FOR PERITONEAL DIALYSIS: TRENDS AND CONSIDERATIONS

End stage renal disease with chronic renal failure is treated with either dialysis or kidney transplant. Dialysis involves substituting renal function by removing waste products from the blood via a specialized interface, either using an artificial membrane outside the patient's body (haemodialysis in Artificial Kidney Units) or using peritoneum as a physical membrane inside the patient's body (peritoneal dialysis). The number of end-stage renal patients with chronic renal fealure tends to increase nowadays, mostly due to the increased incidents of diabetes. In peritoneal dialysis (PD), a special fluid (solute) is inserted into the peritoneal cavity, remains there for a certain period of time and then exits the body. The process is implemented via a permanent catheter and a special mobile unit, and is repeated a few times a day (depending on the specific dialysis scheme). Peritoneal dialysis is performed at the home of the patient, who visits the hospital or PD clinic once a month for a routine check-up. The percentage of patients on peritoneal dialysis differs across countries and is about 10-50 % of patients on dialysis, while the effectiveness and success of the method depends on the dialysis scheme which is designed by the doctor for each patient and is determined among else by physiological parameters such as: patient weight, blood pressure and heart rate (and in specific cases ECG and blood glucose), as well as the type and amount of the solute that is inserted and excreted during the dialysis. There are a number of PD techniques; the most common include the Continuous Ambulatory Peritoneal Dialysis (CAPD), where the patient handles the process of fluid exchanges manually throughout the day, and the Automated Peritoneal Dialysis (APD), where the process is performed automatically by a cycler device during the night.

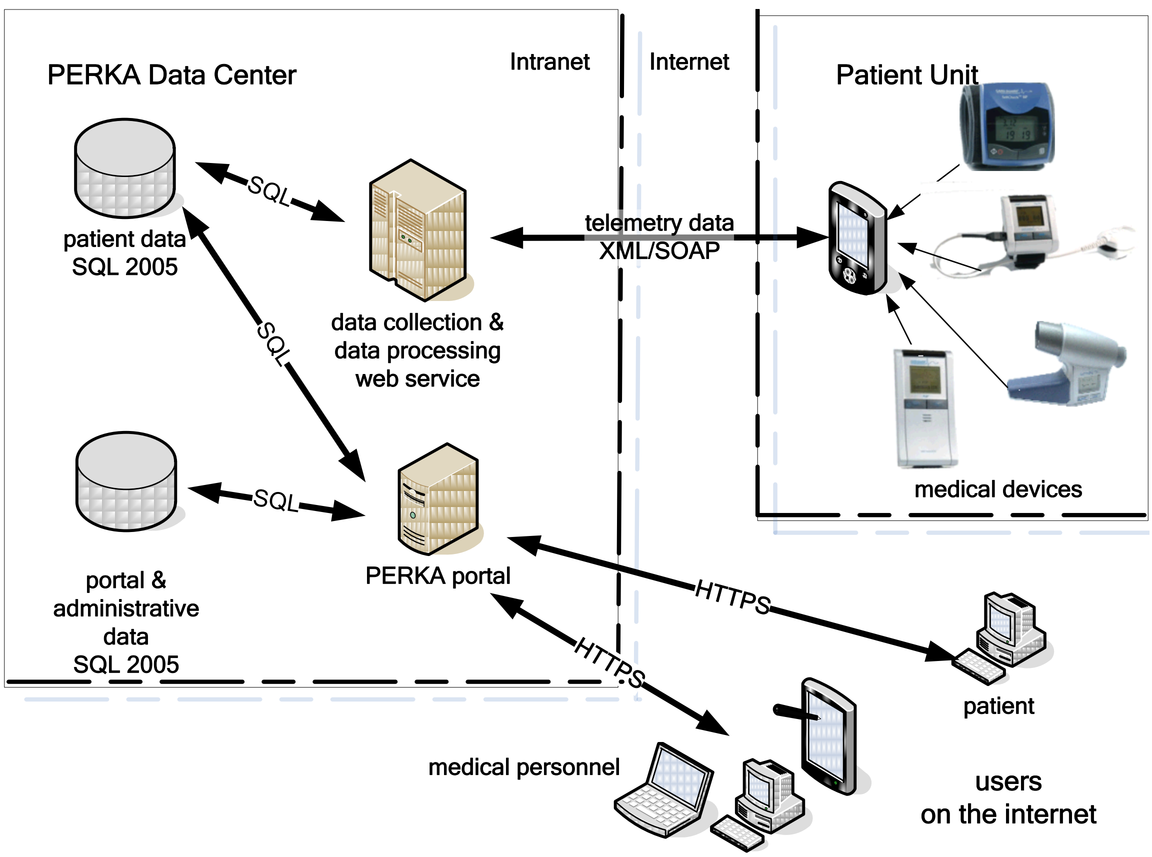
Being performed solely at home, peritoneal dialysis is a unique candidate for support via telematic services. Thus, teleconferencing has been used by various groups for psychological support, patient retraining, evaluation of catheter exit site and oedema presence[9,10]. More recent studies and pilot implementations involve vital sign telemetry. Thus mobile telephony and web-based systems have been proposed to monitor CAPD sessions[11] as well as APD [12]. Automated telemetry between the patient's cycler and a computer in the PD clinic is currently supported by the most prominent manufacturers of APD equipment, such as Fresenious Medical Care (Germany, http://www.fmc-ag.com/) and Baxter International Inc. (IL, USA, http://www.baxter.com/), allowing data transmission and storage, doctor interventions to alter cycler prescription, as well as live patient-physician interaction[13].

All related studies showed that, telemonitoring of dialysis data proved to be useful in detecting and solving the clinical and technical problems of APD. Generally, telematic support in peritoneal dialysis has proven to be a low cost solution, easy to incorporate into clinic daily routine, with save in patient and nurse time and hospital space and load, while the response of the patients has shown to be positive. Moreover, elderly and handicapped patients benefit from such services and they become comfortable enough to maintain CAPD and APD without major problems and accidents while quality of life is in general being improved for the patients and their families. However there are some design considerations and technical limitations to existing solutions that prohibit the widespread adoption of such services. Although telematic support has been incorporated into widely used APD cyclers, this service is provided only with a limited range of models and most importantly it is not provided as an open component system, so the APD telemetry data can only be monitored, archived and managed via proprietary software. Thus a PD center would have to either use APD equipment exclusively from a single ventor, or have to cope with different sets of monitoring and archiving software. In either case, monitoring would have to be restricted on APD patients using only the certain advanced cyclers, excluding users of other devices and/or patients on CAPD.

PERKA: TELEMATIC SERVICES FOR PERITONEAL DIALYSIS

In 2006 the School of Medicine in Democritus University of Thrace and two software companies, ALPHA Information Technology SA (Alexandroupolis, Greece, http://www.alphait.gr) and VIDAVO Information Systems Inc. (Thessaloniki, Greece, http://www.vidavo.gr), formed the PERKA consortium and were granted a competitive R&D fund in order to develop a new telemedicine service to support peritoneal dialysis at home, using standard-based integration between individual units developed independently by various vendors.

FIGURE 1: The PERKA service architecture overview



The PERKA service supports the collection and transmission of data from the patient's home via cellular or conventional phone or data networks to the PD clinic for monitoring and archiving. Transmitted data include: (a) peritoneal dialysis data: PD method, PD prescription, and PD daily treatment schema actually conducted including number of fluid exchanges, exchange duration, solute type and volume, and ultrafiltration volume; (b) general biometric data and biosignals: body weight, blood pressure, heart rate, oxygen saturation, temperature, and, on occasion, electrocardiogram and blood glucose levels; and (c) free text or sound report and/or response to a structured questionnaire. Data are transmitted to the PD Clinic, where they are archived as a patient record segment and processed to create intelligent alarms. Medical personnel can monitor transmitted data either on schedule or as a result of an alarm, and remotely supervise PD procedure, patient adherence to prescription, reaction to PD and the overall wellness of the patient, and can intervene to change the therapy or communicate with the patient. The service can be applied in any PD technique, including CAPD and APD.

The proposed approach builds on open internet standards for communication between well defined and self-described functional units, thus supporting solutions based on integration of components from various vendors. The basic functional units, shown in Figure 1, include:

- A patient unit, a PDA-based mobile application that undertakes local data collection, either automatically from various medical devices with digital output or as manual patient entry.
- A data collection unit, which is implemented as a web service, with standard self-describing interface methods that among else describe the type and details of telemetry data required. This web service collects, manages and processes telemetry data.
- A web-based portal application that provides different views of the telemetry data, according to the user (patient, doctor, nurse, administration, etc) via secure internet protocols.
- A database for patient telemetry data that corresponds to a patient record segment.
- A database for administrative data (user definitions, roles, permissions and other information) as well as content for general information of the medical personnel, patients and the public (which is organized by a content management system).

Communication between the patient unit and the data center is based on XML/SOAP. The published interface methods of the data collection web service allow for third party vendors (including vendors of peritoneal dialysis cyclers and other supportive medical equipment) to develop their own proprietary units for local collection from the patient and thus provide a generic standard interface for integration with special purpose mobile units and medical devices alike.

DISCUSSION

Peritoneal dialysis is the basic alternative solution to regular hemodialysis hospital visits for patients with end stage renal disease and it is related to lower mortality and better quality of life. However, peritoneal dialysis is performed solely at home: patients have to do everything for themselves, including solute exchanges, catheter site care, recording of dialysis session parameters and related biometric data, etc. Telemedicine has thus been used in various cases either to offer consultation via teleconferencing or even support session telemonitoring via telemetry.

However the widespread adoption of such services has been generally prohibited by the fact that existing solutions involve proprietary systems implemented from end-to-end by the same vendor. This paper describes a novel architectural approach for developing homecare telematic services for peritoneal dialysis, based on open internet standards for communication between well defined and self-described functional units, thus allowing for potential solutions based on integration of components from various vendors. Current work involves deploying such as solution with components developed independently by three different partners.

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