Tele-homecare supported by the DITIS collaborative platform

Andreas PITSILLIDES[1], George SAMARAS[1], Dimosthenis GEORGIADIS[1], Panayiotis ANDREOU[1], Eleni CHRISTODOULOU[1], Barbara PITSILLIDES[2]

[1]*University of Cyprus, Department of Computer Science, Nicosia, CY 1678, Cyprus*
Tel: +357 22892700, Fax: + 357 22892701,
Email:{Andreas.Pitsillides cssamara, cspggd, cs98ap1, cseleni}@cs.ucy.ac.cy
[2]*PASYKAF, Association of Cancer Patients and Friends, Nicosia, Cyprus*
Tel: +357 99451681, Fax: + 357 24660856, Email: cspitsil@cytanet.com.cy

Abstract: Nurses, doctors, physiotherapists, social workers, psychologists and others come together to provide care to home residing patients including elderly people, making continuous assessment, diagnosis and treatment possible beyond the walls of hospitals and specialist treatment centers. Such teams of professionals are focused on each individual patient, and are virtual, i.e. they make decisions without being together physically, dynamically, i.e. professionals come and go as needed, and collaborate, as they combine their knowledge to provide effective care. DITIS is a web based system that supports this model. It enables the effective management and collaboration of virtual healthcare teams, and provides secure access to medical information from anyplace and anytime via desktop computers (at work) or a variety of mobile devices from anytime and any place. It includes a set of tools for effective scheduling and coordination of team members, with features including automatic notification and alerting. It makes use of supportive tools relevant to home care that improve efficiency and minimises errors of home care monitoring. The paper introduces the DITIS system, and identifies the needs and challenges of co-ordinated teams of multidisciplinary healthcare professionals. Then the adopted technology is briefly described. Pilot implementations of the systems as well as an evaluation study of the system are also briefly presented.

Keywords: Mobile e-health, home healthcare, collaboration, security, virtual teams.

1. Introduction

The current context of health and health care is characterized by change and transition associated with health care system reform and restructuring [1]. Restructuring initiatives are intended to develop a more results-oriented, integrated and accountable health system that delivers the right services, to the right people, at the most appropriate time, in the right place and in the most cost-effective manner. Further, technological advances are enabling a greater shift from institutional services to ambulatory and community-based services, as for example home-care. The pressure to expand and enhance home-based services is expected to grow as a result of demographic shifts in an increasingly ageing population, changing consumer expectations with respect to service and care options, and technological and scientific advancements in the delivery of health services. Many see home care as a more cost-effective alternative to acute care and/or to long-term institutional care [1,2]. In this paper we will focus on home-based care.

Practice of home-based care should often be a collaborative activity, requiring extensive and interactive communication, within and between members of specialized occupational groups to coordinate patient care services. By maintaining a dynamic collaborative virtual healthcare team, DITIS [3,4] achieves the delivery of better home-care, as well as secure,

easy, and timely access, to the unified Electronic Healthcare Record (EHR) database. The dynamic virtual healthcare team is created explicitly to satisfy the needs of each particular patient at a point in time with each patient having its own virtual medical team. Without an electronic health record this cannot be acheived due to the fact that busy professionals are not able to collaborate, especially virtually. Using DITIS though this can be accomplished irrespective of the physical presence of individual members of the team, or even if different doctors treat the patient, for possibly different symptoms, at different hospitals or at home. It's obvious, that for home-based care the concurrent physical presence at the point of care of all members of the team is rarely possible. This creates difficulties for providing quality care that patients deserve to obtain in a friendly home environment.

The idea of home nursing is not a new one. In Africa nurses have been empowered to take on many independent roles due to the shortage of doctors and financial constraints to health budgets. DITIS aims to help these home care teams to work more efficiently, effectively and safely within the home setting. Allowing the nurse to work independently, but at the same time be part of a team and be able to contact a doctor from anywhere (ie the home via mobile and receive an e prescription while still in the home) and at anytime. DITIS also offers the opportunity to be connected with experts in the field outside of the town or even the country in order to obtain a (second) opinion but furthermore, in this way promote the education of experts within the country or more rural areas.

The paper is organised as follows. Chapter 2 discusses the project objectives and provides an illustrative scenario, Chapter 3 addresses the system design and implementation, Chapter 4 briefly describes two pilot implementations and Chapter 5 an evaluation of DITIS. Finally, Chapter 6 offers our conclusions and future directions.

2. Project Objectives and Illustrative Scenarios

Complex and chronic illnesses demand the use of specialist treatment protocols. According to these, patient care is provided by a team of multidisciplinary healthcare professionals (HCPs), as cardiologists, nurses, physiotherapists and so on. Thus, the provision of as optimum and effective care as possible demands the *cooperation, communication* and *coordination* among all these professionals and the formation of a '*team of care*'. Furthermore, nurses and other mobile HCPs visit patients regularly at home, offer care, which must be provided in co-operation, and often under direction of the treating doctor.

DITIS aims to overcome the above difficulties by maintaining a dynamic collaborative virtual healthcare team, as well as secure, easy, and timely access to the unified EHR. The virtual healthcare team is created explicitly to satisfy the needs of each particular patient at a point in time. As a result many clinical objectives are addressed, which are described in Section 5.2. DITIS will provide the presence of the team by the patient at any given time (via fixed and mobile devices), irrespective of locality or cross country movement, and improve communication within the dynamic home care team, provide flexible and secure access and management of EHR at any time and from anywhere improving continuity of care. Furthermore, improve collection of statistical data for further audit and research within the home care setting, enhanc knowledge and offer the possibility of evidence-based care, providing continuity of care for chronic illness via Virtual Collaborative Medical Teams and aid in making the dependant role of the home-care nurse legally binding. Given the above are satisfied, the quality of life of patients will improve. Next we present an illustrative scenario that describes the modelling process in DITIS platform.

2.1 Illustrative Scenarios

Many scenarios have been identified and implemented in DITIS, including: Referral of a new patient to home-care, referral to other professionals, and first home-care-visit; Home-

care virtual team creation/addition of members and communication with the virtual team members; Service provided in the homecare, requiring collaboration with the treating doctor such as: change of prescription and blood analysis; and continuity of care in outpatients, admissions to hospital and for staff members on call.

To formally model these scenarios, the Unified Modelling Language (UML) is used. To illustrate this modelling process we present the submission and handling of a new patient referral and discuss the creation and management of a virtual team. For the referral scenario, we present a sequence diagram in Figure 1. This same scenario shows aspects of virtual team interaction for the accomplishment of specific tasks.

Illustrative scenario

1. A diagnosed cardiac patient, Athina, is referred to LITO Home Care by Dr Miltiades, the resident cardiologist at LITO Polyclinic.
2. Dr Miltiades completes the Referral Form. Upon submission of the Referral Form for Ms Athina, needed information is transmitted to DITIS database and a patient record is created.
3. Dr John, the Home Care Doctor, after reading the referral form and patient record, assigns nurse Barbara to be the nurse that delivers and oversees the home nursing care for patient. Dr John adds himself and Nurse Barbara to the virtual medical team for patient Ms Athina. He telephones and assesses the immediate needs of the patient and schedules a first visit.
4. On first visit Dr John checks patient's record and visits together with Nurse Barbara. He takes a history both medical and psychosocial, and assessment of symptoms and requirements. He enters the findings in system. Dr Miltiades is informed about the visit.
5. Nurse Barbara then schedules the next appointment in 6 days time and leaves.
6. She is now aware of patient requirements and refers her to other members of the team.
7. Nurse Barbara decides to add a social worker, Ms Andri, to the virtual team as Ms Athina needs to apply for a pension since she will be unable to resume work in the near future.
8. Nurse Barbara also adds a physiotherapist, Ms Viktoria to the team to teach Ms Athina deep breathing and coughing techniques.
9. Messages sent to social worker and physiotherapist informing them for their addition to the HCT. These messages are stored in the DITIS messaging service and SMSs are also sent.
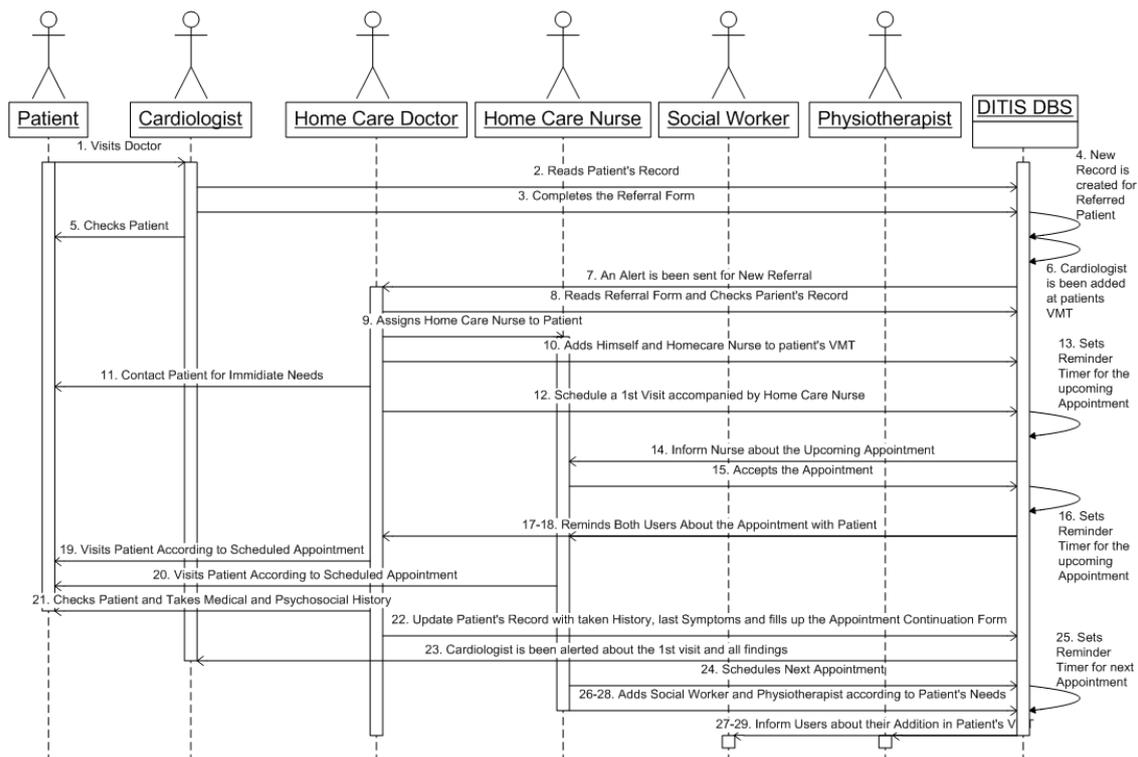

Figure 1: *Sequence diagram*

3. System Design and Implementation

DITIS is an Internet (web) based Group Collaboration system with secure fixed and mobile connectivity. The development of DITIS is based on the HL7, ICD-0 and ICD-10 standards, with a view towards an open Healthcare Information Infrastructure [5]. DITIS is designed to be open to the other services, in order to retrieve information from any medical facility such as hospitals. In order to achieve this, the system supports an HL7 parser for sending and receiving HL7v2.5 messages. Of course, the project team is continuously monitoring relevant international standards so as to ensure interoperability with emerging platforms.

DITIS provides secure access to e-records from any place and anytime via desktop computers (at work) or a variety of mobile devices (when on the go). It includes a set of integrated procedures for effective scheduling and coordination of team members, with features including messaging, automatic notification, and alerting. It also makes use of supportive tools relevant to home care that improve efficiency and minimize errors (e.g. messaging, calendar, symptom and pain diaries, medication charts, wound care assessment, etc) as well as decision support tools (drug interaction, assessment tools, etc).

3.1 Technology Description

The DITIS Framework is a collection of health care services that supports the collaborative patient management via a multi-modal interface. The DITIS architecture is a five-layer architecture. Figure 3 illustrates the relationship between each of the DITIS layers.

The patient record (PMS, EHR) is the foundation of the DITIS Framework. As it can be seen in Figure 4, it is composed of various modules that support the recording and processing of different information concerning the patient. This information includes the patient's demographics, medication, exams, diaries and more.
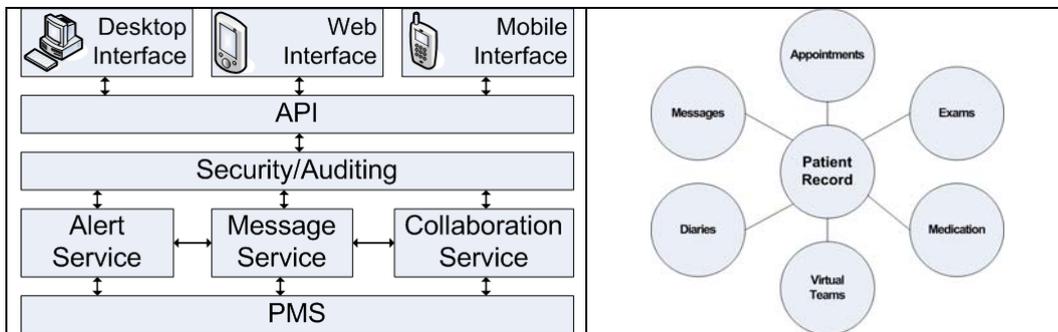

Figure 2: *DITIS layered architecture*   **Figure 3:** *DITIS services*

The main services that access directly the patient record layer are the Collaboration, the Messaging and the Alert Service. The Collaboration Service is responsible for the Virtual Healthcare Team management, and implementation of organization specific requirements and policies. In order to achieve this, the Collaboration Service maintains a collaboration engine which conserves the rules and policies implemented in the system. The Alert Service is responsible for alerting both health care professionals and patients about future appointments, medication alerts, and other. Both the collaboration and alert service are linked to the messaging service as they require messages in order to inform the user or the system about the status and actions that may be required for certain events. The Messaging Service is responsible for delivering messages to the users of DITIS. Messages are structured data stored in the system. In some cases SMS notifications are used in conjunction with messages routed by the system DITIS to increase the chance of alerting the user to specific events or actions, dependant on the importance of the event or action.

Note that all SMSs are generated and sent by the system therefore a log is always kept, for example to generate new actions or for audits.

Next, in the architecture comes the Security and Auditing layer. DITIS implements a multi-layer security strategy based on the OCTAVE methodology (Operationally Critical Threat, Asset, and Vulnerability Evaluation) [6,7,8]. The DITIS system was implemented with the goal of providing end-to-end security, addressing the security needs of the health care team down to the activity level, with ease of use. The security objective includes: Retain the privacy and integrity of medical and personal information; Authentication/Authorization; Achieve non-repudiation (Digital Signatures); Secure the local storage of information; Availability - Failover plan; and Ease of use. An application level auditing mechanism enables system administrators to navigate through the history of each individual record without being obliged to go through complex log files.

Finally the API layer includes a list of all commands for accessing the system. The API is used by all implemented interfaces (desktop, web and mobile) and acts as the bridge to the DITIS system. These interfaces are implemented with state of the art technologies in order to provide accessibility to DITIS by any device and enhance the functionality.

3.2 Mobile Devices

Mobile devices were a necessity since most team members are mobile workers, visiting the patients at home needing to be accessible from anywhere at anytime. To achieve this, DITIS uses devices such as Smartphones, Pocket PCs, Palm PCs and Handheld PCs. To achieve high degree of compatibility a common, light, user friendly interface is provided which is automatically fine tuned to meet each mobile device's requirements and telecommunication costs. ***Figure 5*** illustrates the web interface while and ***Figure 6*** the stand alone interface. Note that the standalone supports the creation of a richer graphical interface since it stored and loaded directly into the device's memory.

The standalone implementation uses a local database that stores locally a subset of the database. This subset includes recent patient records, appointments, medication and other. This introduces an additional benefit, as the user can have continuity of service even during periods of no connectivity with the network. The synchronisation aspects were analysed for a number of scenarios and the synchronisation strategy was implemented [9,10].

Figure 4: Example screens (web interface)   *Figure 5: Example screens (standalone interface)*

The standalone implementation uses a local database system that stores locally a subset of the entire database. This subset includes recent patient records, appointments, medication and other. This introduces an additional benefit, as user can have continuity of service even during periods of no connectivity with the network. As soon as the user connects to the mobile network (GSM/GPRS/UMTS) or cradle the device synchronizes with the backend server. The synchronisation aspects were analysed for a number of scenarios and the synchronisation strategy was implemented [11,12]. As mobile device technology evolves so is the opportunity to include more sophisticated functionality on the mobile device itself.

4. Pilot Implementations

The system was initially installed in 1999 and has been supporting the activities of the Cyprus Association of Cancer Patients and Friends (PA.SY.KA.F.) who offers home-care services to more than 1000 cancer patients per year in Cyprus. One of the district offices has gone paperless with DITIS since 2003. PA.SY.KA.F. personnel received training to use DITIS [13], and virtual collaborative healthcare teams are carrying out home care services using mobile devices. At the same time DITIS is being extended to collaborate with other cancer health care entities. It is worth pointing out that prior to DITIS, the team of professionals was (loosely) coordinated by weekly meetings, or in case of some urgent event information was exchanged by telephone calls, or face-to-face meetings. Often the same information was requested from the patient, so as each professional can build their own medical and psychosocial history and treatment notes (handwritten). Therefore there was limited possibility for continuity of care, audits, and statistics. Research was difficult, evidence-based medicine was not supported, dynamic coordination of the team was almost impossible, and communication overheads were very high and costly in human and monetary terms. DITIS offers a solution to these problems [14].

Since 2005 DITIS has also been successfully integrated in a health care monitoring platform developed under the Healthservice24 (HS24) and LinkCare e-Ten projects [15,16] aimed at providing a viable mobile health care service, permitting healthcare professionals to remotely and interactively diagnose, collaborate with each other and treat patients whilst the patients are free to continue their normal daily life activities. Ongoing monitoring is especially important in case of chronic and high-risk patients, e.g. cardiac patients discharged early from hospital after a surgery and high-risk cardiac patients that require almost constant monitoring. Today these patients are often hospitalised for long periods, resulting in high hospital costs and moral degradation.
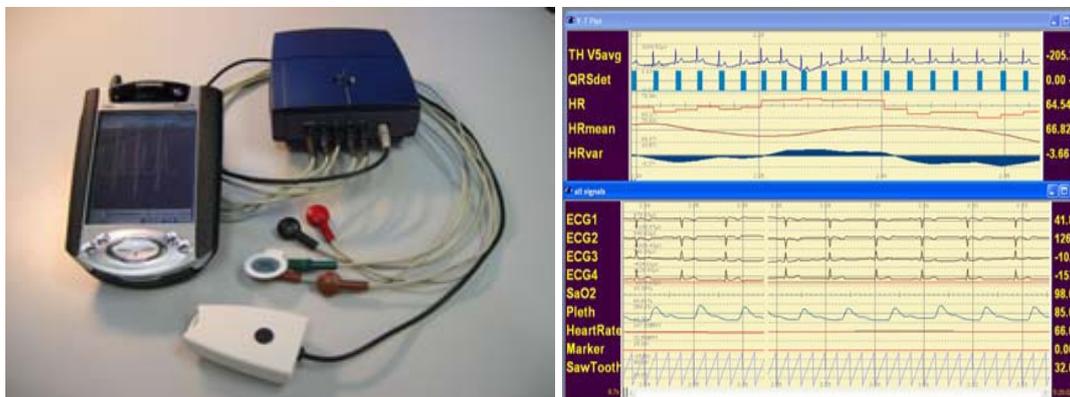

Figure 6: HealthService24 Body Area Network and example doctor interface

The integrated system is in pilot use in Cyprus LITO Clinic providing home care monitoring to cardiac patients. In the HS24 project a patient/user is equipped with diverse vital signs sensors, like blood pressure, pulse rate and ECG interconnected under a wireless Body Area Network managed by a PDA or mobile telephone and worn on the body, thus moving around with person. Patients can thus stay mobile, being continuously monitored and receive advice when needed. In the LinkCare project specialists are collaborating though DITIS to improve the healthcare provision. In the HS24 setup, vital signals are transmitted to an intermediate data center, with streaming functionality, that enables users to download and view data on any supported devices. HCPs, to whom the patients' data is transferred, can remotely assess, and diagnose whilst patients stay fully mobile and continue with their daily activities. The integrated home care monitoring platform is incorporated into DITIS which supports additional functionality as described in Section 2.

The integrated DITIS and monitoring system can decrease hospital time for chronic and high-risk patients, but also for elderly people at home, while their feeling of safety remains intact by allowing them to obtain health advice by experts at any moment and place. Consequently, the system reduces health care costs resulting from the occupation of hospital beds significantly. Cost reduction aspect makes the service potentially interesting for health insurances and governmental institutions paying for medical services [15].

5. Evaluation

5.1 Longitudinal Study

A longitudinal study on DITIS in the home-care of cancer patients can be found in [14]. The study adopts the stakeholders' analysis [17] to explore various groups that have directly or indirectly supported the system during its implementation. It aims to understand these challenges and results of the study point to a diversity of interests and different degrees of support. The adopted research was interpretive, as our aim is to capture stakeholders' interpretations of the system itself and their use of the system. To this end, our research method is qualitative in nature, examining "humans within their social settings" ([18]). The fieldwork has taken place in various district sites in Cyprus. Each site is served by a number of palliative-care nurses who visit patients regularly in their house. Data on DITIS were collected on different stages of the implementation process.

Overall, results revealed that DITIS is an invaluable tool for palliative care, offering innumerable opportunities for HCPs. However, the study also revealed implementation problems. During first three phases of study, it was recognized that effectiveness of system was jeopardized due to financial resources. In addition, some HCPs felt that DITIS had not yet been sufficiently incorporated into their daily work activities. Based on the results of the longitudinal assessment, corrective measures were taken, including creation of a more stable team due to commitment of all relevant actors and availability of funding. During this phase, there was a general feeling of satisfaction about the use of DITIS in the day-to-day work practices as users have by now began seeing the benefits of the system.

5.2 Clinical and Societal Benefits

On the Clinical side the objectives were addressed by DITIS are: continuity of care: promotion of dependant role of home-nurse: improved communication: cost effectiveness: secure timely access to patient information: flexible collection of statistical data; improved health practices and reduction of bureaucratic overhead.

Societal benefits include improved quality of life for patients and HCPs. Our study on Cardiac patients reports that the impact on the attitude of the patients during the HS24 trials was very high. Through DITIS a patient can communicate and collaborate with his virtual team, leading to the comprehension that patient could play a more vital role in his own health care supervision., feeling more reassured that they were given a higher level of care.

5.3 Economic Benefits

DITIS showed substantial home care savings regarding cancer patients in Cyprus (population under 1 million). For about 1000 cancer patients it is roughly estimated that the yearly cost of their care without homecare services could be about 6 million Euro per year (only considering cost estimates for Hospitalisation, Hospice care, Outpatient treatment, Palliative Care Nurse visits to the hospital, visits to Oncologist and other specialists, travelling and time costs for patient and family). If home care is offered substantial savings could be offered, with the costs being around 1 million Euro per year (assuming 30 nurses

and 20000 home care visits per year, i.e. 20 home care visits per patient per year, on average), mainly by savings on the above mentioned costs, offset by home healthcare costs. Beyond that, with the use of DITIS system there is a further saving of about 300k Euro (about 12,000 Euro savings per nurse per year). It must be noted that the above estimates are very 'rough' and also exclude medicine and overhead related expenses (e.g. running a hospital, running a home care service, etc). Also, the local IT support for the system is not factored in. It is dependant on the local IT business and users IT knowledge; it can prove easy and inexpensive, or difficult and expensive if local IT support is totally absent. Note that DITIS server can be in any part of the world. Only local PCs and telephone devices/smart phones need to be supported, which do not require specialist IT knowledge.

Indicative cost savings through DITIS are due to reductions in hospitalisation, reduction of healthcare staff visits to the head office, e.g. to consult paper patient records, savings in travelling to patient house from previous patient or from base (distance and time), time to handover patients and history taking on admission, reduction in preparation work prior and after the visit in the head office (reporting and management), more efficient communication/collaboration saving time among HCPs

5.4 Problems Faced

Despite benefits, there were also problems faced during the deployment of DITIS. Some of these problems were phobia of technology, limited budget and reorganization of the working process, lack of local IT support. Despite the fact that the system was robust and forgiving, there was a lot of mistrust because of the unreliability of the telecommunications infrastructure, especially in the rural areas. One of the most challenging problems was the lack of legal framework, e.g. for electronic prescription. In addition the constant technology change required continuous upgrades of the system as well as re-training of the users.

6. Conclusions

In this paper we motivated virtual collaborative teams for home healthcare and discussed their implementation issues through the project DITIS, which supports home-care by offering wireless health care services for chronic illnesses. The main service is the dynamic creation, management and co-ordination of virtual collaborative healthcare teams for the continuous treatment of patients at home, independently of physical location of the team's members, or patient. This virtual team is able to provide dedicated, personalized service to home residing patients on a need based and timely fashion, under the direction of the treating specialist, thus minimising the necessity to move the patient from his home. Also in case of need for hospitalisation better planning can be achieved, so as to minimise expensive hospital stays, as well as better manage scarce resources, by coordinating the admission and discharge with the cooperation of the home-care team. This results in the provision of better care and a reduction of number of visits to health professionals or hospitals away from patient's home.

DITIS delivers a product that can improve the quality of the citizen's life. Contrary to today's health processing structure which is, facility-based, this project shifts the focus onto home-based care, where everything is moving around the patient. Thus patients can now enjoy 'optimum' health service, with improved quality of life, in the warmth of their own friendly environment, feeling safe and secure that in case of a change in their condition the health care team will be (virtually) present to support them. Africa stands to benefit by DITIS supporting home care teams to work more efficiently, effectively and safely within the home setting. For example, by allowing the nurse to work independently but at the same time be part of a team and be able to contact a doctor from anywhere (ie at the home via mobile and receive an e prescription while still in the home) and at anytime. Also, the

mobile telecommunication infrastructure can be usefully employed, given that Africa has been the fastest-growing mobile market in the world during the past five years [19].

DITIS is at present being deployed for its healthcare collaboration and patient-management aspects in context of two EU funded e-TEN market validation projects involving trials for cardiac-patient monitoring. Furthermore, an OEM is currently being signed with a major telecommunication equipment manufacturer, which aims to market DITIS worldwide. Future extensions to DITIS include further evaluation of system benefits, including cost benefit analysis, a formal study of interactions between team members to be undertaken with a view to the provision of adaptability in the virtual team interactions and work flow. Furthermore, through the involvement in a European Commission funded project MPOWER [20] we are planning to integrate DITIS with Smart Homes and Sensor Networks, with a focus on the cognitively impaired and the elderly.

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