# DITIS: Collaborative Virtual Medical team for home healthcare of cancer patients

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**Abstract:** Complex and chronic illnesses, such as Cancer demand the use of specialist treatment protocols, administered and monitored by a co-ordinated team of professionals. Home based care of chronic illnesses (e.g. cancer patients) by a team of professionals is often a necessity, due to the protracted length of the illness. Hospital based treatment is limited, often demand based for short periods of time. As it is not possible for the health care team to be physically present by the patient at all times, or at any time physically together, whilst the patient is undergoing treatment, a principal aim of the current project is to overcome this problem, through DITIS[1], (ΔΙΤΗΣ, in Greek). DITIS is a system that supports Virtual Medical Teams dealing with the home-healthcare of cancer patients in Cyprus. It aims to support the creation, management and co-ordination of virtual medical teams, for the continuos treatment of the patient at home, and if need for periodic visits to places of specialist treatment and back home.

## 1. Introduction

A serious (chronic) illness, such as cancer, demands the use of specialised protocols for treatment and symptom control from a coordinated team of experts (such as minimisation of pain using medicine, psychology, physiotherapy, etc…). It is obvious that the simultaneous physical presence of the team by the side of the patient, when the patient is at home (demanded by the length of the illness—till cure or death, which may last for years), at all times of need, is almost impossible. A fundamental aim of this project is to circumvent this problem through the use of a system (DITIS) for the support of a *virtual medical team*, using *tele-presence* based on communication network solution [1], [2], for the continued support of the cancer patient at home.

The provision of home health care for serious (chronic) illnesses, such as Cancer, demands specialised medical protocols by a team of medical professionals attending the different needs of the patient:

- The patient care is provided by a team of more than one professionals, such as specialist and general medical doctors, nurses, physiotherapists, psychorteherapists, dieticians, social workers, and so on. The provision of as optimum and effective care as possible demands the *cooperation* and *coordination* among all these professionals, and the formation of a '*team of care*'
- Specialist medical and nursing professionals visit regularly the patient at her/his house, offering home care, which must be provided in co-operation, and often under the direction by the treating doctors of a hospital (e.g. oncology).

[1] DITIS (ΔΙΤΗΣ, in Greek) stands for: *Network for Medical Collaboration*

The provision of top quality care necessitates close collaboration, easy and timely exchange of information, and coordination of the team activities. This should be achieved irrespective of the physical presence of the individual members of the team, or even if different doctors treat the patient, for possibly different symptoms at different hospitals, or visit him at home. It is of course obvious, that the *concurrent physical presence* at the *point of care* of all members of the team is not often possible. This creates serious difficulties for providing the quality care that Cancer patients deserve to obtain in a friendly (to them) home environment. A fundamental aim of the current project is to overcome these difficulties by developing a novel system for supporting a *collaborative virtual medical team*, having the patient at the core.

In brief, the project aims to design, develop and deploy a novel networked system for Telecollaboration in the area of patient care at the home by a virtual team of medical and paramedical professionals, using a patient centric paradigm (see Figure 1), initially concentrating on cancer patients [3, 4].

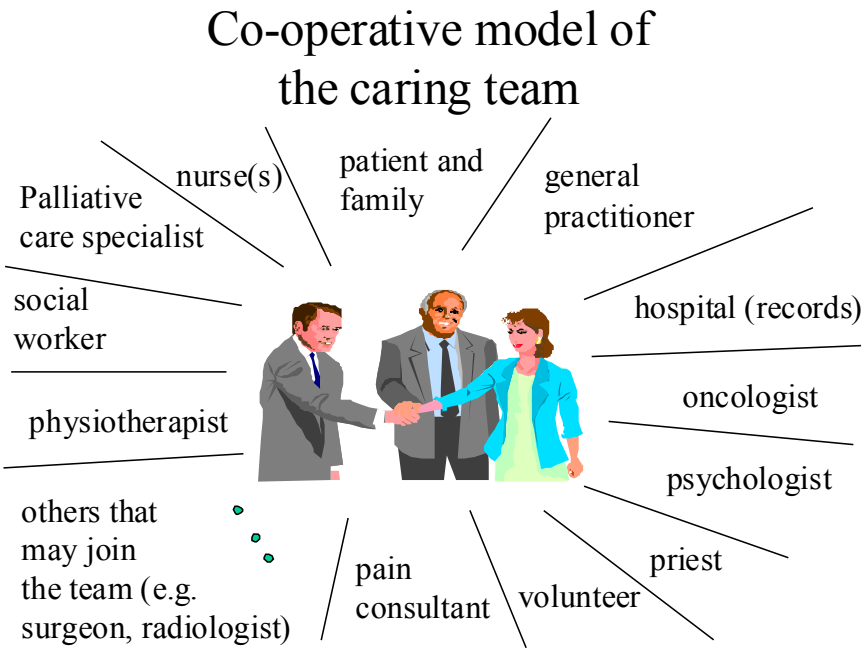


**Figure 1 Patient centric home health care model**

DITIS will be an Internet (web) based Group Collaboration system with fixed and GSM mobile connectivity. It will employ Mobile Agents, Web Databases with Java Database Connectivity, and web based database for storage and processing of information, including Electronic Medical Record (EMR) pertinent to cancer patients, in accordance with National and International standards (e.g. WHO ICD-10, ICD-0) [5], software for collaborative work, intelligent interface for uniform access to the common database and the Group Collaboration software from both fixed and mobile computing units. DITIS is expected to develop novelty in the above mentioned technologies, as well as the

integration of new technologies, in Telemedicine and to support the home care service for cancer patients through the use of Mobile Computing Units (e.g. Handheld PCs).

DITIS will be used in a pilot for supporting the activities of the medical and paramedical PASYKAF (Cyprus Association of Cancer Patients and Friends**)** staff that offers care to cancer patients in the home, using a patient centric philosophy.

# 2. DITIS System

## 2.1 Design and development of DITIS

The design and development of a pilot system for Tele-cooperation, named DITIS, (ΔΙΤΗΣ, in Greek, stands for: Network for Medical Collaboration) will be based on Internet and GSM connectivity, and will include and integrate (see Figure 2):

- **Mobile Agents** [6], [7] e.g. IBM's Aglets Workbench [8] and Mitsubishi's Concordia, and Voyager [9], for the implementation of flexible communication infrastructure [10] for the support of mobile users. The mobile agents may be extended to offer intelligence and co-operation.
- **Web Databases** with **Java Database Connectivity** [11], [12], [13],
- **Web based database** [14] for the storage and processing of the **Electronic Medical Record**
- **Telecooperation system** for sharing of information, team communication, coordination of team activities
- **Adaptive intelligent interface** [15], [16] for database access from a variety of access units, such as:
    - Mobile Computing Units with GSM Internet connectivity.
    - Fixed units with Internet Access supporting Tele-cooperation.

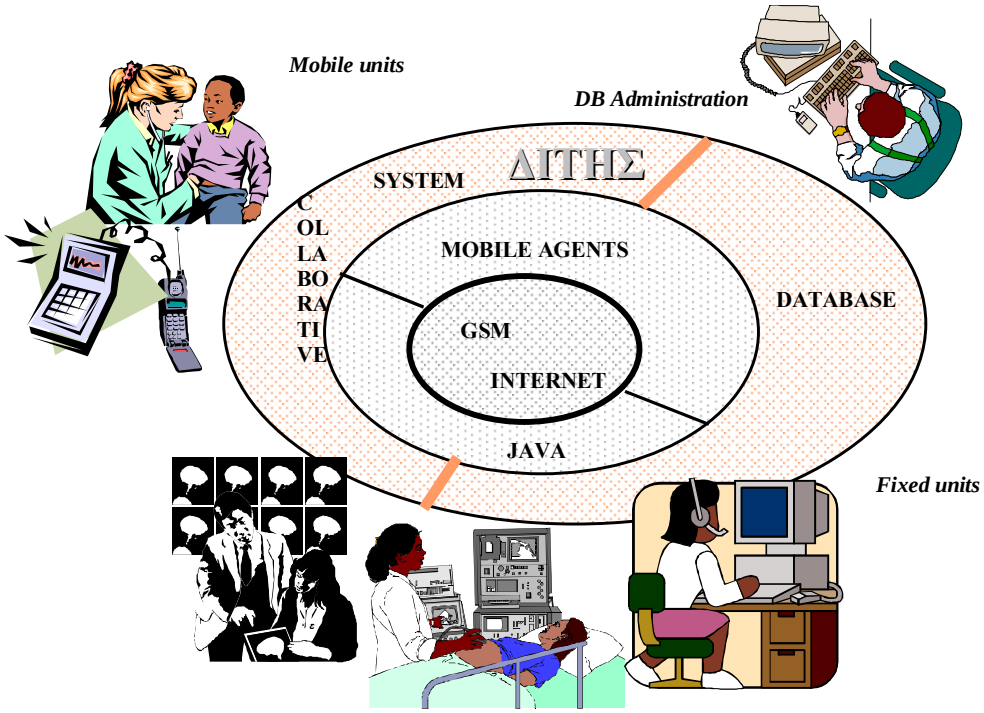


**Figure 2** DITIS System diagram

## 2.2 DITIS functionality

With the following hypothetical scenario we illustrate the functioning of DITIS.
*Nurse Mary wakes up early in the morning. After showering and having her breakfast she connects (**with her wireless PDA Unit**) to the central office web server to check in and acquire her day's visit schedule (note that the nurse does not have to physically check in). Her schedule includes a number of visits. For each patient to visit, Mary downloads on her PDA the needed information, plans her route, and updates the Web server of her schedule. At first she visits Mr. P., a nice sweet old man who while enjoying the comfort and love of his home he daily requires (**and receives**) attention due to the seriousness of his situation. Arriving at his house and examining Mr P nurse Mary realises an extreme rise in temperature and blood pressure. She immediately (**via GSM**) connects with the web server and via the PDA's intelligent application interface reports the incident. The system records (**into the electronic medical record of the patient in the database**) the new data, identifies the implication of such an event **(via the intelligence built into it)** and triggers and transmits messages (**via the mobile agents**) to the other members of the team alerting them and requiring their services. For each member of the team DITIS extracts from the EMR only the needed (and authorised) parts of the information, prepares it and then forwards to them. That is the PDA device of every team member is receiving not only the data of the triggering incident (i.e., patient P. experiences extreme rise in temperature and blood pressure) but also any relevant patient history. (**A virtual team around patient P. has been now set in motion in seconds defying distance and geographical barriers**.) The responsible doctor, Dr. A., studies the information submitted to her and prescribes the health care protocol which nurse M. and other team members (e.g. a prescribed physiotherapy) should administer. Also a new appointment is*

*scheduled for patient P. with the oncologist. Nurse Mary performs her tasks and Mr P. returns back to his smiley and happy self; the virtual medical team made the 'miracle'. His family are thanking nurse Mary who is headed to her next appointment. She is checking her schedule when a message (**via an agent**) comes in informing her that Mrs. D., her next patient, has suffered an extreme crisis and she has been taken to the hospital. Nurse Mary, while sorry for Mrs. D., is headed to the next patient in her list, Mr. X. On route she is informed of a new admission that she can schedule right now. Nurse M. visits the patient Mr Y. for the first time. DITIS already has his EMR (sent by the treating doctor) to the PASYKAF Web server, and has forwardewd the relevant information to the PDA of Nurse M. Nurse M examines patient Y. and updates the Web server by performing **on the spot data entry** through the user friendly user interface of her PDA. And so the day goes on.*

Efficient and effective nursing care has been provided. All this is made possible by DITIS which provides an intelligent **centralised web based database with direct wireless connectivity linking all members of the virtual medical team**.

## 2.3 Infrastructure

Since the team cannot be physically present at the point-of-care at all times, the project aims to create a virtual team using "tele-presence" based on communication network solution. The communication model (see Figure 3) should have the following characteristics: (a) it must be open and flexible, b) it must be efficient, structured, coordinated and enhanced with some intelligence built into the system so that it can avoid duplication of information, and be able to route information only to essential recipients, (c) geographic barriers must be broken, (e.g. a pain specialist can be in any part of the world).

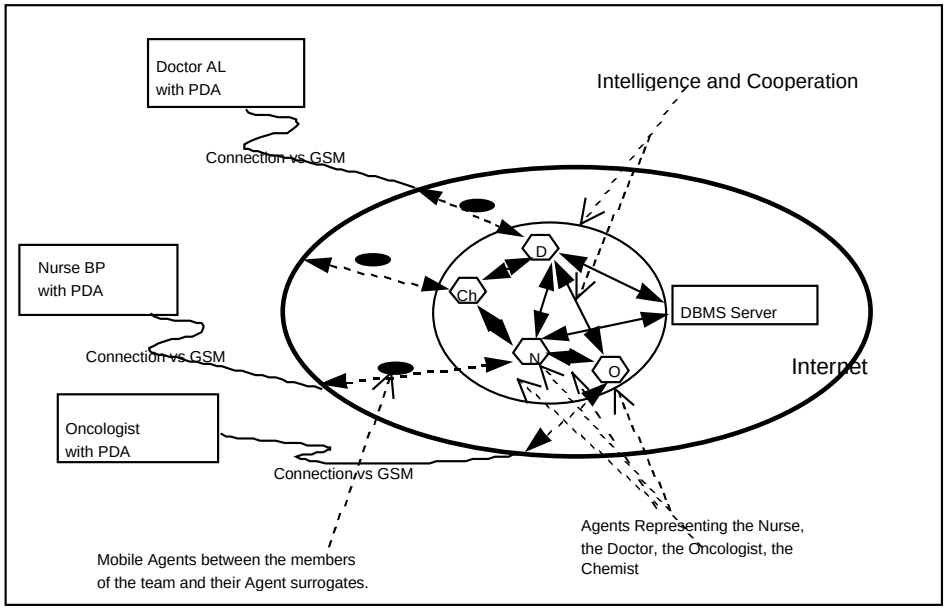


**Figure 3** Schematic of DITIS system infrastructure

The philosophy adopted for modelling the networked solution incorporates the paradigm shift in computing toward network centric (client-server like) networks, nomadic computing and mobile computing networks, based on the observations that:

1. The Internet offers global connectivity, and the World Wide Web offers access to distributed information [17]. A goal of this project is to employ this capability in conjunction with todays wireless connectivity [18] for the realization of the virtual "always" present medical team. The internet provides the fixed network infrastructure while the various wireless networks (namely GSM) the mobile/nomadic network. We must marry and enhance these two technologies efficiently, intelligently, cooperatively and in a light portable manner [19], [20]. The project should take advantage the evolution of information and communication technologies, and emerging protocols and standards.
2. The fixed network will host servers containing the data of the patients. Around it an application layer will be build to handle cooperation and system intelligence. We envisions the virtual team to be equipped with small, portable and light handheld PCs or devices (PDA's) that are capable of wireless connectivity. Servers are designed to support a number of clients located in any part of the world. Networked handheld PCs or devices are able to seamlessly synchronize, communicate and exchange information with servers. They offer standard communication support, enabling access to the Internet for email and Web browsing. Emerging protocols and standards will be investigated (e.g. the Wireless Application Protocol, WAP [21]).
3. Mobility and tele-presence, come however, with certain cost. This cost is the limitations of the wireless link; expensive, low bandwidth, high latency and low reliability. The cumulative effect of these limitations is frequent disconnection (i.e., intermittent connectivity) and weak connectivity. To alleviate this we propose to use state of the art technology based of mobile agents and investigate the emerging Wireless Application Protocol. In general, mobile agents offer autonomy and asynchronous connectivity and can be easily enhanced with intelligence.

In summary the proposed infrastructure will seamlessly brings together a number of new technologies, specifically:

- The internet; for global connectivity and for hosting the patients database
- The various wireless networks; to support user's mobility and wireless connectivity
- The new generation of handheld computing devices; for portability and ease of use

These technologies mainly support the communication requirements of the applications. The implementation model responsible for the functionality of the applications is supported by the following software:

- Database Server; for the storing and maintenance of the patients database
- Web; for the client's interface to the application
- Java; for the development of the application. Java is the language for developing internet applications. While it lacks a bit on efficiency it is portable and specific for network programming.
- Java will be used for the development of the cooperation and intelligent part (model) of the project.

- Mobile Agents; to efficiently bring together the various technologies. For the agent execution environment we will investigate the use of the various Java based mobile agents, such IBM's Aglets Workbench, Mitsubishi Concordia. Aglets are Java based mobile agents; they are going to be used for asynchronous communications and they can be extended to acquire intelligence and cooperative skill. We aim to base the development of the application on mobile agents.

## 3. Unified information space

The implementation of DITIS will be based on the establishment of an **Electronic Medical Record – EMR** for the management of medical patient information (entry, update, query, process), in accordance with national and international standards (such as ICD-10, ICD-0). Furthemore by enhancing the EMR database with intelligence and a flexible interface and collaborative system, it is expected to improve the exchange of patient medical record and the co-ordination between different medical professionals treating the patient (patient centric approach). This is expected, irrespective of the patient locality (home, hospital), or even when the collaborating parties do not have a fixed point of work (mobile worker, telehome nurse).

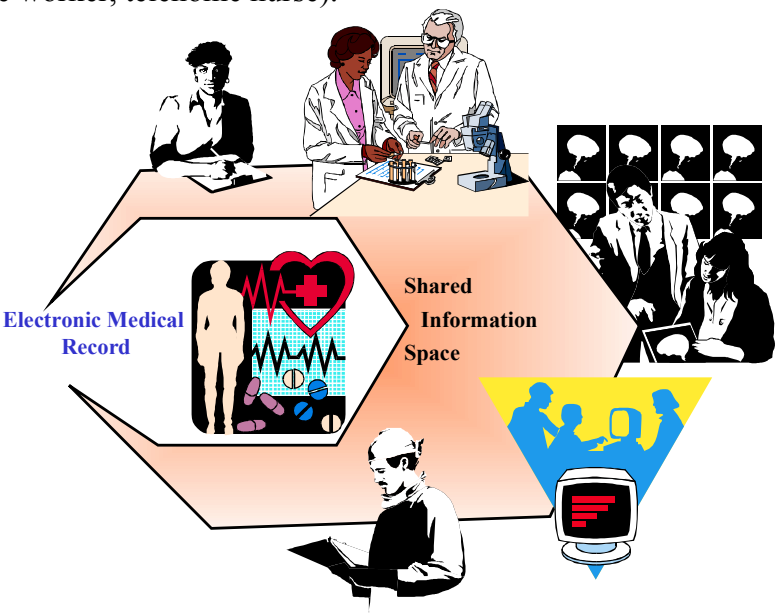


**Figure 4** The unified information space of DITIS

Using the collaborative virtual medical team system and accessing the unified Electronic Medical Record database (see Figure 4) enables the team to function effectively without the necessity of *physical and concurrent togetherness* at the point of care by all members of the team.

By use of the unified information space DITIS is expected to provide improved patient care. This will become possible through:

1. Solution of the problem of how to manage medical information observed among medical and paramedical staff.

2. Flexible management and accessing of the relevant parts of the medical record of a patient by all members of the treating team, in accordance with their authorisation levels. In this way a common unified information space centered around the patient is created, which enhances collaboration and co-ordination for the provision of quality health care (see Figure 4).
3. The capability to consult within a team of experts (e.g. the home nurse with the treating doctor and with the expert oncologist) without the need to move the patient from his home to each one of them. This will reduce the burden not only on the patient but also his relatives and also reduce the cost of treatment (by a reduction in the transport costs and the time saved by his/hers working relatives). This capability also makes better use of the scarce and expensive medical professionals, irrespective of geographic or organisational barriers.

## 4. Conclusions

DITIS is expected to deliver a product that can improve the quality of the citizen's life. It will improve the quality of health service that is now provided to the citizen. Contrary to todays health processing structure which is, in all practical terms, doctor centric this project aims to transform it into a patient centric one where everything is moving around the patient. Via tele-homemursing the team of specialist will be virtually in the patients home co-operating in timely fashion to serve him. Thus, the virtual team will be able to provide dedicated, personalized and private service to the home residing patient on a need based and timely fashion. Thus it is expected that chronic and severe patients, such as cancer patients, can now enjoy the best health service in the comfort of their home, with improved quality of life, in the warmth of their own friendly environment, without a degradation in the quality of care provided to them.
Additionally, with the patient moved into his own home the economic benefits are numerous. Aside of the comfort provided by his own home and family the monetary savings for the family and the hospitals are tremendous. With good home service the patient can be moved to his house much earlier than before reserving the team's service only when necessary. The hospitals get free rooms earlier, their personnel can more effectively distribute their service thus reducing their cost per patient dramatically.

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